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Deterministic Networking (DetNet) Data Plane: MPLS over UDP/IP

Abstract

This document specifies the MPLS Deterministic Networking (DetNet) data plane operation and encapsulation over an IP network. The approach is based on the operation of MPLS-over-UDP technology.

Status of This Memo

This is an Internet Standards Track document.

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Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc9025.

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1. Introduction

Deterministic Networking (DetNet) is a service that can be offered by a network to DetNet flows. DetNet provides these flows extremely low packet loss rates and assured maximum end-to-end delivery latency. General background and concepts of DetNet can be found in [RFC8655].

To carry DetNet MPLS flows with full functionality at the DetNet layer over an IP network, the following components are required (these are a subset of the requirements for MPLS encapsulation listed in [RFC8964]):

1. A method for identifying DetNet flows to the processing element.

2. A method for carrying the DetNet sequence number.

3. A method for distinguishing DetNet Operations, Administration, and Maintenance (OAM) packets from DetNet data packets.

4. A method for carrying queuing and forwarding indication.

These requirements are satisfied by the DetNet over MPLS Encapsulation described in [RFC8964] and they are partly satisfied (i.e., IP flows can be identified; however, no DetNet sequence number is carried) by the DetNet IP data plane defined in [RFC8939].

This document specifies use of the MPLS DetNet encapsulation over an IP network. The approach is modeled on the operation of MPLS over an IP Packet Switched Network (PSN) using UDP encapsulation [RFC7510]. It maps the MPLS data plane encapsulation described in [RFC8964] to the DetNet IP data plane defined in [RFC8939].

[RFC7510] specifies that "MPLS-in-UDP MUST NOT be used over the general Internet, or over non-cooperating network operators, to carry traffic that is not congestion controlled." This constraint does apply to the use of RFC 7510 in a DetNet network because DetNet is constrained to operate within a single administrative control or within a closed group of administrative control.

2. Terminology

2.1. Terms Used in This Document

This document uses the terminology established in the DetNet architecture [RFC8655]; the reader is assumed to be familiar with that document and its terminology.

2.2. Abbreviations

The following abbreviations are used in this document:

d-CW	A DetNet Control Word (d-CW) is used for sequencing and identifying duplicate packets of a DetNet flow at the DetNet service sub-layer.
DetNet	Deterministic Networking
DSCP	Differentiated Services Code Point
A-Label	A special case of an S-Label, whose properties are

known only at the aggregation and deaggregation endpoints.

F-Label — A DetNet "forwarding" label that identifies the LSP used to forward a DetNet flow across an MPLS PSN, e.g., a hop-by-hop label used between label-switching routers.

MPLS — Multiprotocol Label Switching

OAM — Operations, Administration, and Maintenance

PEF — Packet Elimination Function

POF — Packet Ordering Function

PREOF — Packet Replication, Elimination, and Ordering Functions

PRF — Packet Replication Function

PSN — Packet Switched Network

S-Label — A DetNet "service" label that is used between DetNet nodes that also implement the DetNet service sub-layer functions. An S-Label is also used to identify a DetNet flow at the DetNet service sub-layer.

2.3. Requirements 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 BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. DetNet MPLS Operation over DetNet IP PSNs

This document builds on the specification of MPLS over UDP defined in [RFC7510]. It may partly or entirely replace the F-Label(s) used in [RFC8964] with UDP and IP headers. The UDP and IP header information is used to identify DetNet flows, including member flows, per [RFC8939]. The resulting encapsulation is shown in Figure 1. There may be zero or more F-Labels between the S-Label and the UDP header.

Note that this encapsulation works equally well with IPv4, IPv6, and IPv6-based Segment Routing [RFC8754].

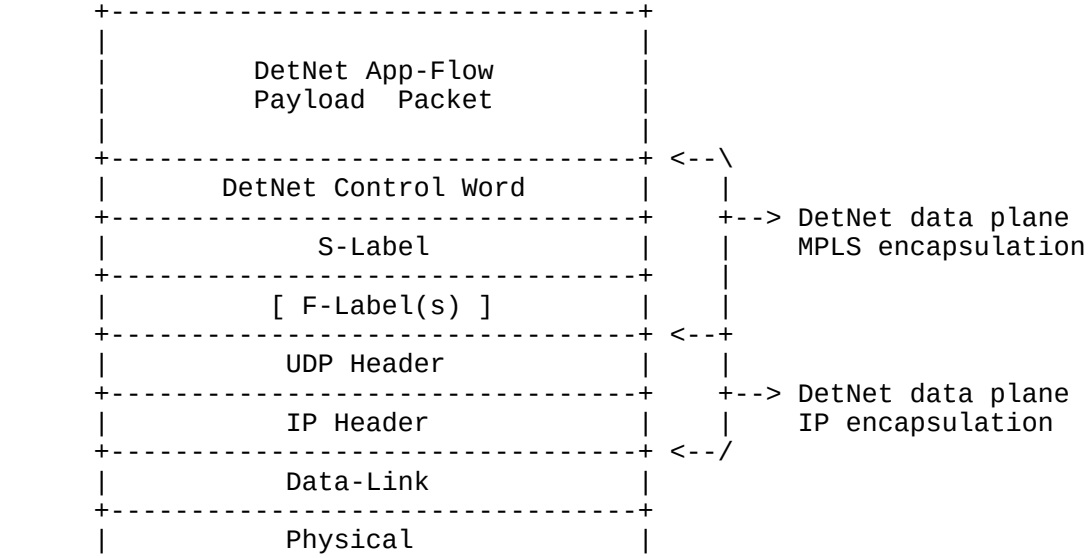

Figure 1: UDP/IP Encapsulation of DetNet MPLS

S-Labels, A-Labels (when present), d-CW, and zero or more F-Labels are used as defined in [RFC8964] and are not modified by this document.

4. DetNet Data Plane Procedures

To support outgoing DetNet MPLS over UDP encapsulation, an implementation MUST support the provisioning of UDP and IP header information in addition to or in place of F-Label(s). Note, when the PRF is performed at the MPLS service sub-layer, there will be multiple member flows, and each member flow will require the provisioning of their own UDP and IP header information. The headers for each outgoing packet MUST be formatted according to the configuration information and as defined in [RFC7510], and the UDP Source Port value MUST be set to uniquely identify the DetNet flow. The packet MUST then be handled as a DetNet IP packet, per [RFC8939]. This includes QoS-related traffic treatment.

To support the receive processing defined in this document, an implementation MUST also support the provisioning of received UDP and IP header information. The provisioned information MUST be used to identify incoming app flows based on the combination of S-Label and incoming encapsulation header information. Normal receive processing as defined in [RFC8964], including PEF and POF, can then take place.

5. Management and Control Information Summary

The following summarizes the minimum set of information that is needed to configure DetNet MPLS over UDP/IP:

* Label information (A-Labels, S-Labels, and F-Labels) to be mapped to UDP/IP flows. Note that, for example, a single S-Label can map to multiple sets of UDP/IP information when PREOF is used.

* IPv4 or IPv6 source address field

* IPv4 or IPv6 destination address field

* DSCP Field in either IPv4 Type of Service or IPv6 Traffic Class Fields

* UDP Source Port

* UDP Destination Port

* Use/non-use of UDP checksum

This information MUST be provisioned per DetNet flow via configuration, e.g., via the controller [RFC8655] or management plane. Not using the UDP checksum has to be evaluated on a case-by-case basis for a given network scenario based on the exception criteria defined in [RFC7510], particularly when IPv6 is used.

It is the responsibility of the DetNet Controller Plane to properly provision both flow identification information and the flow-specific resources needed to provide the traffic treatment needed to meet each flow's service requirements. This applies for both aggregated and individual flows.

> Note: In the presence of network (and port) address translation devices/functions, it would be up to the Controller Plane to

| determine the appropriate information to ensure proper mapping
| at the sender/receiver.

6. Security Considerations

The solution defined in this document reuses mechanisms specified in other documents, and the security considerations in those documents apply equally to this document. Of particular note is [RFC7510], as this document is primarily an application of MPLS-over-UDP. Additionally, the security considerations of DetNet in general are discussed in [RFC8655] and [DETNET-SECURITY]. Finally, MPLS- and IP-specific security considerations are described in [RFC8964] and [RFC8939]. This document does not have additional security considerations.

7. IANA Considerations

This document has no IANA actions.

8. References

8.1. Normative References

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