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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.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

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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Table of Contents

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].

```
        +----------------------------------+
        |                                  |
        |        DetNet App-Flow           |
        |        Payload  Packet           |
        |                                  |
        +----------------------------------+  <--\
        |        DetNet Control Word       |     |
        +----------------------------------+     +--> DetNet data plane
        |             S-Label              |     |    MPLS encapsulation
        +----------------------------------+     |
        |          [ F-Label(s) ]          |     |
        +----------------------------------+  <--+
        |            UDP Header            |     |
        +----------------------------------+     +--> DetNet data plane
        |            IP Header             |     |    IP encapsulation
        +----------------------------------+  <--/
        |            Data-Link             |
        +----------------------------------+
        |            Physical              |
        +----------------------------------+
```
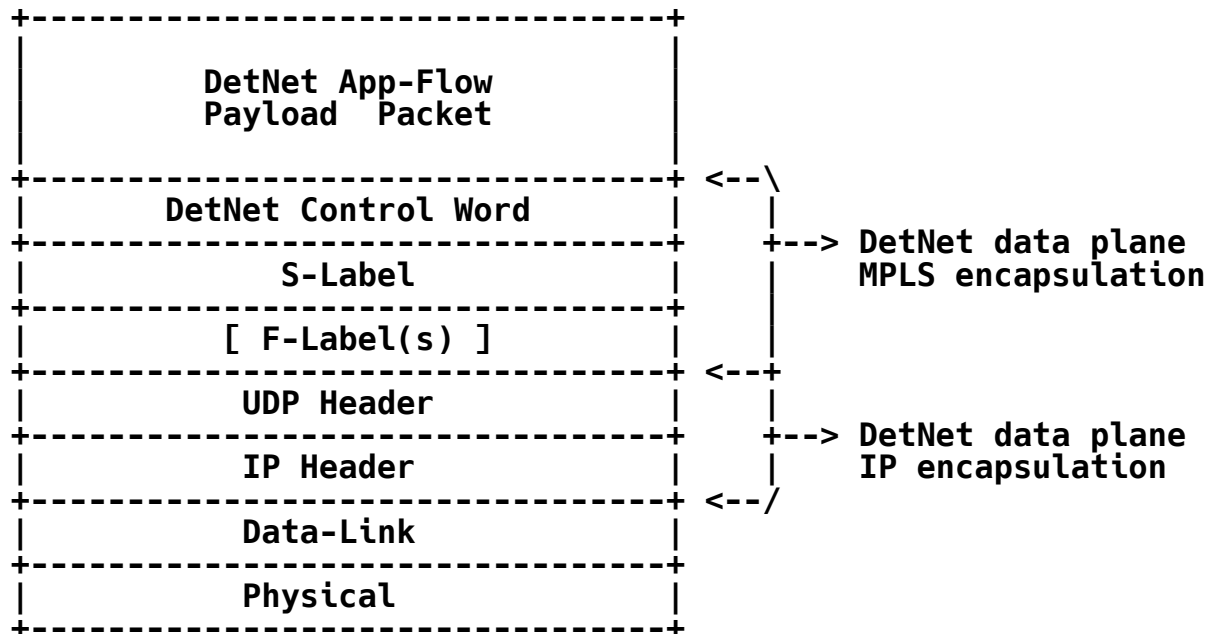
            Figure 1: UDP/IP Encapsulation of DetNet MPLS

   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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8.2. Informative References

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