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**Operations, Administration and Maintenance Version field is neededance (OAM)
for Deterministic Networks (DetNet) with MPLS Data Plane**

Abstract

This document defines format and use principles of the Deterministic Network (DetNet) service Associated Channel (ACH) over a DetNet network with the MPLS data plane. The DetNet service ACH can be used to carry test packets of active Operations, Administration, and Maintenance protocols that are used to detect DetNet failures and measure performance metrics.

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1. Introduction

[[RFC8655](#)] introduces and explains Deterministic Networks (DetNet) architecture and how the Packet Replication, Elimination, and Ordering functions (PREOF) can be used to ensure a low packet drop ratio in a DetNet domain.

Operations, Administration, and Maintenance (OAM) protocols are used to detect and localize network defects, and to monitor network performance. Some OAM functions (e.g., failure detection) are usually performed proactively in the network, while others (e.g., defect localization) are typically performed on demand. These tasks can be achieved through a combination of active and hybrid, as defined in [[RFC7799](#)], OAM methods.

Also, this document defines format and use principles of the DetNet service Associated Channel over a DetNet network with the MPLS data plane [[RFC8964](#)].

2. Conventions used in this document

2.1. Terminology and Acronyms

The term "DetNet OAM" used in this document interchangeably with longer version "set of OAM protocols, methods and tools for Deterministic Networks".

CW Control Word

DetNet Deterministic Network

d-ACH DetNet Associated Channel Header

d-CW DetNet Control Word

GAL Generic Associated Channel Label

G-ACh Generic Associated Channel

OAM: Operations, Administration, and Maintenance

PREOF Packet Replication, Elimination, and Ordering Functions

PW Pseudowire

E2E End-to-end

BFD Bidirectional Forwarding Detection

TSN IEEE 802.1 Time-Sensitive Networking

LSR Label Switching Router

F-Label A Detnet "forwarding" label. The F-Label 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 (LSR).

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

Underlay Network or Underlay Layer: The network that provides connectivity between the DetNet nodes. One example of an underlay layer is an MPLS network that provides LSP connectivity between DetNet nodes.

DetNet Node - a node that is an actor in the DetNet domain. Examples of DetNet nodes include DetNet domain Edge nodes, and DetNet nodes that perform PREOF within the DetNet domain.

2.2. Keywords

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. Active OAM for DetNet Networks with MPLS Data Plane

OAM protocols and mechanisms act within the data plane of the particular networking layer, thus it is critical that the data plane encapsulation supports OAM mechanisms that comply with the OAM requirements listed in [[I-D.ietf-detnet-oam-framework](#)]. One such example that requires special consideration is requirement #5:

DetNet OAM packets MUST be in-band, i.e., follow precisely the same path as DetNet data plane traffic both for unidirectional and bi-directional DetNet paths.

Operation of a DetNet data plane with an MPLS underlay network is specified in [[RFC8964](#)]. Within the MPLS underlay network, DetNet flows are to be encapsulated analogous to pseudowires as specified in [[RFC3985](#)], [[RFC4385](#)]. For reference, the Generic PW MPLS CW (as defined in [[RFC4385](#)] and used with DetNet) is reproduced in [Figure 1](#).

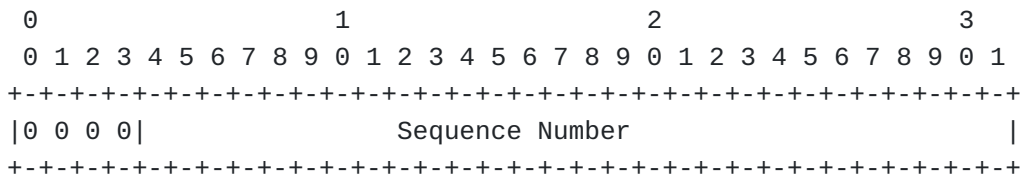


Figure 1: DetNet Control Word Format

PREOF in the DetNet domain is composed of a combination of nodes that perform replication and elimination functions. The Elimination sub-function always uses the S-Label in conjunction with the packet sequencing information (i.e., the Sequence Number encoded in the d-CW). The Replication sub-function uses the S-Label information only. An example of a PREOF sequence of operations for data packets in a DetNet domain is shown in [Figure 2](#).

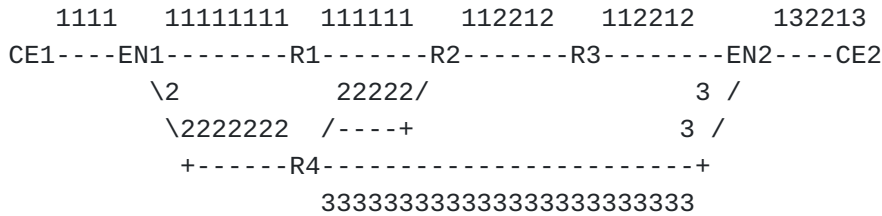


Figure 2: DetNet Data Plane Based on PW

3.1. DetNet Active OAM Encapsulation

DetNet OAM, like PW OAM, uses PW Associated Channel Header defined in [\[RFC4385\]](#). At the same time, a DetNet PW can be viewed as a Multi-Segment PW, where DetNet service sub-layer functions are at the segment endpoints. However, DetNet service sub-layer functions operate per packet level (not per segment level). These per-packet level characteristics of PREOF require additional fields for proper OAM packet processing. Encapsulation of a DetNet MPLS [\[RFC8964\]](#) active OAM packet is shown in [Figure 3](#).

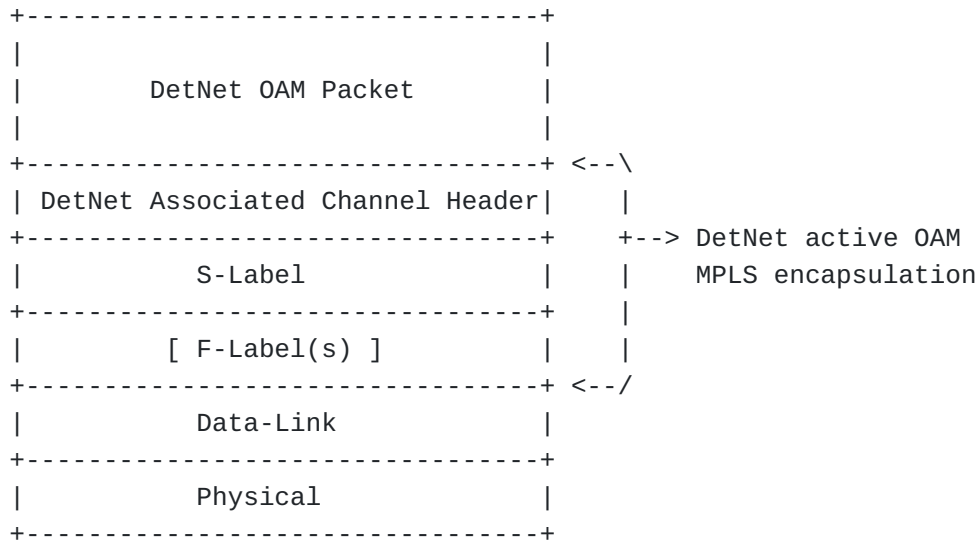


Figure 3: DetNet Active OAM Packet Encapsulation in MPLS Data Plane

[Figure 4](#) displays encapsulation of a test packet of an active DetNet OAM protocol in case of MPLS-over-UDP/IP [\[RFC9025\]](#).

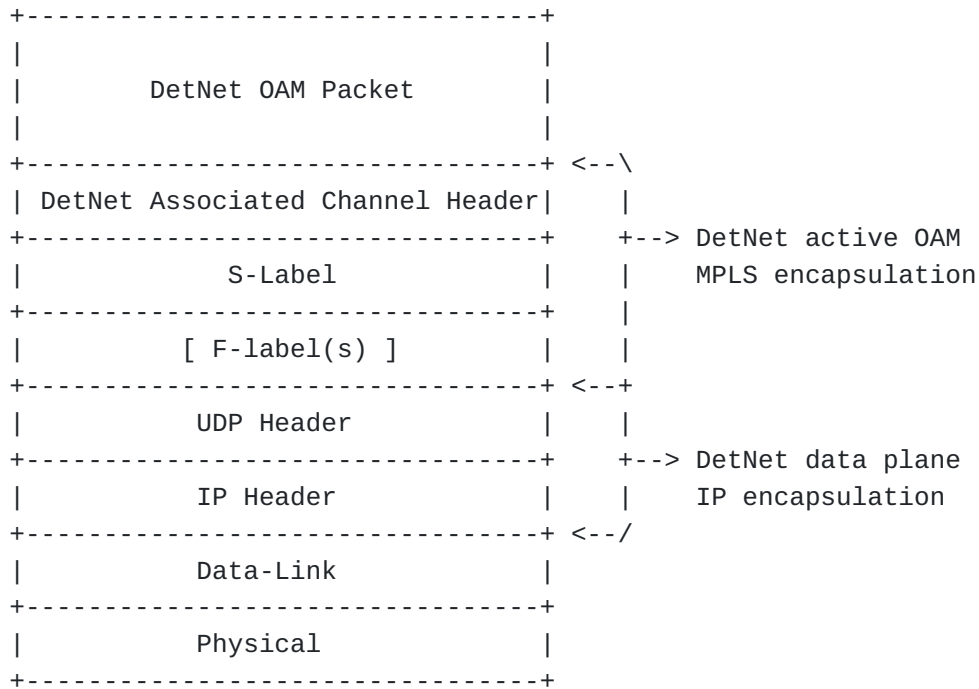


Figure 4: DetNet Active OAM Packet Encapsulation in MPLS-over-UDP/IP

[Figure 5](#) displays the format of the DetNet Associated Channel Header (d-ACH).

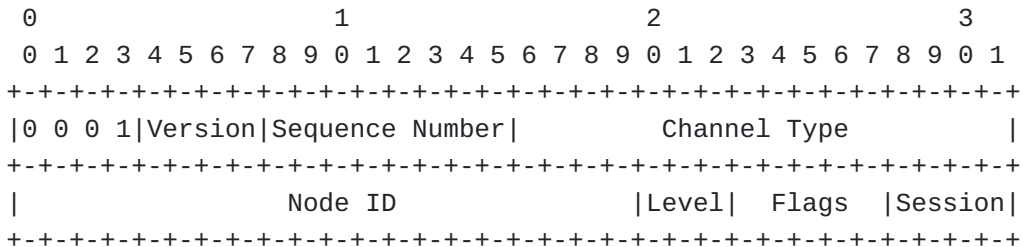


Figure 5: DetNet Associated Channel Header Format

The d-ACH encodes the following fields:

Bits 0..3 MUST be 0b0001. This value of the first nibble distinguishes an IP packet [[RFC4928](#)] from a DetNet data packet [[RFC8964](#)].

Version - is a 4-bit field, and the value is the version number of the d-ACH. Version field is needed if the update to d-ACH can not be introduced in a backward-compatible way. This specification defines version 0x1 to further differentiate d-ACH from PW ACH defined in [[RFC4385](#)].

Sequence Number - is an unsigned 8-bit field. The sequence number space is circular with no restriction on the initial value. The originator DetNet node MUST set the value of the Sequence Number field before the transmission of a packet. The originator node MUST increase the value of the Sequence Number field by 1 for each active OAM packet.

Channel Type - is a 16-bit field, and the value of DetNet Associated Channel Type. It MAY be one of the values defined in the IANA MPLS Generalized Associated Channel (G-ACh) Types (including Pseudowire Associated Channel Types) registry [[IANA-G-ACh-Types](#)]. New values can be defined in the future.

Node ID - is an unsigned 20-bit field. The value of the Node ID field identifies the DetNet node that originated the packet. Methods of distributing Node ID are outside the scope of this specification.

Level - is a 3-bit field. Level field is used to cope with the "all active path forwarding" characteristics of the PREOF concept. A hierarchical relationship between OAM domains can be created using the Level field value.

Flags - is a 5-bit field. Flags field contains five 1-bit flags. [Section 5.1](#) creates an IANA registry for new flags to be defined. The flags defined in this specification presented in [Figure 6](#).

```
  0 1 2 3 4
+-+--+--+--+
|U|U|U|U|U|
+-+--+--+--+
```

Figure 6: DetNet Associated Channel Header Flags Field Format

U: Unused and for future use. MUST be 0 on transmission and ignored on receipt.

Session ID is a 4-bits field. Session field is used to distinguish OAM sessions originated from the same node (a given Maintenance End Point may have multiple simultaneously active OAM sessions).

The DetNet flow, according to [[RFC8964](#)], is identified by the S-label that MUST be at the bottom of the stack. An Active OAM packet MUST include d-ACH immediately following the S-label.

3.2. DetNet Packet Replication, Elimination, and Ordering Functions Interaction with Active OAM

At the DetNet service sub-layer, special functions (notably PREOF) MAY be applied to the particular DetNet flow to potentially lower packet loss, improve the probability of on-time packet delivery, and ensure in-order packet delivery. PREOF relies on sequencing information in the DetNet service sub-layer. For a DetNet active OAM packet, PREOF MUST use the bit string from bit 4 through bit 31 inclusive of the first 32-bit word of the d-ACH, i.e., the concatenation of Version, Sequence Number, and Channel Type fields, as the source of this sequencing information.

4. OAM Interworking Models

Interworking of two OAM domains that utilize different networking technology can be realized either by a peering or a tunneling model. In a peering model, OAM domains are within the corresponding network domain. When using the peering model, state changes that are detected by a Fault Management OAM protocol can be mapped from one OAM domain into another or a notification, e.g., an alarm, can be sent to a central controller. In the tunneling model of OAM interworking, usually, only one active OAM protocol is used. Its test packets are tunneled through another domain along with the data flow, thus ensuring the fate sharing among test and data packets.

4.1. OAM of DetNet MPLS Interworking with OAM of TSN

Active DetNet OAM can be used to provide the E2E fault management and performance monitoring for a DetNet flow. In the case of DetNet with an MPLS data plane and a TSN underlay network, this implies interworking of DetNet active OAM with TSN OAM, which is specified in [\[RFC9037\]](#).

When the peering model is used in CFM OAM, then the node that borders both TSN and DetNet MPLS domains MUST support [\[RFC7023\]](#). [\[RFC7023\]](#) specifies the mapping of defect states between Ethernet Attachment Circuits and associated Ethernet PWs that are part of an E2E emulated Ethernet service, and are also applicable to E2E OAM across DetNet MPLS and TSN domains. The Connectivity Fault Management protocol [\[IEEE.CFM\]](#) or in [\[ITU.Y1731\]](#) can provide fast detection of a failure in the TSN segment of the DetNet service. In the DetNet MPLS domain BFD (Bidirectional Forwarding Detection), specified in [\[RFC5880\]](#) and [\[RFC5885\]](#), can be used. To provide E2E failure detection, the TSN and DetNet MPLS segments could be treated as concatenated such that the diagnostic codes (see Section 6.8.17 of [\[RFC5880\]](#)) MAY be used to inform the upstream DetNet MPLS node of a failure of the TSN segment. Performance monitoring can be supported by [\[RFC6374\]](#) in the DetNet MPLS and [\[ITU.Y1731\]](#) in the TSN

domains, respectively. Performance objectives for each domain should refer to metrics that additive or be defined for each domain separately.

The following considerations apply when using the tunneling model of OAM interworking between DetNet MPLS and TSN domains based on general principles described in Section 4 [[RFC9037](#)]:

- *Active OAM test packets MUST be mapped to the same TSN Stream ID as the monitored DetNet flow.

- *Active OAM test packets MUST be treated in the TSN domain based on its S-label and Class of Service marking (the Traffic Class field value).

Note that the tunneling model of the OAM interworking requires that the remote peer of the E2E OAM domain supports the active OAM protocol selected on the ingress endpoint. For example, if BFD is used for proactive path continuity monitoring in the DetNet MPLS domain, BFD support (as defined in [[RFC5885](#)]) is necessary at any TSN endpoint of the DetNet service.

4.2. OAM of DetNet MPLS Interworking with OAM of DetNet IP

Interworking between active OAM segments in DetNet MPLS and DetNet IP domains can also be realized using either the peering or the tunneling model, as discussed in [Section 4.1](#). Using the same protocol, e.g., BFD, over both segments, simplifies the mapping of errors in the peering model. To provide performance monitoring over a DetNet IP domain, STAMP [[RFC8762](#)] and its extensions [[RFC8972](#)] can be used.

5. IANA Considerations

5.1. DetNet MPLS OAM Flags Registry

This document describes a new IANA-managed registry to identify DetNet MPLS OAM Flags bits. The registration procedure is "IETF Review" [[RFC8126](#)]. The registry name is "DetNet MPLS OAM Flags". IANA should treat "DetNet MPLS OAM Flags" as the name of the registry group. There are five flags in the five-bit Flags field, defined as in [Table 1](#).

Bit	Description	Reference
0-4	Unassigned	This document

Table 1: DetNet MPLS OAM Flags

6. Security Considerations

Security considerations discussed in DetNet specifications [RFC8655], [RFC9055], [RFC8964] are applicable to this document. Security concerns and issues related to MPLS OAM tools like LSP Ping [RFC8029], BFD over PW [RFC5885] also apply to this specification.

7. Acknowledgment

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