## Operations, Administration and Maintenance (OAM) for Deterministic Networks (DetNet)
### draft-mirsky-detnet-oam-02

Abstract

   This document lists functional requirements for Operations,
   Administration and Maintenance (OAM) toolset in Deterministic
   Networks (DetNet) and, using these requirements; defines format and
   use principals of the DetNet service Associated Channel.

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## 1.  Introduction

   [I-D.ietf-detnet-architecture] introduces and explains Deterministic
   Networks (DetNet) architecture and how the Packet Replication and
   Elimination function (PREF) can be used to ensure low packet drop
   ratio in DetNet domain.

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

   This document lists the functional requirements toward OAM for DetNet
   domain.  The list can further be used for gap analysis of available
   OAM tools to identify possible enhancements of existing or whether
   new OAM tools are required to support proactive and on-demand path
   monitoring and service validation.

## 2.  Conventions used in this document

### 2.1.  Terminology

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 Networks

d-ACH DetNet Associated Channel Header

d-CW DetNet Control Word

DNH DetNet Header

GAL Generic Associated Channel Label

G-ACh Generic Associated Channel

OAM: Operations, Administration and Maintenance

PREF Packet Replication and Elimination Function

POF Packet Ordering Function

PW Pseudowire

RDI Remote Defect Indication

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

DetNet Node - a node that is an actor in the DetNet domain.  DetNet domain edge node and node that performs PREF within the domain are examples of DetNet node.

### 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](#). Requirements

This section lists requirements for OAM in DetNet domain:

1.  The listed requirements MUST be supported for any type of
    underlay network over which a DetNet domain can be realized.

2.  It MUST be possible to initiate DetNet OAM session from any
    DetNet node towards another DetNet node(s) within given domain.

3.  It SHOULD be possible to initialize DetNet OAM session from a
    centralized controller.

4.  DetNet OAM MUST support proactive and on-demand OAM monitoring
    and measurement methods.

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.

6.  DetNet OAM MUST support unidirectional OAM methods, continuity
    check, connectivity verification, and performance measurement.

7.  DetNet OAM MUST support bi-directional OAM methods.  Such OAM
    methods MAY combine in-band monitoring or measurement in the
    forward direction and out-of-bound notification in the reverse
    direction, i.e., from egress to ingress end point of the OAM
    test session.

8.  DetNet OAM MUST support proactive monitoring of a DetNet node
    availability in the given DetNet domain.

9.  DetNet OAM MUST support Path Maximum Transmission Unit
    discovery.

10. DetNet OAM MUST support Remote Defect Indication (RDI)
    notification to the DetNet node performing continuity checking.

11. DetNet OAM MUST support performance measurement methods.

12. DetNet OAM MAY support hybrid performance measurement methods.

13. DetNet OAM MUST support unidirectional performance measurement
    methods.  Calculated performance metrics MUST include but are
    not limited to throughput, packet loss, delay and delay
    variation metrics.  [RFC6374] provides excellent details on
    performance measurement and performance metrics.

14.  DetNet OAM MUST support defect notification mechanism, like
     Alarm Indication Signal.  Any DetNet node in the given DetNet
     domain MAY originate a defect notification addressed to any
     subset of nodes within the domain.

15.  DetNet OAM MUST support methods to enable survivability of the
     DetNet domain.  These recovery methods MAY use protection
     switching and restoration.

16.  DetNet OAM MUST support the discovery of Packet Replication,
     Elimination, and Order preservation sub-functions locations in
     the domain.

17.  DetNet OAM MUST support testing of Packet Replication,
     Elimination, and Order preservation sub-functions in the domain.

18.  DetNet OAM MUST support monitoring any sub-set of paths
     traversed through the DetNet domain by the DetNet flow.

## 4.  DetNet Data Plane in Support of Active OAM

OAM protocols and mechanisms act within the data plane of the
particular networking layer.  And thus it is critical that the data
plane encapsulation supports OAM mechanisms in such a way to comply
with the above-listed requirements.  One of such examples that
require 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.

### 4.1.  MPLS Encapsulation

The Det Net data plane encapsulation in transport network with MPLS
and IP encapsulations specified in [I-D.ietf-detnet-dp-sol-mpls] and
[I-D.ietf-detnet-dp-sol-ip] respectively.  For the MPLS underlay
network, DetNet flows to be encapsulated analogous to pseudowires
(PW) over MPLS packet switched network, as described in [RFC3985],
[RFC4385].  Generic PW MPLS Control Word (CW), defined in [RFC4385],
for DetNet displayed in Figure 1.

```
 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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 0 0 0|                Sequence Number                        |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
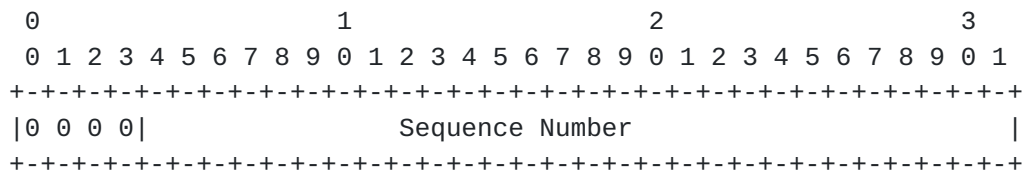
Figure 1: DetNet Control Word Format

PREF in the DetNet domain composed by a combination of nodes that
perform replication and elimination sub-functions.  The elimination
sub-function always uses the S-Label and packet sequencing
information, e.g., the value in the Sequence Number field of DetNet
CW (d-CW).  The replication sub-function uses the S-Label information
only.  For data packets Figure 2 presents an example of PREF in
DetNet domain.

```
     1111    11111111  111111   112212   112212      132213
   CE1----EN1--------R1-------R2-------R3--------EN2----CE2
           \2            22222/                   3 /
           \2222222  /----+                   3 /
            +------R4-----------------------+
                    33333333333333333333333
```

Figure 2: DetNet Data Plane Based on PW

## 4.1.1.  DetNet Active OAM Encapsulation

DetNet OAM, like PW OAM, uses PW Associated Channel Header defined in
[RFC4385].  Figure 3 displays the encapsulation of a DetNet active
OAM packet.

```
      +-------------------------------+
      |                               |
      |          DetNet  Flow         |
      |          OAM    Packet        |
      |                               |
      +-------------------------------+ <--\
      | DetNet Associated Channel Header|   |
      +===============================+   +--> DetNet OAM data plane
      |            S-Label            |   |    MPLS encapsulation
      +-------------------------------+ <--/
      |           T-Label(s)          |
      +-------------------------------+
      |           Data-Link           |
      +-------------------------------+
      |           Physical            |
      +-------------------------------+
```
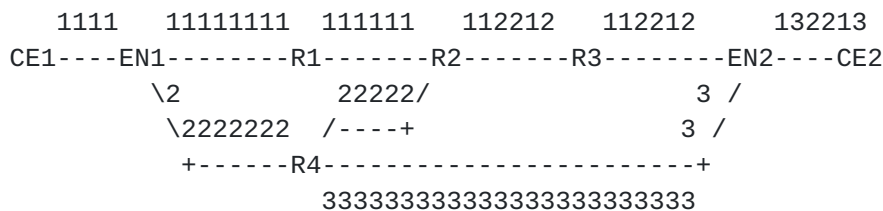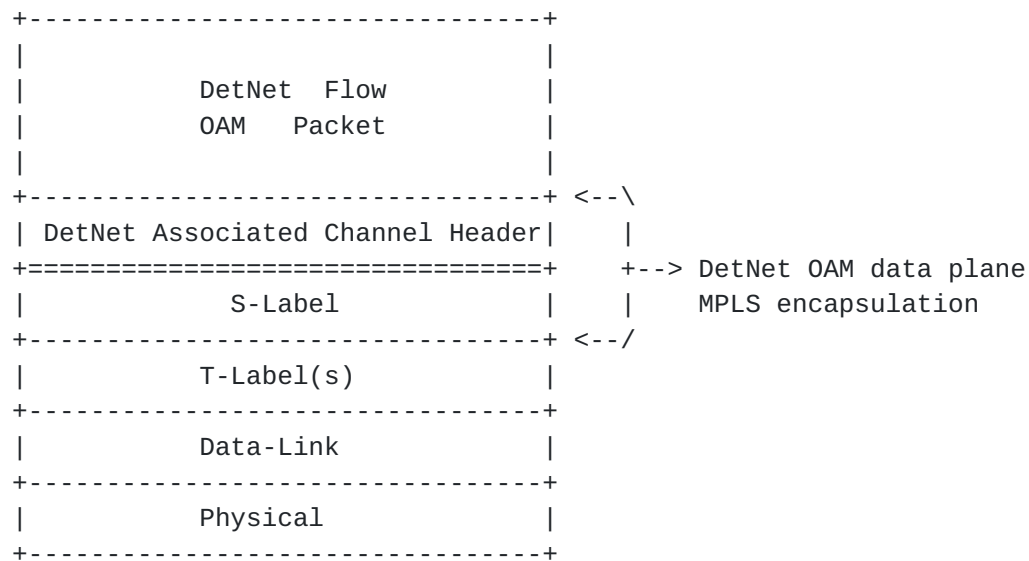
Figure 3: DetNet active OAM Packet Encapsulation

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 1|Version|Sequence Number|        Channel Type           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
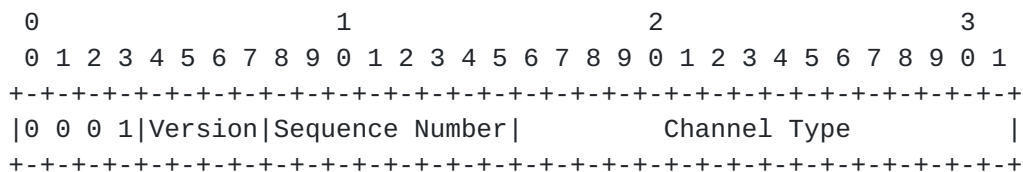
Figure 4: DetNet Associated Channel Header Format

Figure 4 displays the format of the DetNet Associated Channel Header
(d-ACH).  The meanings of the fields in the d-ACH are:

   Bits 0..3 MUST be 0b0001.  This value of the first nibble allows
   the packet to be distinguished from an IP packet [RFC4928] and a
   DetNet data packet [I-D.ietf-detnet-dp-sol-mpls].

   Version: this is the version number of the d-ACH.  This
   specification defines version 0.

   Sequence Number: this is unsigned eight bits-long field.  The
   originating DetNet node MUST set the value of the Sequence Number
   field to a non-zero before packet being transmitted.  The
   originating node MUST monotonically increase the value of the
   Sequence Number field for the every next active OAM packet.

   Channel Type: the value of DetNet Associated Channel Type is one
   of values defined in the IANA PW Associated Channel Type registry.

The DetNet flow, according to [I-D.ietf-detnet-dp-sol-mpls], is
identified by the S-label that MUST be at the bottom of the stack.
Active OAM packet MUST have d-ACH immediately following the S-label.A
DetNet node originating an OAM packet MUST ensure that the value of
the Sequence Number field in d-ACH is monotonically increasing for
the given value of the Channel Type field.

The Generic Associated Channel Label (GAL), defined in [RFC5586] and
[RFC6423], provides a generalized label-based exception mechanism to
indicate that the packet is on a Generic Associated Channel (G-ACh)
and that ACH immediately follows the label stack.  For the DetNet
domain in MPLS transport network, GAL MAY be used.  If GAL is used,
it MUST precede S-Label on the label stack, and the S-Label MUST be
followed by d-ACH.

## 4.1.2.  IP Encapsulation

[Author's Note: This will be defined based on the DetNet Flow ID
specification for IP underlay in [I-D.ietf-detnet-dp-sol-ip].]

## 4.2.  DetNet Replication, Elimination, and Ordering Sub-functions Interaction with Active OAM

At the DetNet service layer, special functions MAY be applied to the
particular DetNet flow - PREF to potentially lower packet loss,
improve the probability of on-time packet delivery and Packet
Ordering Function (POF) to ensure in-order packet delivery.  As data
and the active OAM packets have the same Flow ID, S-label, sub-
functions that rely on sequencing information in the DetNet service
layer MUST process 28 MSBs of the d-ACH as the source of the
sequencing information for the OAM packet.

## 5.  Use of Hybrid OAM in DetNet

Hybrid OAM methods are used in performance monitoring and defined in
[RFC7799] as:

> Hybrid Methods are Methods of Measurement that use a combination
> of Active Methods and Passive Methods.

A hybrid measurement method may produce metrics as close to passive,
but it still alters something in a data packet even if that is the
value of a designated field in the packet encapsulation.  One example
of such a hybrid measurement method is the Alternate Marking method
described in [RFC8321].  Reserving the field for the Alternate
Marking method in the DetNet Header will enhance available to an
operator set of DetNet OAM tools.

6.  IANA Considerations

   TBA

7.  Security Considerations

   This document lists the OAM requirements for a DetNet domain and does
   not raise any security concerns or issues in addition to ones common
   to networking.

8.  Acknowledgment

   Authors extend their appreciation to Pascal Thubert for his
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   the document.

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Authors' Addresses

   Greg Mirsky
   ZTE Corp.

   Email: gregimirsky@gmail.com

   Mach(Guoyi) Chen
   Huawei

   Email: mach.chen@huawei.com