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**Operations, Administration and Maintenance (OAM) for Deterministic  
Networks (DetNet) with IP Data Plane**

**Abstract**

This document defines the principles for using Operations, Administration, and Maintenance protocols and mechanisms in the Deterministic Networking networks with the IP data plane.

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## Table of Contents

- [1. Introduction](#)
- [2. Conventions used in this document](#)
  - [2.1. Terminology](#)
  - [2.2. Keywords](#)
- [3. Active OAM for DetNet Networks with the IP Data Plane](#)
  - [3.1. Mapping Active OAM and IP DetNet flows](#)
  - [3.2. Active OAM Using IP-in-UDP Encapsulation](#)
  - [3.3. Active OAM Using DetNet-in-UDP Encapsulation](#)
  - [3.4. Active OAM Using GRE-in-UDP Encapsulation](#)
- [4. Active OAM for DetNet IP Interworking with OAM of non-IP DetNet domains](#)
- [5. IANA Considerations](#)
- [6. Security Considerations](#)
- [7. Acknowledgment](#)
- [8. References](#)
  - [8.1. Normative References](#)
  - [8.2. Informational References](#)
- [Authors' Addresses](#)

## 1. Introduction

[[RFC8655](#)] introduces and explains Deterministic Networks (DetNet) architecture.

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.

[[I-D.tpmb-detnet-oam-framework](#)] 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. Also, the document defines the OAM use principals for the DetNet networks with the IP data plane.

## 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".

DetNet Deterministic Networks

DiffServ Differentiated Services

OAM: Operations, Administration, and Maintenance

PREF Packet Replication and Elimination Function

POF Packet Ordering Function

RDI Remote Defect Indication

ICMP Internet Control Message Protocol

ACH Associated Channel Header

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. Active OAM for DetNet Networks with the IP Data Plane**

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 that DetNet OAM packets are in-band with a DetNet flow being monitored, i.e., DetNet OAM test packets follow precisely the same path as DetNet data plane traffic both for unidirectional and bi-directional DetNet paths.

The DetNet data plane encapsulation in a transport network with IP encapsulations specified in Section 6 of [[RFC8939](#)]. For the IP underlay network, DetNet flows are identified by the ordered match to the provisioned information set that, among other elements, includes the IP protocol, source port number, destination port number. Active IP OAM protocols like Bidirectional Forwarding Detection (BFD) [[RFC5880](#)] or Simple Two-way Active Measurement Protocol (STAMP) [[RFC8762](#)], use UDP transport and the well-known UDP port numbers as the destination port. Thus a DetNet node MUST be

able to associate an IP DetNet flow with the particular test session to ensure that test packets experience the same treatment as the DetNet flow packets. For example, that can be achieved with a 3-tuple (destination and source IP addresses in combination with DSCP value) used to identify the IP DetNet flow. In such a scenario, an IP OAM session between the same pair of IP nodes would share the network treatment with the monitored IP DetNet flow regardless of whether ICMP, BFD, or STAMP protocol is used.

Most of on-demand failure detection and localization in IP networks is being done by using the Internet Control Message Protocol (ICMP) Echo Request, Echo Reply and the set of defined error messages, e.g., Destination Unreachable, with the more detailed information provided through code points. [\[RFC0792\]](#) and [\[RFC4443\]](#) define the ICMP for IPv4 and IPv6 networks, respectively. Because ICMP is another IP protocol like, for example, UDP, a DetNet node MUST be able to associate an ICMP packet generated by the specified IP DetNet node and addressed to the another IP DetNet node with an IP DetNet flow between this pair of endpoints.

### **3.1. Mapping Active OAM and IP DetNet flows**

IP OAM protocols that use UDP transport, e.g., BFD [\[RFC5880\]](#) and STAMP [\[RFC8762\]](#), can be used to detect failures or performance degradation that affects an IP DetNet flow. When the UDP destination port number used by the OAM protocol is one of the assigned by IANA, then the UDP source port can be used to achieve co-routedness of OAM, and the monitored IP DetNet flow in the multipath environments, e.g., Link Aggregation Group or Equal Cost Multipath. (That also applies to encapsulation techniques described in [Section 3.2](#) and [Section 3.3](#).) To maximize the accuracy of OAM results in detecting failures and monitoring performance of IP DetNet, test packets should receive the same treatment by the nodes as experienced by the IP DetNet packet. Hence, the DSCP value used for a test packet MUST be mapped to DetNet.

### **3.2. Active OAM Using IP-in-UDP Encapsulation**

As described above, IP active OAM is realized through several protocols. Some protocols use UDP transport, while ICMP is a network-layer protocol. The amount of operational work mapping IP OAM protocols to the monitored DetNet flow can be reduced by using an IP/UDP tunnel to carry IP test packets. Then, to ensure that OAM packets traverse the same set of nodes and links, the IP/UDP tunnel MUST be mapped to the monitored DetNet flow. Note that the DetNet domain for the test packet is seen as a single IP link in such a case. As a result, transit DetNet IP nodes cannot be traced using the usual traceroute procedure, and a modification of the traceroute may be required.

### 3.3. Active OAM Using DetNet-in-UDP Encapsulation

Active OAM in IP DetNet can be realized using DetNet-in-UDP encapsulation. Using DetNet-in-UDP tunnel between IP DetNet nodes ensures that active OAM test packets are fate-sharing with the monitored IP DetNet flow packets. As a result, a test packet shares the tunnel with the IP DetNet flow and shares the fate, statistically speaking, of the IP DetNet flow being monitored.

[[I-D.varga-detnet-ip-preof](#)] describes how DetNet with MPLS over UDP/IP data plane [[RFC9025](#)] can be used to support Packet Replication, Elimination, and Ordering Functions to potentially lower packet loss, improve the probability of on-time packet delivery and ensure in-order packet delivery in IP DetNet's service sub-layer. To ensure that an active OAM test packet follows the path of the monitored DetNet flow in the DetNet service sub-layer the encapsulation shown in [Figure 1](#) is used.

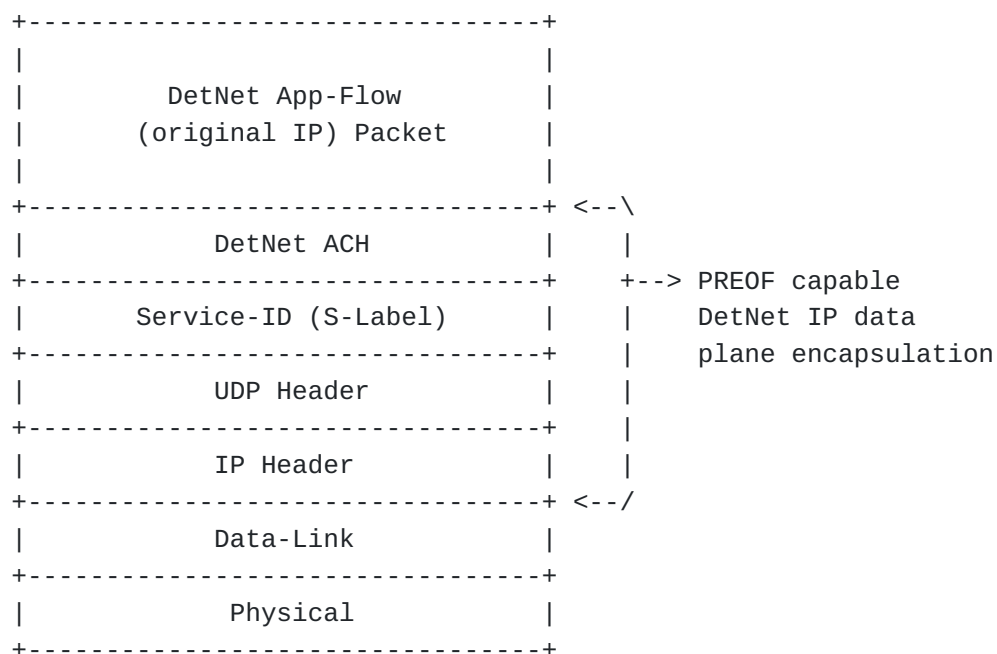


Figure 1: DetNet Associated Channel Header Format

where DetNet ACH is the DetNet Associated Channel Header defined in [[I-D.ietf-detnet-mpls-oam](#)].

### 3.4. Active OAM Using GRE-in-UDP Encapsulation

[[RFC8086](#)] has defined the method of encapsulating GRE (Generic Routing Encapsulation) headers in UDP. GRE-in-UDP encapsulation can be used for IP DetNet OAM as it eases the task of mapping an OAM test session to a particular IP DetNet flow that is identified by N-

tuple. Matching a GRE-in-UDP tunnel to the monitored IP DetNet flow enables the use of Y.1731/G.8013 [[ITU-T.1731](#)] as a comprehensive toolset of OAM. The Protocol Type field in GRE header MUST be set to 0x8902 assigned by IANA to IEEE 802.1ag Connectivity Fault Management (CFM) Protocol / ITU-T Recommendation Y.1731. Y.1731/G.8013 supports necessary for IP DetNet OAM functions, i.e., continuity check, one-way packet loss and packet delay measurement.

#### **4. Active OAM for DetNet IP Interworking with OAM of non-IP DetNet domains**

A domain in which IP data plane provides DetNet service could be used in conjunction with a TSN and a DetNet domain with MPLS data plane to deliver end-to-end service. In such scenarios, the ability to detect defects and monitor performance using OAM is essential. [[I-D.ietf-detnet-mpls-oam](#)] identified two OAM interworking models - peering and tunneling. Interworking between DetNet domains with IP and MPLS data planes analyzed in Section 6.2 of [[I-D.ietf-detnet-mpls-oam](#)]. Also, requirements and recommendations for OAM interworking between a DetNet domain with MPLS data plane and OAM of a TSN equally apply to a DetNet domain with an IP data plane.

#### **5. IANA Considerations**

This document does not have any requests for IANA allocation. This section can be deleted before the publication of the draft.

#### **6. Security Considerations**

This document describes the applicability of the existing Fault Management and Performance Monitoring IP OAM protocols, and does not raise any security concerns or issues in addition to ones common to networking or already documented for the referenced DetNet and OAM protocols.

#### **7. Acknowledgment**

TBA

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