DetNet Working Group   G. Mirsky
Internet-Draft   ZTE Corp.
Intended status: Standards Track   M. Chen
Expires: September 28, 2020   Huawei
                                                          March 27, 2020

Operations, Administration and Maintenance (OAM) for Deterministic Networks (DetNet) with MPLS Data Plane
draft-ietf-detnet-mpls-oam-00

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 over a DetNet network with the MPLS data plane..

Table of Contents

1. Introduction

[RFC8655] 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. Also, this document defines format and use principals of the DetNet service Associated Channel over a DetNet network with the MPLS data plane [I-D.ietf-detnet-mpls].

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

TSN Time-Sensitive Network

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 (LSR).

S-Label A DetNet "service" label that 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. 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 with MPLS data plane:

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

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

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

4. DetNet OAM packets MUST be in-band, i.e., follow precisely the same path as DetNet data plane traffic.

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

6. 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.

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

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

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

10. DetNet OAM MUST support performance measurement methods.

11. DetNet OAM MAY support hybrid performance measurement methods.

12. 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.

13. 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.

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

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

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

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

4. Active OAM for DetNet Networks with MPLS 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 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.

The Det Net data plane encapsulation in transport network with MPLS encapsulation specified in [I-D.ietf-detnet-mpls]. 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-----------------------+
                          333333333333333333333333
```

Figure 2: DetNet Data Plane Based on PW

4.1. 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 MPLS [I-D.ietf-detnet-mpls] active OAM packet.

```
      +---------------------------------+
      |                                 |
      |         DetNet App-Flow         |
      |         Payload  Packet         |
      |                                 |
      +---------------------------------+ <--\
      | DetNet Associated Channel Header|    |
      +---------------------------------+    +--> DetNet active OAM
      |           S-Label               |    |    MPLS encapsulation
      +---------------------------------+    |
      |         [ F-Label(s) ]          |    |
      +---------------------------------+ <--/
      |           Data-Link             |
      +---------------------------------+
      |           Physical              |
      +---------------------------------+
```

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 [I-D.ietf-detnet-mpls-over-udp-ip].

```
      +---------------------------------+
      |                                 |
      |         DetNet App-Flow         |
      |         Payload  Packet         |
      |                                 |
      +---------------------------------+ <--\
      | DetNet Associated Channel Header|    |
      +---------------------------------+    +--> DetNet active OAM
      |             S-Label             |    |    MPLS encapsulation
      +---------------------------------+    |
      |          [ F-label(s) ]         |    |
      +---------------------------------+ <--+
      |           UDP Header            |    |
      +---------------------------------+    +--> DetNet data plane
      |           IP Header             |    |    IP encapsulation
      +---------------------------------+ <--/
      |           Data-Link             |
      +---------------------------------+
      |           Physical              |
      +---------------------------------+
```

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).

```
 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 5: DetNet Associated Channel Header Format

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-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-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.

Special consideration for DetNet active OAM with MPLS data plane interworking with OAM in IEEE 802.1 Time-Sensitive Networking (TSN) domain based on [I-D.ietf-detnet-mpls-over-tsn]:

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

- o Active OAM test packets MUST be treated in the TSN domain based on its S-label and CoS marking (TC field value).

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. OAM of DetNet MPLS Interworking with OAM of DetNet IP

TBA

7. OAM of DetNet MPLS Interworking with OAM of TSN

TBA

8. IANA Considerations

TBA

9. 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.

10. Acknowledgment

Authors extend their appreciation to Pascal Thubert for his insightful comments and productive discussion that helped to improve the document.

11. References

11.1. Normative References

[I-D.ietf-detnet-mpls]
Varga, B., Farkas, J., Berger, L., Fedyk, D., Malis, A., Bryant, S., and J. Korhonen, "DetNet Data Plane: MPLS", draft-ietf-detnet-mpls-05 (work in progress), February 2020.

[I-D.ietf-detnet-mpls-over-tsn]
Varga, B., Farkas, J., Malis, A., and S. Bryant, "DetNet Data Plane: MPLS over IEEE 802.1 Time Sensitive Networking (TSN)", draft-ietf-detnet-mpls-over-tsn-02 (work in progress), March 2020.

[I-D.ietf-detnet-mpls-over-udp-ip]
Varga, B., Farkas, J., Berger, L., Malis, A., and S. Bryant, "DetNet Data Plane: MPLS over UDP/IP", draft-ietf-detnet-mpls-over-udp-ip-05 (work in progress), February 2020.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8655] Finn, N., Thubert, P., Varga, B., and J. Farkas, "Deterministic Networking Architecture", RFC 8655, DOI 10.17487/RFC8655, October 2019, <https://www.rfc-editor.org/info/rfc8655>.

11.2. Informational References

[RFC3985] Bryant, S., Ed. and P. Pate, Ed., "Pseudo Wire Emulation Edge-to-Edge (PWE3) Architecture", RFC 3985, DOI 10.17487/RFC3985, March 2005, <https://www.rfc-editor.org/info/rfc3985>.

[RFC4385] Bryant, S., Swallow, G., Martini, L., and D. McPherson, "Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN", RFC 4385, DOI 10.17487/RFC4385, February 2006, <https://www.rfc-editor.org/info/rfc4385>.

[RFC4928] Swallow, G., Bryant, S., and L. Andersson, "Avoiding Equal Cost Multipath Treatment in MPLS Networks", BCP 128, RFC 4928, DOI 10.17487/RFC4928, June 2007, <https://www.rfc-editor.org/info/rfc4928>.

[RFC6374] Frost, D. and S. Bryant, "Packet Loss and Delay Measurement for MPLS Networks", RFC 6374, DOI 10.17487/RFC6374, September 2011, <https://www.rfc-editor.org/info/rfc6374>.

[RFC7799] Morton, A., "Active and Passive Metrics and Methods (with Hybrid Types In-Between)", RFC 7799, DOI 10.17487/RFC7799, May 2016, <https://www.rfc-editor.org/info/rfc7799>.

[RFC8321] Fioccola, G., Ed., Capello, A., Cociglio, M., Castaldelli, L., Chen, M., Zheng, L., Mirsky, G., and T. Mizrahi, "Alternate-Marking Method for Passive and Hybrid Performance Monitoring", RFC 8321, DOI 10.17487/RFC8321, January 2018, <https://www.rfc-editor.org/info/rfc8321>.

Authors' Addresses

Greg Mirsky
ZTE Corp.

Email: gregimirsky@gmail.com

Mach(Guoyi) Chen
Huawei

Email: mach.chen@huawei.com