DetNet Data Plane: MPLS over IEEE 802.1 Time Sensitive Networking (TSN)
                    draft-ietf-detnet-mpls-over-tsn-00

Abstract

   This document specifies the Deterministic Networking MPLS data plane
   when operating over a TSN network.

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.

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   time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on November 6, 2019.

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1. Introduction

[Editor's note: Introduction to be made specific to DetNet MPLS over
TSN scenario. May be similar to intro of DetNet IP over TSN.].

Deterministic Networking (DetNet) is a service that can be offered by
a network to DetNet flows. DetNet provides these flows with a low
packet loss rates and assured maximum end-to-end delivery latency.
General background and concepts of DetNet can be found in
[I-D.ietf-detnet-architecture].

The DetNet Architecture decomposes the DetNet related data plane
functions into two sub-layers: a service sub-layer and a forwarding
sub-layer. The service sub-layer is used to provide DetNet service
protection and reordering. The forwarding sub-layer is used to
provides congestion protection (low loss, assured latency, and
limited reordering) leveraging MPLS Traffic Engineering mechanisms.

This document specifies the DetNet data plane operation and the on-wire encapsulation of DetNet flows over an MPLS-based Packet Switched Network (PSN). The specified encapsulation provides the building blocks to enable the DetNet service and forwarding sub-layer functions and supports flow identification as described in the DetNet Architecture. As part of the service sub-layer functions, this document describes DetNet node data plane operation. It also describes the function and operation of the Packet Replication (PRF) Packet Elimination (PEF) and Packet Ordering (POF) functions with an MPLS data plane. It also describes an MPLS-based DetNet forwarding sub-layer that eliminates (or reduces) contention loss and provides bounded latency for DetNet flows.

MPLS encapsulated DetNet flows can be carried over network technologies that can provide the DetNet required level of service. This document defines examples of such, specifically carrying DetNet MPLS flows over IEEE 802.1 TSN sub-networks, and over DetNet IP PSN.

The intent is for this document to support different traffic types being mapped over DetNet MPLS, but this is out side the scope of this document. An example of such can be found in [I-D.ietf-detnet-dp-sol-ip]. This document also allows for, but does not define, associated controller plane and Operations, Administration, and Maintenance (OAM) functions.

2. Terminology

[Editor's note: Needs clean up.].

2.1. Terms Used in This Document

This document uses the terminology established in the DetNet architecture [I-D.ietf-detnet-architecture], and the reader is assumed to be familiar with that document and its terminology.

The following terminology is introduced in this document:

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.

   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.

2.2. Abbreviations

   The following abbreviations are used in this document:

   AC   Attachment Circuit.

   CE   Customer Edge equipment.

   CoS   Class of Service.

   CW   Control Word.

   DetNet   Deterministic Networking.

   DF   DetNet Flow.

   DN-IWF   DetNet Inter-Working Function.

   L2   Layer 2.

   L2VPN   Layer 2 Virtual Private Network.

   L3   Layer 3.

   LSR   Label Switching Router.

   MPLS   Multiprotocol Label Switching.

   MPLS-TE   Multiprotocol Label Switching - Traffic Engineering.

   MPLS-TP   Multiprotocol Label Switching - Transport Profile.

   MS-PW   Multi-Segment PseudoWire (MS-PW).

   NSP   Native Service Processing.

   OAM   Operations, Administration, and Maintenance.

   PE   Provider Edge.

   PEF   Packet Elimination Function.

   PRF   Packet Replication Function.

PREOF   Packet Replication, Elimination and Ordering Functions.

POF   Packet Ordering Function.

PSN   Packet Switched Network.

PW   PseudoWire.

QoS   Quality of Service.

S-PE   Switching Provider Edge.

T-PE   Terminating Provider Edge.

TSN   Time-Sensitive Network.

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.

4. DetNet MPLS Data Plane Overview

[Editor's note: simplify this section and highlight DetNet MPLS over
subnets scenario being the focus in the remaining part of the
document.].

4.1. Layers of DetNet Data Plane

This document describes how DetNet flows are carried over MPLS
networks. The DetNet Architecture, [I-D.ietf-detnet-architecture],
decomposes the DetNet data plane into two sub-layers: a service sub-
layer and a forwarding sub-layer. The basic approach defined in this
document supports the DetNet service sub-layer based on existing
pseudowire (PW) encapsulations and mechanisms, and supports the
DetNet forwarding sub-layer based on existing MPLS Traffic
Engineering encapsulations and mechanisms. Background on PWs can be
found in [RFC3985] and [RFC3031]. Background on MPLS Traffic
Engineering can be found in [RFC3272] and [RFC3209].

```
                         DetNet        MPLS
                           .
                           .
                  +------------+
                  |  Service   | d-CW, S-Label
                  +------------+
                  | Forwarding | F-Label(s)
                  +------------+
                           .
                           .
```
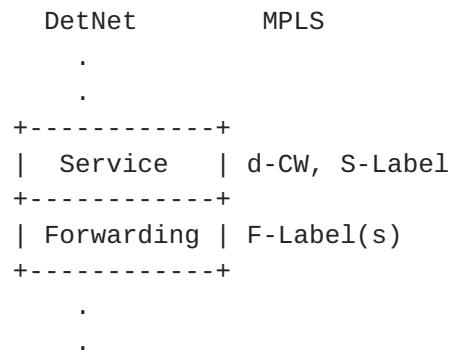
             Figure 1: DetNet Adaptation to MPLS Data Plane

   The DetNet MPLS data plane approach defined in this document is shown
   in Figure 1. The service sub-layer is supported by a DetNet control
   word (d-CW) which conforms to the Generic PW MPLS Control Word
   (PWMCW) defined in [RFC4385]. A d-CW identifying service label
   (S-Label) is also used.

   A node operating on a DetNet flow in the Detnet service sub-layer,
   i.e. a node processing a DetNet packet which has the S-Label as top
   of stack uses the local context associated with that S-Label, for
   example a received F-Label, to determine what local DetNet
   operation(s) are applied to that packet. An S-Label may be unique
   when taken from the platform label space [RFC3031], which would
   enable correct DetNet flow identification regardless of which input
   interface or LSP the packet arrives on.

   The DetNet MPLS data plane builds on MPLS Traffic Engineering
   encapsulations and mechanisms to provide a forwarding sub-layer that
   is responsible for providing resource allocation and explicit routes.
   The forwarding sub-layer is supported by one or more forwarding
   labels (F-Labels).

4.2. DetNet MPLS Data Plane Scenarios

   [Editor's note: simplify this section and highlight DetNet MPLS over
   subnets scenario being the focus in the remaining part of the
   document.].

```
   DetNet MPLS       Relay       Transit       Relay       DetNet MPLS
   End System        Node         Node          Node        End System
     (T-PE)          (S-PE)       (LSR)         (S-PE)         (T-PE)
   +----------+                                           +----------+
   |  Appl.   |<------------ End to End Service ---------->|  Appl.   |
   +----------+   +---------+                 +---------+   +----------+
   | Service  |<--| Service |-- DetNet flow --| Service |-->| Service  |
   +----------+   +---------+ +----------+    +---------+   +----------+
   |Forwarding|   |Fwd| |Fwd| |Forwarding|    |Fwd| |Fwd|   |Forwarding|
   +--------.--+   +-.-+ +-.-+ +----.---.-+    +-.-+ +-.-+   +---.------+
        : Link :    / ,-----. \   : Link :    / ,-----. \
        +........+    +-[  Sub  ]-+  +......+    +-[  Sub  ]-+
                      [Network]                 [Network]
                       `-----'                   `-----'
        |<- LSP -->| |<-------- LSP -----------| |<--- LSP -->|

        |<---------------- DetNet MPLS -------------------->|
```
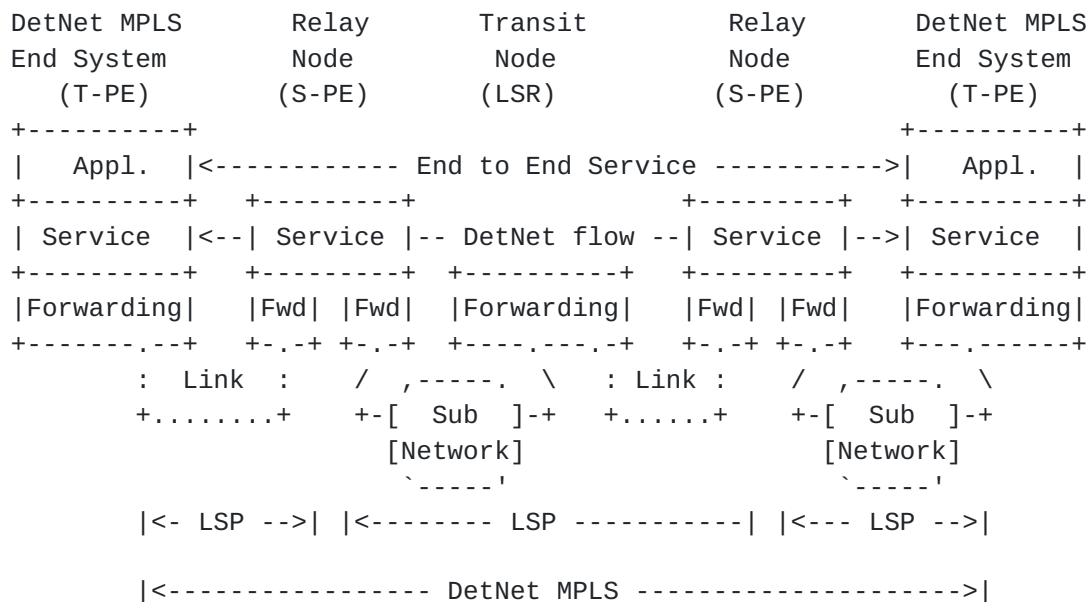
                      Figure 2: A DetNet MPLS Network

   Figure 2 illustrates a hypothetical DetNet MPLS-only network composed
   of DetNet aware MPLS enabled end systems, operating over a DetNet
   aware MPLS network. In this figure, relay nodes sit at MPLS LSP
   boundaries and transit nodes are LSRs.

   DetNet end system and relay nodes are DetNet service sub-layer aware,
   understand the particular needs of DetNet flows and provide both
   DetNet service and forwarding sub-layer functions. They add, remove
   and process d-CWs, S-Labels and F-labels as needed. MPLS enabled end
   system and relay nodes can enhance the reliability of delivery by
   enabling the replication of packets where multiple copies, possibly
   over multiple paths, are forwarded through the DetNet domain. They
   can also eliminate surplus previously replicated copies of DetNet
   packets. DetNet MPLS nodes provide functionality similar to T-PEs
   when they sit at the edge of an MPLS domain, and functionality
   similar to S-PEs when they are in the middle of an MPLS domain, see
   [RFC6073]. End system and relay nodes also include DetNet forwarding
   sub-layer functions, support for notably explicit routes, and
   resources allocation to eliminate (or reduce) congestion loss and
   jitter.

   DetNet transit nodes reside wholly within a DetNet domain, and also
   provide DetNet forwarding sub-layer functions in accordance with the
   performance required by a DetNet flow carried over an LSP. Unlike
   other DetNet node types, transit nodes provide no service sub-layer
   processing. In a DetNet MPLS network, transit nodes may be DetNet
   service aware or may be DetNet unaware MPLS Label Switching Routers

(LSRs). In this latter case, such LSRs would be unaware of the
special requirements of the DetNet service sub-layer, but would still
provide traffic engineering services and the QoS need to ensure that
the (TE) LSPs meet the service requirements of the carried DetNet
flows.

The LSPs may be provided by any MPLS controller method. For example
they may be provisioned via a management plane, RSVP-TE, MPLS-TP, or
MPLS Segment Routing (when extended to support resource allocation).

[Editor's note: Figure 3. and surrunding text are candidates to
delete from this document.].

Figure 3 illustrates how an end to end MPLS-based DetNet service is
provided in a more detail. In this figure, the end systems, CE1 and
CE2, are able to send and receive MPLS encapsulated DetNet flows, and
R1, R2 and R3 are relay nodes as they sit in the middle of a DetNet
network. The 'X' in the end systems, and relay nodes represents
potential DetNet compound flow packet replication and elimination
points. In this example, service protection is supported over four
DetNet member flows and TE LSPs. For a unidirectional flow, R1
supports PRF, R2 supports PREOF and R3 supports PEF and POF. Note
that the relay nodes may change the underlying forwarding sub-layer,
for example tunneling MPLS over IEEE 802.1 TSN Section 6, or simply
over interconnect network links.

```
        DetNet                                      DetNet
   MPLS  Service           Transit         Transit   Service MPLS
   DetNet  |            |<-Tnl->|        |<-Tnl->|        | DetNet
   End     |           V   1   V        V   2   V         | End
   System  |    +--------+        +--------+        +--------+  | System
   +---+   |    |   R1   |======|   R2   |======|   R3   |  |   +---+
   | X...DFa...|._X_....|..DF1..|.__ ___.|..DF3..|....._X_.|.DFa..|.X |
   |CE1|=======|    \   |       |    X   |       |    /    |======|CE2|
   |   |   |    |     \_.|..DF2..|._/ \__.|..DF4..|._/      |   |  |   |
   +---+   |    |        |======|        |======|           |   +---+
      ^     +--------+        +--------+        +--------+    ^
      |        Relay Node       Relay Node       Relay Node  |
      |         (S-PE)           (S-PE)           (S-PE)      |
      |                                                       |
      |<--------------------- DetNet MPLS --------------------->|
      |                                                       |
      |<--------------- End to End DetNet Service -------------->|

      ------------------------- Data Flow ------------------------>
```

```
   X   = Optional service protection (none, PRF, PREOF, PEF/POF)
   DFx = DetNet member flow x over a TE LSP
```
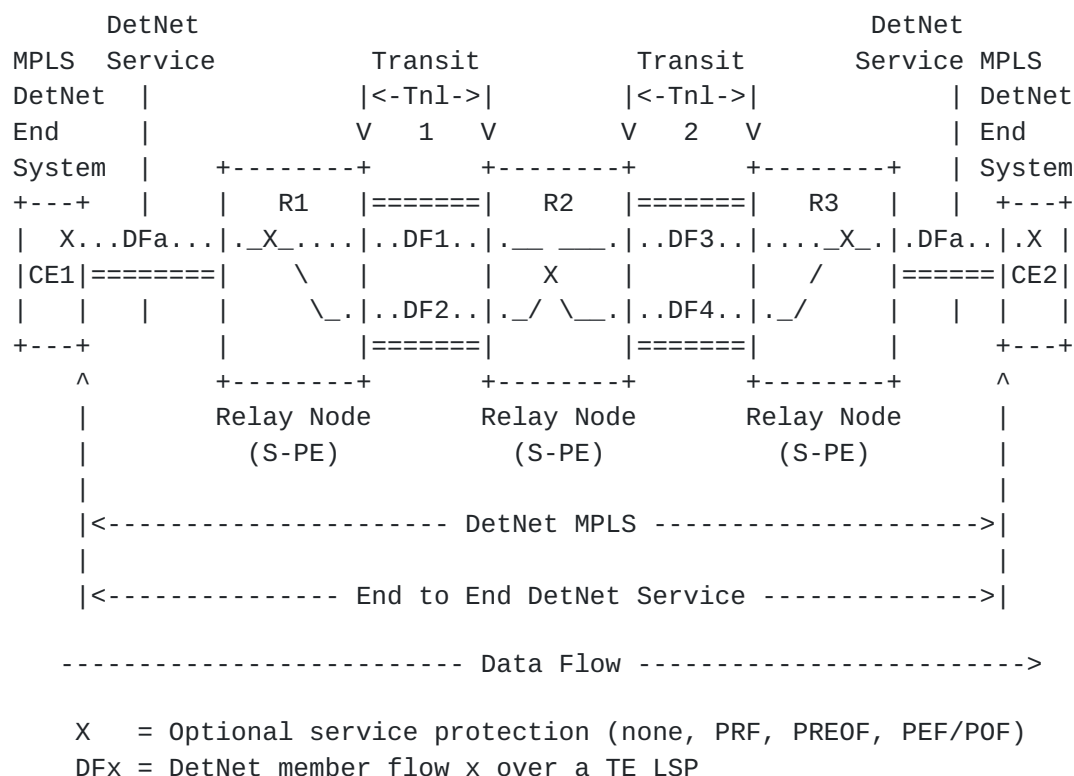
                   Figure 3: MPLS-Based Native DetNet

   As previously mentioned, this document specifies how MPLS is used to
   support DetNet flows using an MPLS data plane as well as how such can
   be mapped to IEEE 802.1 TSN and IP DetNet PSNs. An equally import
   scenario is when IP is supported over DetNet MPLS and this is covered
   in [I-D.ietf-detnet-dp-sol-ip]. Another important scenario is where
   an Ethernet Layer 2 service is supported over DetNet MPLS and this is
   covered in [TBD-TSN-OVER-DETNET].

4.3. Packet Flow Example with Service Protection

   [Editor's note: this text might be relevant for the discussion of
   FRER within the TSN sub-network. Needs revision.].

   An example DetNet MPLS network fragment and packet flow is
   illustrated in Figure 4.

```
    1      1.1       1.1      1.2.1    1.2.1      1.2.2
 CE1----EN1--------R1-------R2-------R3--------EN2-----CE2
         \              1.2.1 /                      /
          \1.2     /-----+                        /
           +------R4----------------------+
                    1.2.2
```
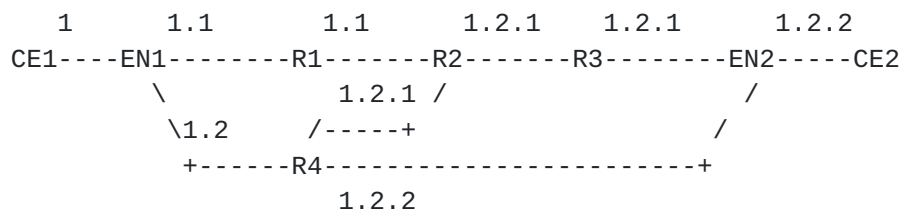
Figure 4: Example Packet Flow in DetNet Enabled MPLS Network

In Figure 4 the numbers are used to identify the instance of a
packet. Packet 1 is the original packet, and packets 1.1, and 1.2
are two first generation copies of packet 1. Packet 1.2.1 is a
second generation copy of packet 1.2 etc. Note that these numbers
never appear in the packet, and are not to be confused with sequence
numbers, labels or any other identifier that appears in the packet.
They simply indicate the generation number of the original packet so
that its passage through the network fragment can be identified to
the reader.

Customer Equipment CE1 sends a packet into the DetNet enabled MPLS
network. This is packet (1). Edge Node EN1 encapsulates the packet
as a DetNet Packet and sends it to Relay node R1 (packet 1.1). EN1
makes a copy of the packet (1.2), encapsulates it and sends this copy
to Relay node R4.

Note that along the MPLS path from EN1 to R1 there may be zero or
more LSRs which, for clarity, are not shown. The same is true for
any other path between two DetNet entities shown in Figure 4.

Relay node R4 has been configured to send one copy of the packet to
Relay Node R2 (packet 1.2.1) and one copy to Edge Node EN2 (packet
1.2.2).

R2 receives packet copy 1.2.1 before packet copy 1.1 arrives, and,
having been configured to perform packet elimination on this DetNet
flow, forwards packet 1.2.1 to Relay Node R3. Packet copy 1.1 is of
no further use and so is discarded by R2.

Edge Node EN2 receives packet copy 1.2.2 from R4 before it receives
packet copy 1.2.1 from R2 via relay Node R3. EN2 therefore strips
any DetNet encapsulation from packet copy 1.2.2 and forwards the
packet to CE2. When EN2 receives the later packet copy 1.2.1 this is
discarded.

The above is of course illustrative of many network scenarios that
can be configured. Between a pair of relay nodes there may be one or
more transit nodes that simply forward the DetNet traffic, but these
are omitted for clarity.

5. **DetNet MPLS Data Plane Considerations**

   [Editor's note: Sort out what data plane considerations are relevant
   for sub-net scenarios.].

   This section provides informative considerations related to providing
   DetNet service to flows which are identified based on their header
   information. At a high level, the following are provided on a per
   flow basis:

   Eliminating contention loss and jitter reduction:

      Use of allocated resources (queuing, policing, shaping) to ensure
      that the congestion-related loss and latency/jitter requirements
      of a DetNet flow are met.

   Explicit routes:

      Use of a specific path for a flow. This limits misordering and
      bounds latency.

   Service protection:

      Which in the case of this document primarily relates to
      replication and elimination. Changing the explicit path after a
      failure is detected in order to restore delivery of the required
      DetNet service characteristics is also possible. Path changes,
      even in the case of failure recovery, can lead to the out of order
      delivery of data.

   Load sharing:

      Generally, distributing packets of the same DetNet flow over
      multiple paths is not recommended. Such load sharing, e.g., via
      ECMP or UCMP, impacts ordering and possibly jitter.

   Troubleshooting:

      For example, to support identification of misbehaving flows.

   Recognize flow(s) for analytics:

      For example, increase counters.

   Correlate events with flows:

      For example, unexpected loss.

The DetNet data plane also allows for the aggregation of DetNet
flows, e.g., via MPLS hierarchical LSPs, to improved scaling. When
DetNet flows are aggregated, transit nodes provide service to the
aggregate and not on a per-DetNet flow basis. In this case, nodes
performing aggregation will ensure that per-flow service requirements
are achieved.

5.1. Sub-Network Considerations

As shown in Figure 2, MPLS nodes are interconnected by different sub-
network technologies, which may include point-to-point links. Each
of these need to provide appropriate service to DetNet flows. In
some cases, e.g., on dedicated point-to-point links or TDM
technologies, all that is required is for a DetNet node to
appropriately queue its output traffic. In other cases, DetNet nodes
will need to map DetNet flows to the flow semantics (i.e.,
identifiers) and mechanisms used by an underlying sub-network
technology. Figure 5 shows several examples of header formats that
can be used to carry DetNet MPLS flows over different sub-network
technologies. L2 represent a generic layer-2 encapsulation that
might be used on a point-to-point link. TSN represents the
encapsulation used on an IEEE 802.1 TSN network, as described in
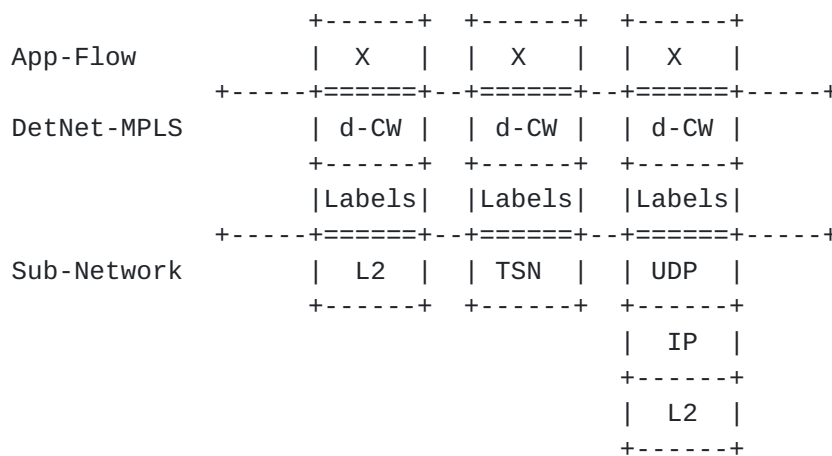Section 6. UDP/IP represents the encapsulation used on a DetNet IP
PSN.

```
                       +------+  +------+  +------+
          App-Flow     |  X   |  |  X   |  |  X   |
                     +-----+======+--+======+--+======+-----+
          DetNet-MPLS    | d-CW |  | d-CW |  | d-CW |
                       +------+  +------+  +------+
                       |Labels|  |Labels|  |Labels|
                     +-----+======+--+======+--+======+-----+
          Sub-Network    |  L2  |  | TSN  |  | UDP  |
                       +------+  +------+  +------+
                                           |  IP  |
                                           +------+
                                           |  L2  |
                                           +------+
```
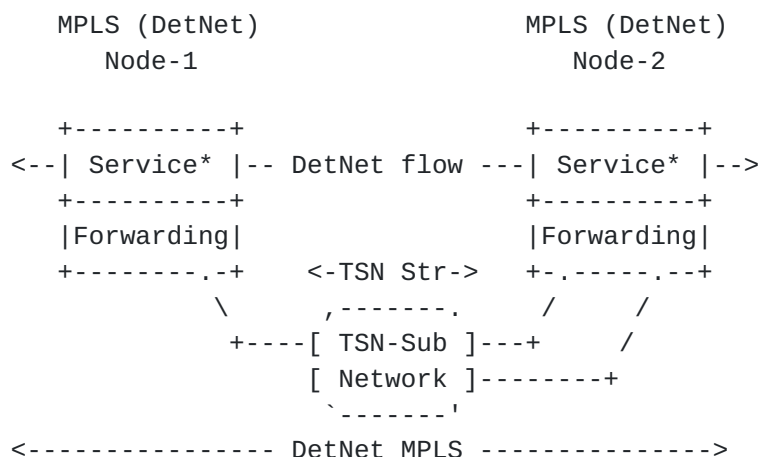
Figure 5: Example DetNet MPLS Sub-Network Formats

6. DetNet MPLS Operation Over IEEE 802.1 TSN Sub-Networks

[Editor's note: this is a place holder section. A standalone section
on MPLS over IEEE 802.1 TSN. Includes RFC2119 Language.]

This section covers how DetNet MPLS flows operate over an IEEE 802.1
TSN sub-network. Figure 6 illustrates such a scenario, where two
MPLS (DetNet) nodes are interconnected by a TSN sub-network. Node-1
is single homed and Node-2 is dual-homed. MPLS nodes can be (1)
DetNet MPLS End System, (2) DetNet MPLS Edge or Relay node or (3)
MPLS Transit node.

Note: in case of MPLS Transit node there is no DetNet Service sub-
layer processing.

```
      MPLS (DetNet)                 MPLS (DetNet)
         Node-1                        Node-2


      +----------+                  +----------+
  <--| Service* |-- DetNet flow ---| Service* |-->
      +----------+                  +----------+
      |Forwarding|                  |Forwarding|
      +--------.-+     <-TSN Str->   +-.------.--+
              \       ,-------.      /     /
               +----[ TSN-Sub ]---+     /
                    [ Network ]--------+
                     `-------'
  <--------------- DetNet MPLS --------------->
```

Note: * no service sub-layer required for transit nodes

     Figure 6: DetNet Enabled MPLS Network Over a TSN Sub-Network

The Time-Sensitive Networking (TSN) Task Group of the IEEE 802.1
Working Group have defined (and are defining) a number of amendments
to IEEE 802.1Q [IEEE8021Q] that provide zero congestion loss and
bounded latency in bridged networks. Furthermore IEEE 802.1CB
[IEEE8021CB] defines frame replication and elimination functions for
reliability that should prove both compatible with and useful to,
DetNet networks. All these functions have to identify flows those
require TSN treatment.

As is the case for DetNet, a Layer 2 network node such as a bridge
may need to identify the specific DetNet flow to which a packet
belongs in order to provide the TSN/DetNet QoS for that packet. It
also may need a CoS marking, such as the priority field of an IEEE
Std 802.1Q VLAN tag, to give the packet proper service.

The challange for MPLS DeNet flows is that the protocol interworking
function defined in IEEE 802.1CB [IEEE8021CB] works only for IP
flows. The aim of the protocol interworking function is to convert
an ingress flow to use a specific multicast destination MAC address
and VLAN, for example to direct the packets through a specific path

inside the bridged network. A similar interworking pair at the other
end of the TSN sub-network would restore the packet to its original
destination MAC address and VLAN.

As protocol interworking function defined in [IEEE8021CB] does not
work for MPLS labeled flows, the DetNet MPLS nodes MUST ensure proper
TSN sub-network specific Ethernet encapsulation of the DetNet MPLS
packets. For a given TSN Stream (i.e., DetNet flow) an MPLS (DetNet)
node MUST behave as a TSN-aware Talker or a Listener inside the TSN
sub-network.

6.1. Mapping of TSN Stream ID and Sequence Number

TSN capable MPLS (DetNet) nodes are TSN-aware Talker/Listener as
shown in Figure 7. MPLS (DetNet) node MUST provide the TSN sub-
network specific Ethernet encapsulation over the link(s) towards the
sub-network. An TSN-aware MPLS (DetNet) node MUST support the
following TSN components:

1. For recognizing flows:

    * Stream Identification (MPLS-flow-aware)

2. For FRER used inside the TSN domain, additonaly:

    * Sequencing function (MPLS-flow-aware)

    * Sequence encode/decode function

3. For FRER when the node is a TSN replication or elimination point,
    additionally:

    * Stream splitting function

    * Individual recovery function

[Editor's note: Should we added here requirements regarding IEEE
802.1Q C-VLAN component?]

The Stream Identification and The Sequencing functions are slightly
modified for frames passed down the protocol stack from the upper
layers.

Stream Identification MUST pair MPLS flows and TSN Streams and encode
that in data plane formats as well. The packet's stream_handle
subparameter (see IEEE 802.1CB [IEEE8021CB]) inside the Talker/
Listener is defined based on the Flow-ID used in the upper DetNet
MPLS layer. Stream Identification function MUST encode Ethernet

header fields namely (1) the destination MAC-address, (2) the VLAN-ID
and (3) priority parameters with TSN sub-network specific values.
Encoding is provided for the frame passed down the stack from the
upper layers.

The sequence generation function resides in the Sequencing function.
It generates a sequence_number subparameter for each packet of a
Stream passed down to the lower layers. Sequencing function MUST
copy sequence information from the MPLS d-CW of the packet to the
sequence_number subparameter for the frame passed down the stack from
the upper layers.

```
    MPLS (DetNet)
       Node-1
    <---------->


    +----------+
<--| Service  |-- DetNet flow ------------------
    +----------+
    |Forwarding|
    +----------+    +---------------+
    | L2 with  |<---| L2 Relay with |---- TSN ----
    |   TSN    |    | TSN function  |    Stream
    +-----.----+    +--.---------.--+
          _____/          _____

     TSN-aware
      Talker /          TSN-Bridge
      Listener            Relay


           <--------- TSN sub-network ------------
```
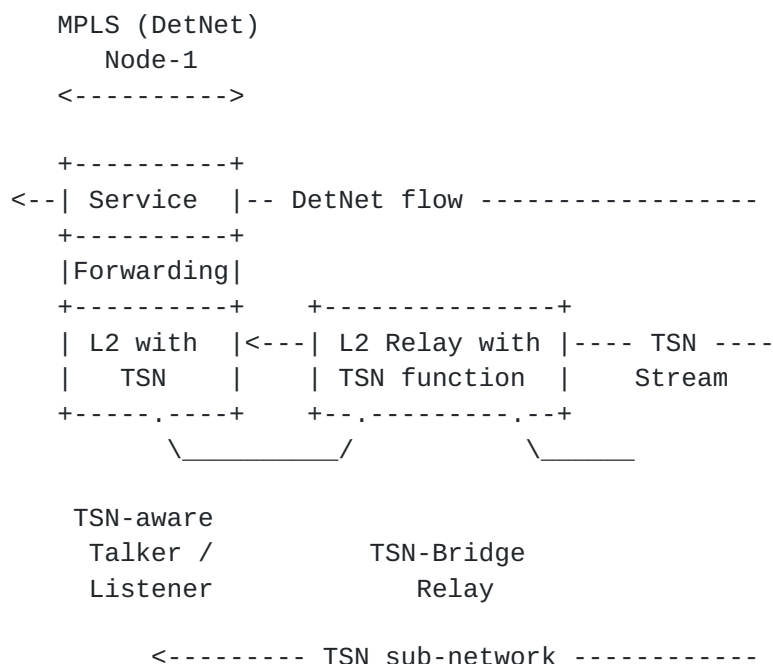
                Figure 7: MPLS (DetNet) Node with TSN Functions

The Sequence encode/decode function MUST support the Redundancy tag
(R-TAG) format as per Clause 7.8 of IEEE 802.1CB [IEEE8021CB].

6.2. TSN Usage of FRER

TSN Streams supporting DetNet flows may use Frame Replication and
Elimination for Redundancy (FRER) [802.1CB] based on the loss service
requirements of the TSN Stream, which is derived from the DetNet
service requirements of the DetNet mapped flow. The specific
operation of FRER is not modified by the use of DetNet and follows
IEEE 802.1CB [IEEE8021CB].

FRER function and the provided service recovery is available only
within the TSN sub-network however as the Stream-ID and the TSN

   sequence number are paired with the MPLS flow parameters they can be
   combined with PREOF functions.

6.3. Procedures

   [Editor's note: This section is TBD - covers required behavior of a
   TSN-aware DetNet node using a TSN underlay.]

6.4. Layer 2 Addressing and QoS Considerations

   [Editor's NOTE: review and simplify this section. May overlap with
   previous sections.]

   The Time-Sensitive Networking (TSN) Task Group of the IEEE 802.1
   Working Group have defined (and are defining) a number of amendments
   to IEEE 802.1Q [IEEE8021Q] that provide zero congestion loss and
   bounded latency in bridged networks. IEEE 802.1CB [IEEE8021CB]
   defines packet replication and elimination functions that should
   prove both compatible with and useful to, DetNet networks.

   As is the case for DetNet, a Layer 2 network node such as a bridge
   may need to identify the specific DetNet flow to which a packet
   belongs in order to provide the TSN/DetNet QoS for that packet. It
   also will likely need a CoS marking, such as the priority field of an
   IEEE Std 802.1Q VLAN tag, to give the packet proper service.

   Although the flow identification methods described in IEEE 802.1CB
   [IEEE8021CB] are flexible, and in fact, include IP 5-tuple
   identification methods, the baseline TSN standards assume that every
   Ethernet frame belonging to a TSN stream (i.e. DetNet flow) carries
   a multicast destination MAC address that is unique to that flow
   within the bridged network over which it is carried. Furthermore,
   IEEE 802.1CB [IEEE8021CB] describes three methods by which a packet
   sequence number can be encoded in an Ethernet frame.

   Ensuring that the proper Ethernet VLAN tag priority and destination
   MAC address are used on a DetNet/TSN packet may require further
   clarification of the customary L2/L3 transformations carried out by
   routers and edge label switches. Edge nodes may also have to move
   sequence number fields among Layer 2, PW, and IP encapsulations.

7. Management and Control Considerations

   [Editor's note: This section is TBD Covers Creation, mapping, removal
   of TSN Stream IDs, related parameters and,when needed, configuration
   of FRER. Supported by management/control plane. SEE sections in
   removed text file.]

While management plane and control planes are traditionally
considered separately, from the Data Plane perspective there is no
practical difference based on the origin of flow provisioning
information, and the DetNet architecture
[I-D.ietf-detnet-architecture] refers to these collectively as the
'Controller Plane'. This document therefore does not distinguish
between information provided by distributed control plane protocols,
e.g., RSVP-TE [RFC3209] and [RFC3473], or by centralized network
management mechanisms, e.g., RestConf [RFC8040], YANG [RFC7950], and
the Path Computation Element Communication Protocol (PCEP)
[I-D.ietf-pce-pcep-extension-for-pce-controller] or any combination
thereof. Specific considerations and requirements for the DetNet
Controller Plane are discussed below.

8. Security Considerations

The security considerations of DetNet in general are discussed in
[I-D.ietf-detnet-architecture] and [I-D.sdt-detnet-security]. Other
security considerations will be added in a future version of this
draft.

9. IANA Considerations

This document makes no IANA requests.

10. Acknowledgements

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Appendix A. Example of DetNet Data Plane Operation

[Editor's note: Add a simplified example of DetNet data plane and how
labels etc work in the case of MPLS-based PSN and utilizing PREOF.
The figure is subject to change depending on the further DT decisions
on the label handling..]

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