
Workgroup: Network Working Group
Internet-Draft: draft-ietf-detnet-yang-18
Published: 29 June 2023
Intended Status: Standards Track
Expires: 31 December 2023
Authors: X. Geng Y. Ryoo D. Fedyk R. Rahman
Huawei Technologies ETRI LabN Consulting, L.L.C. Individual
Z. Li
China Mobile

Deterministic Networking (DetNet) YANG Model

Abstract

This document contains the specification for the Deterministic Networking YANG Model for configuration and operational data of DetNet Flows. The model allows for provisioning of end-to-end DetNet service on devices along the path without dependency on any signaling protocol. It also specifies operational status for flows.

The YANG module defined in this document conforms to the Network Management Datastore Architecture (NMDA).

Status of This Memo

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

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any 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 31 December 2023.

Copyright Notice

Copyright (c) 2023 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions

with respect to this document. Code Components extracted from this document must include Revised BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Revised BSD License.

Table of Contents

- 1. Introduction
- 2. Abbreviations
- 3. Terminology
- 4. DetNet YANG Module
 - 4.1. DetNet Application Flow YANG Attributes
 - 4.2. DetNet Service Sub-layer YANG Attributes
 - 4.3. DetNet Forwarding Sub-layer YANG Attributes
- 5. DetNet Flow Aggregation
- 6. DetNet YANG Structure Considerations
- 7. DetNet Configuration YANG Structures
- 8. DetNet Configuration YANG Model
- 9. IANA Considerations
- 10. Security Considerations
- 11. Contributors
- 12. Acknowledgments
- 13. References
 - 13.1. Normative References
 - 13.2. Informative References
- Appendix A. DetNet Configuration YANG Tree
- Appendix B. Examples
 - B.1. Example A-1 JSON Configuration/Operational
 - B.2. Example B-1 XML Config: Aggregation using a Forwarding Sub-layer
 - B.3. Example B-2 JSON Service Aggregation Configuration
 - B.4. Example C-1 JSON Relay Aggregation/Disaggregation Configuration
 - B.5. Example C-2 JSON Relay Aggregation/Disaggregation Service Sub-Layer
 - B.6. Example C-3 JSON Relay Service Sub-Layer Aggregation/Disaggregation

[B.7. Example C-4 JSON Relay Service Sub-Layer Aggregation/Disaggregation](#)

[B.8. Example D-1 JSON Transit Forwarding Sub-Layer Aggregation/Disaggregation](#)

[Authors' Addresses](#)

1. Introduction

DetNet (Deterministic Networking) provides a capability to carry specified unicast or multicast data flows for real-time applications with extremely low packet loss rates and assured maximum end-to-end delivery latency. A description of the general background and concepts of DetNet can be found in [\[RFC8655\]](#).

This document defines a YANG model for DetNet based on YANG data types and modeling language defined in [\[RFC6991\]](#) and [\[RFC7950\]](#). DetNet service, which is designed for describing the characteristics of services being provided for application flows over a network, and DetNet configuration, which is designed for DetNet flow path establishment, flow status reporting, and DetNet functions configuration in order to achieve end-to-end bounded latency and zero congestion loss, are both included in this document.

2. Abbreviations

The following abbreviations are used in this document:

PEF	Packet Elimination Function
PRF	Packet Replication Function
PEOF	Packet Elimination and Ordering Functions
PERF	Packet Elimination and Replication Functions
PREOF	Packet Replication, Elimination and Ordering Functions
MPLS	Multiprotocol Label Switching

3. Terminology

This document uses the terminology defined in [\[RFC8655\]](#). The terms A-label, S-label, and F-label are used in this document as defined in [\[RFC8964\]](#).

4. DetNet YANG Module

The DetNet YANG module includes DetNet App-flow, DetNet Service Sub-layer, and DetNet Forwarding Sub-layer configuration and operational objects. The corresponding attributes used in different sub-layers are defined in Section 3.1, 3.2, 3.3 respectively.

Layers of the objects typically occur in the different data instances forming the node types defined in [RFC8655]. Figure 1 illustrates the relationship between data instance node types and the included layers. Node types are logical roles per DetNet service: a device along one DetNet service can be of one node type, while another service may use the same device with a different node type. This model is a controller based model because a controller or operator configures all the devices to form a service.

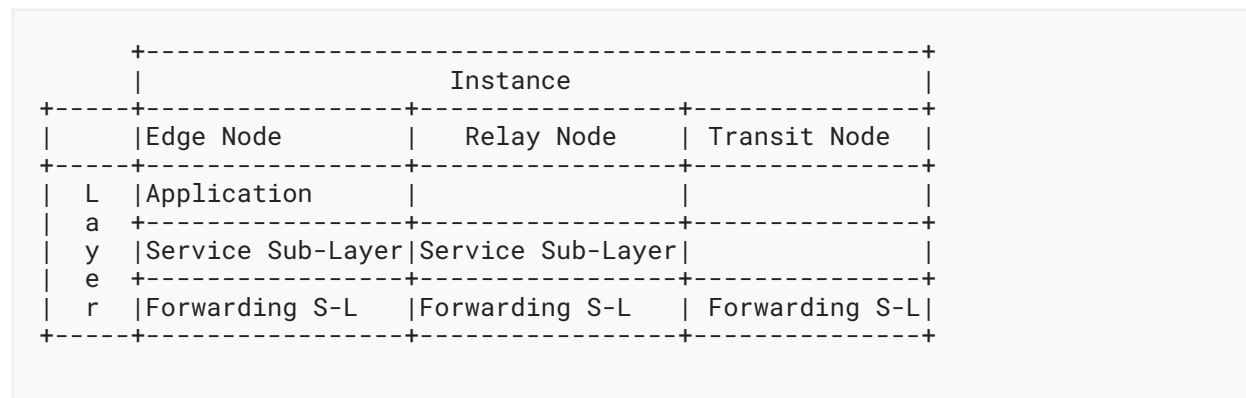


Figure 1: Detnet Layers and Node Types

All of the layers have ingress/incoming and egress/outgoing operations, but any instance may be configured as only unidirectional. Ingress refers to any DetNet layer where a DetNet context is applied. Ingress allows functions such as switching, aggregation and encapsulation. Likewise, egress refers to any DetNet layer where a Detnet context is removed. Egress allows functions such as switching, disaggregation and decapsulation. This means that each unidirectional flow identifier configuration is programmed starting at the ingress and flow status is reported at ingress on each end. In the MPLS cases once encapsulated, the IP 6-tuple parameters may not be required to be programmed again. In the IP case, without encapsulation, various IP flow id parameters must be configured along the flow path.

In the YANG model the terms source and destination are used as flow identifiers whereas ingress and egress refer to a DetNet application direction from the application edge. Ingress is to the DetNet application and egress is from the application. The terms incoming and outgoing generally represent the flow direction towards the remote application. Outgoing is viewed as going down the stack from Application to Service sub-layer to Forwarding sub-layer and incoming is the reverse. Although, in examples where there is aggregation and disaggregation outgoing relates to the aggregating output and incoming relates to the disaggregating flows.

At the egress point, forwarding information is determined by the App-flow type with all DetNet-related headers removed. The forwarding information can specify an output port, set a next-hop-address in case of IP, or set an MPLS label in case of MPLS.

4.1. DetNet Application Flow YANG Attributes

DetNet application flow is responsible for mapping between application flows and DetNet flows at the edge node (egress/ingress node). The application flows can be either layer 2 or layer 3 flows. To map a flow at the User Network Interface (UNI), the corresponding attributes are defined in [RFC9016].

4.2. DetNet Service Sub-layer YANG Attributes

DetNet service functions, e.g., DetNet tunnel initialization/termination and service protection, are provided in the DetNet service sub-layer. To support these functions, the following service attributes need to be configured:

- DetNet flow identification
- Service function indication, indicates which service function will be invoked at a DetNet edge, relay node or end station. (DetNet tunnel initialization or termination are default functions in the DetNet service layer, so there is no need for explicit indication). The corresponding arguments for service functions also need to be defined.

4.3. DetNet Forwarding Sub-layer YANG Attributes

As defined in [RFC8655], DetNet forwarding sub-layer optionally provides congestion protection for DetNet flows over paths provided by the underlying network. Explicit route is another mechanism that is used by DetNet to avoid temporary interruptions caused by the convergence of routing or bridging protocols, and it is also implemented at the DetNet forwarding sub-layer.

To support congestion protection and explicit route, the following transport layer related attributes are necessary:

- Flow Specification and Traffic Requirements, as described in the information model in [RFC9016]. These may be used for resource reservation, flow shaping, filtering and policing by a control plane or other network management and control mechanisms.
- Since this model programs the data plane existing explicit route mechanisms can be reused. If a static MPLS tunnel is used as the transport tunnel, the configuration needs to be at every transit node along the path. For an IP-based path, the static configuration is similar to the static MPLS case. This document provides data-plane configuration of IP addresses or MPLS labels but it does not provide control plane mapping or other aspects.

5. DetNet Flow Aggregation

DetNet provides the capability of flow aggregation to improve scalability of DetNet data, management and control planes. Aggregated flows can be viewed by some DetNet nodes as individual DetNet flows. When aggregating DetNet flows, the flows should be compatible: if

bandwidth reservations are used, the reservation should be a reasonable representation of the individual reservations; if maximum delay bounds are used, the system should ensure that the aggregate does not exceed the delay bounds of the individual flows.

The DetNet YANG model defined in this document supports DetNet flow aggregation with the following functions:

- Aggregated flow encapsulation/decapsulation/identification
- Mapping individual DetNet flows to an aggregated flow
- Changing traffic specification parameters for aggregated flows

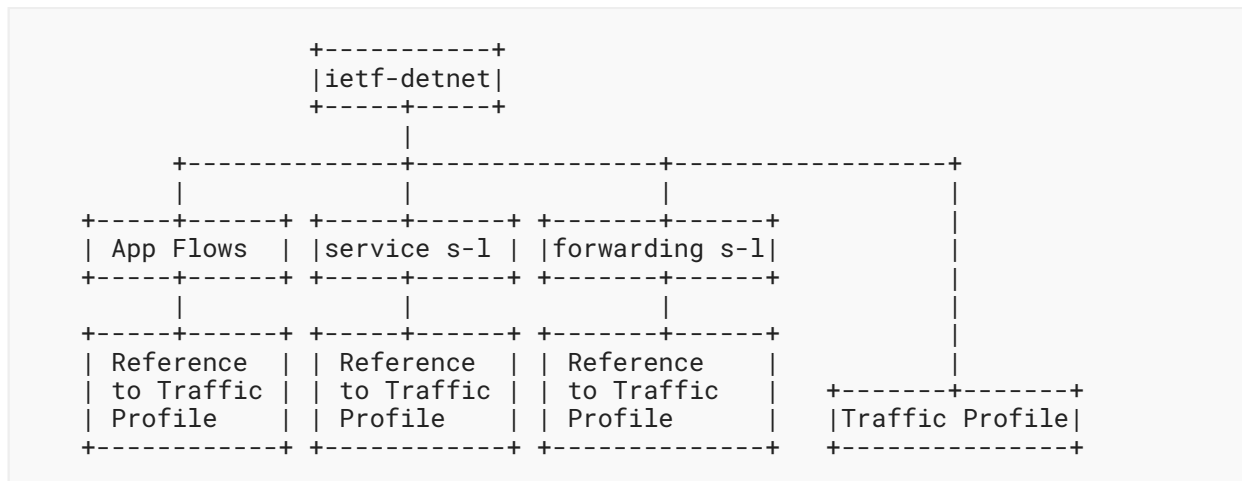
The following cases of DetNet aggregation are supported:

- Ingress node aggregates App flows into a service sub-layer of DetNet flow
- In ingress node, the service sub-layers of DetNet flows are aggregated into a forwarding sub-layer
- In ingress node, the service sub-layers of DetNet flows are aggregated into a service sub-layer of an aggregated DetNet flow
- Relay node aggregates the forwarding sub-layers DetNet flows into a forwarding sub-layer
- Relay node aggregates the service sub-layers of DetNet flows into a forwarding sub-layer
- Relay node aggregates the service sub-layers of DetNet flows into a service sub-layer of Aggregated DetNet flow
- Relay node aggregates the forwarding sub-layers of DetNet flow into a service sub-layer of Aggregated DetNet flow
- Transit node aggregates the forwarding sub-layers of DetNet flows into a forwarding sub-layer

Traffic requirements and traffic specification may be tracked for individual or aggregate flows but reserving resources and tracking the services in the aggregated flow is out of scope.

6. DetNet YANG Structure Considerations

The picture shows the general structure of the DetNet YANG Model:



There are three layer types in the DetNet YANG Model: App-flow data layer, service sub-layer and forwarding sub-layer. Additionally, the Traffic parameters are captured in a Traffic profile that can be referenced by any of the layers.

Below is a summary YANG tree showing the major items. A complete YANG tree is in section [Appendix A](#).

A traffic profile can be created for an application, a service sub-layer or a forwarding sub-layer. A single profile may be shared by multiple applications/sub-layer. Each profile indicates the members currently using that profile.

Depending on which DetNet layers and functions are required, some or all of the components may be configured. Examples are shown in [Appendix B](#).

7. DetNet Configuration YANG Structures

The following is a partial tree representation of the YANG as defined in [\[RFC8340\]](#). This corresponds to the structure layout in the previous section.

```

module: ietf-detnet
  +--rw detnet
    +--rw traffic-profile* [name]
      | +--rw name string
      | +--rw traffic-requirements
      | +--rw traffic-spec
      | +--ro member-app* app-flow-ref
      | +--ro member-service* service-sub-layer-ref
      | +--ro member-fwd-sublayer* forwarding-sub-layer-ref
    +--rw app-flows
      | +--rw app-flow* [name]
      |   +--rw name string
      |   +--rw bidir-congruent? boolean
      |   +--ro outgoing-service? service-sub-layer-ref
      |   +--ro incoming-service? service-sub-layer-ref
      |   +--rw traffic-profile? traffic-profile-ref
      |   +--rw ingress
      |   | ...
      |   +--rw egress
      |   | ...
    +--rw service
      | +--rw sub-layer* [name]
      |   +--rw name string
      |   +--rw service-rank? uint8
      |   +--rw traffic-profile? traffic-profile-ref
      |   +--rw service-protection
      |   | ...
      |   +--rw operation? operation
      |   +--rw incoming
      |   | ...
      |   +--rw outgoing
      |   | ...
    +--rw forwarding
      +--rw sub-layer* [name]
        +--rw name string
        +--rw traffic-profile? traffic-profile-ref
        +--rw operation? forwarding-operations
        +--rw incoming
        | ...
        +--rw outgoing
        | ...

```

8. DetNet Configuration YANG Model

This YANG model imports typedefs from [\[RFC6991\]](#), [\[RFC8519\]](#), [\[RFC8294\]](#), [\[RFC8343\]](#), [\[IEEE8021Q\]](#), and [\[IEEE8021QCX\]](#). This YANG model also has the following references to RFCs that are not in the document text body [\[RFC0791\]](#), [\[RFC4303\]](#), [\[RFC8349\]](#), [\[RFC8938\]](#), [\[RFC8960\]](#), [\[RFC8964\]](#), and [\[RFC8200\]](#).

```

<CODE BEGINS> file "ietf-detnet@2022-01-05.yang"

module ietf-detnet {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-detnet";

```



```
prefix dnet;

import ietf-yang-types {
  prefix yang;
  reference
    "RFC 6991 - Common YANG Data Types.";
}
import ietf-inet-types {
  prefix inet;
  reference
    "RFC 6991 - Common YANG Data Types.";
}
import ietf-ethertypes {
  prefix ethertypes;
  reference
    "RFC 8519 - YANG Data Model for Network Access Control
      Lists (ACLs).";
}
import ietf-routing-types {
  prefix rt-types;
  reference
    "RFC 8294 - Common YANG Data Types for the Routing Area.";
}
import ietf-packet-fields {
  prefix packet-fields;
  reference
    "RFC 8519 - YANG Data Model for Network Access Control Lists
      (ACLs).";
}
import ietf-interfaces {
  prefix if;
  reference
    "RFC 8343 - A YANG Data Model for Interface Management.";
}
import ieee802-dot1q-types {
  prefix dot1q-types;
  reference
    "IEEE 802.1Qcx-2020 - IEEE Standard for Local and Metropolitan
      Area Networks--Bridges and Bridged Networks Amendment 33: YANG
      Data Model for Connectivity Fault Management.";
}

organization
  "IETF DetNet Working Group";

contact
  "WG Web:  <https://datatracker.ietf.org/wg/detnet/>
  WG List:  <mailto:detnet@ietf.org>

  Editor:   Xuesong Geng
            <mailto:gengxuesong@huawei.com>

  Editor:   Yeoncheol Ryoo
            <mailto:dbduscjf@etri.re.kr>

  Editor:   Don Fedyk
            <mailto:dfedyk@labn.net>;
```

```
Editor: Reshad Rahman
       <mailto:reshad@yahoo.com>

Editor: Zhenqiang Li
       <mailto:lizhenqiang@chinamobile.com>;
description
"This YANG module describes the parameters needed
for DetNet flow configuration and flow status
reporting. This YANG module conforms to the Network
Management Datastore Architecture (NMDA).

Copyright (c) 2022 IETF Trust and the persons identified as
authors of the code. All rights reserved.

Redistribution and use in source and binary forms, with or
without modification, is permitted pursuant to, and subject to
the license terms contained in, the Revised BSD License set
forth in Section 4.c of the IETF Trust's Legal Provisions
Relating to IETF Documents
(https://trustee.ietf.org/license-info).

This version of this YANG module is part of RFC XXXX;
see the RFC itself for full legal notices.";

// RFC Ed.: replace XXXX with actual RFC number and remove
// this note

// replace '2022-10-04' with the module publication date
// the format is (year-month-day)

revision 2023-06-28 {
  description
    "Initial revision";
  reference
    "RFC XXXX: Deterministic Networking (DetNet) YANG Model";
}

identity app-status {
  description
    "Base identity from which all application-status
    status types are derived.";
  reference
    "RFC 9016 Section 5.8";
}

identity none {
  base app-status;
  description
    "This Application has no status. This identity is
    expected when the configuration is incomplete.";
  reference
    "RFC 9016 Section 5.8";
}

identity ready {
  base app-status;
  description
    "Application ingress/egress ready.";
```

```
        reference
          "RFC 9016 Section 5.8";
      }

      identity failed {
        base app-status;
        description
          "Application ingres/egress failed.";
        reference
          "RFC 9016 Section 5.8";
      }

      identity out-of-service {
        base app-status;
        description
          "Application Administratively blocked.";
        reference
          "RFC 9016 Section 5.8";
      }

      identity partial-failed {
        base app-status;
        description
          "This is an Application with one or more Egress ready, and one
           or more Egress failed. The DetNet flow can be used if the
           Ingress is Ready.";
        reference
          "RFC 9016 Section 5.8";
      }

      typedef app-flow-ref {
        type leafref {
          path "/dnet:detnet"
            + "/dnet:app-flows"
            + "/dnet:app-flow"
            + "/dnet:name";
        }
        description
          "This is an Application Reference.";
      }

      typedef service-sub-layer-ref {
        type leafref {
          path "/dnet:detnet"
            + "/dnet:service"
            + "/dnet:sub-layer"
            + "/dnet:name";
        }
        description
          "This is a Service sub-layer Reference.";
      }

      typedef forwarding-sub-layer-ref {
        type leafref {
          path "/dnet:detnet"
            + "/dnet:forwarding"
            + "/dnet:sub-layer"
            + "/dnet:name";
        }
      }
```

```
    }
    description
      "This is a Forwarding sub-layer Reference.";
  }

  typedef traffic-profile-ref {
    type leafref {
      path "/dnet:detnet"
        + "/dnet:traffic-profile"
        + "/dnet:name";
    }
    description
      "This is a Traffic Profile Reference.";
  }

  typedef ipsec-spi {
    type uint32 {
      range "1..max";
    }
    description
      "IPsec Security Parameters Index. A 32 bit value
       where 0 is reserved.";
    reference
      "IETF RFC 4303 Encapsulating Security Payload (ESP).";
  }

  typedef operation {
    type enumeration {
      enum initiation {
        description
          "This is an initiating service sub-layer encapsulation.";
      }
      enum termination {
        description
          "Operation for DetNet service sub-layer decapsulation.";
      }
      enum relay {
        description
          "Operation for DetNet service sub-layer swap.";
      }
      enum non-detnet {
        description
          "No operation for DetNet service sub-layer.";
      }
    }
    description
      "Operation type identifies the behavior for this service
       sub-layer. Operations are described as unidirectional
       but a service sub-layer may combine operation types.";
  }

  typedef forwarding-operations {
    type enumeration {
      enum impose-and-forward {
        description
          "This operation imposes outgoing label(s) and forwards to
           next-hop.";
        reference

```

```
    " A YANG Data Model for MPLS Base RFC 8960.";
  }
  enum pop-and-forward {
    description
      "This operation pops the incoming label and forwards to
       the next-hop.";
    reference
      " A YANG Data Model for MPLS Base RFC 8960.";
  }
  enum pop-impose-and-forward {
    description
      "This operation pops the incoming label, imposes one or
       more outgoing label(s) and forwards to the next-hop.";
    reference
      " A YANG Data Model for MPLS Base RFC 8960.";
  }
  enum swap-and-forward {
    description
      "This operation swaps an incoming label, with an outgoing
       label and forwards to the next-hop.";
    reference
      " A YANG Data Model for MPLS Base RFC 8960.";
  }
  enum forward {
    description
      "This operation forwards to next-hop.";
  }
  enum pop-and-lookup {
    description
      "This operation pops an incoming label and performs a
       lookup.";
  }
}
description
  "MPLS operations types. This is an enum modeled after the
   MPLS enum. The enums are the same as A YANG Data Model
   for MPLS Base. RFC 8960.";
}

typedef service-protection {
  type enumeration {
    enum none {
      description
        "No service protection provided.";
    }
    enum replication {
      description
        "A Packet Replication Function (PRF) replicates DetNet
         flow packets and forwards them to one or more next hops in
         the DetNet domain. The number of packet copies sent to
         each next hop is a DetNet flow-specific parameter at the
         node doing the replication. PRF can be implemented by an
         edge node, a relay node, or an end system.";
    }
    enum elimination {
      description
        "A Packet Elimination Function (PEF) eliminates duplicate
         copies of packets to prevent excess packets flooding the
```

```
        network or duplicate packets being sent out of the DetNet
        domain. PEF can be implemented by an edge node, a relay
        node, or an end system.";
    }
    enum ordering {
        description
        "A Packet Ordering Function (POF) re-orders packets within
        a DetNet flow that are received out of order. This
        function can be implemented by an edge node, a relay node,
        or an end system.";
    }
    enum elimination-ordering {
        description
        "A combination of PEF and POF that can be implemented by
        an edge node, a relay node, or an end system.";
    }
    enum elimination-replication {
        description
        "A combination of PEF and PRF that can be implemented by
        an edge node, a relay node, or an end system.";
    }
    enum elimination-ordering-replication {
        description
        "A combination of PEF, POF and PRF that can be implemented
        by an edge node, a relay node, or an end system.";
    }
}
description
"This typedef describes the service protection enumeration
values.";
}

typedef sequence-number-generation {
    type enumeration {
        enum copy-from-app-flow {
            description
            "Copy-from-app-flow is to extend and use the
            sequence number used in App-flow. This function is
            required when encapsulating App-flows that have been
            replicated and received through multiple ingress nodes
            into a member flow, and then eliminate it at the relay
            node.";
        }
        enum generate-by-detnet-flow {
            description
            "Generate-by-detnet-flow is used to create a new
            sequence number for a DetNet flow at the ingress node.
            Care must be taken when using this option to ensure
            there is only one source for generating sequence
            numbers.";
        }
    }
}
description
"This typedef defines how to generate sequence numbers to
be used in DetNet encapsulation.";
}

typedef sequence-number-field {
    type enumeration {
```

```
    enum zero-sn {
      description
        "No DetNet sequence number field is used.";
    }
    enum short-sn {
      value 16;
      description
        "A 16-bit DetNet sequence number field is used.";
    }
    enum long-sn {
      value 28;
      description
        "A 28-bit DetNet sequence number field is used.";
    }
  }
  description
    "This enumeration configures the sequence number behavior.";
}

grouping ip-header {
  description
    "This grouping captures the IPv4/IPv6 packet header
    information. It is modeled after existing fields.";
  leaf src-ip-address {
    type inet:ip-address-no-zone;
    description
      "The source IP address in the header.";
    reference
      "RFC 6991 Common YANG Data Types";
  }
  leaf dest-ip-address {
    type inet:ip-address-no-zone;
    description
      "The destination IP address in the header.";
    reference
      "RFC 6991 Common YANG Data Types";
  }
  leaf protocol-next-header {
    type uint8;
    description
      "Internet Protocol number. Refers to the protocol of the
      payload. In IPv6, this field is known as 'next-header',
      and if extension headers are present, the protocol is
      present in the 'upper-layer' header.";
    reference
      "RFC 791: Internet Protocol
      RFC 8200: Internet Protocol, Version 6 (IPv6)
      Specification.";
  }
  leaf dscp {
    type inet:dscp;
    description
      "The traffic class value in the header.";
    reference
      "RFC 6991 Common YANG Data Types";
  }
  leaf flow-label {
    type inet:ipv6-flow-label;
  }
}
```

```
        description
          "The flow label value of the header. IPv6 only.";
        reference
          "RFC 6991 Common YANG Data Types";
      }
    leaf source-port {
      type inet:port-number;
      description
        "The source port number.";
      reference
        "RFC 6991 Common YANG Data Types";
    }
    leaf destination-port {
      type inet:port-number;
      description
        "The destination port number.";
      reference
        "RFC 6991 Common YANG Data Types";
    }
  }

  grouping l2-header {
    description
      "The Ethernet or TSN packet header information.";
    leaf source-mac-address {
      type yang:mac-address;
      description
        "The source MAC address value of the Ethernet header.";
    }
    leaf destination-mac-address {
      type yang:mac-address;
      description
        "The destination MAC address value of the Ethernet header.";
    }
    leaf ethertype {
      type ethertypes:ethertype;
      description
        "The Ethernet packet type value of the Ethernet header.";
    }
    leaf vlan-id {
      type dot1q-types:vlanid;
      description
        "The VLAN value of the Ethernet header.";
      reference
        "IEEE 802.1Qcx-2020.";
    }
    leaf pcpc {
      type dot1q-types:priority-type;
      description
        "The priority value of the Ethernet header.";
      reference
        "IEEE 802.1Qcx-2020.";
    }
  }

  grouping destination-ip-port-id {
    description
      "The TCP/UDP port destination identification
```



```
        information.";
    container destination-port {
        uses packet-fields:port-range-or-operator;
        description
            "This grouping captures the destination port fields.";
    }
}

grouping source-ip-port-id {
    description
        "The TCP/UDP port source identification
        information.";
    container source-port {
        uses packet-fields:port-range-or-operator;
        description
            "This grouping captures the source port fields.";
    }
}

grouping ip-flow-id {
    description
        "The IPv4/IPv6 packet header identification information.";
    leaf src-ip-prefix {
        type inet:ip-prefix;
        description
            "The source IP prefix.";
        reference
            "RFC 6991 Common YANG Data Types";
    }
    leaf dest-ip-prefix {
        type inet:ip-prefix;
        description
            "The destination IP prefix.";
        reference
            "RFC 6991 Common YANG Data Types";
    }
    leaf protocol-next-header {
        type uint8;
        description
            "Internet Protocol number. Refers to the protocol of the
            payload. In IPv6, this field is known as 'next-header', and
            if extension headers are present, the protocol is present in
            the 'upper-layer' header.";
        reference
            "RFC 791: Internet Protocol
            RFC 8200: Internet Protocol, Version 6 (IPv6)
            Specification.";
    }
    leaf dscp {
        type inet:dscp;
        description
            "The traffic class value in the header.";
        reference
            "RFC 6991 Common YANG Data Types";
    }
    leaf flow-label {
        type inet:ipv6-flow-label;
        description
```

```
        "The flow label value of the header.";
        reference
            "RFC 6991 Common YANG Data Types";
    }
    uses source-ip-port-id;
    uses destination-ip-port-id;
    leaf ipsec-spi {
        type ipsec-spi;
        description
            "IPsec Security Parameters Index of the Security
            Association.";
        reference
            "IETF RFC 4303 Encapsulating Security Payload (ESP).";
    }
}

grouping mpls-flow-id {
    description
        "The MPLS packet header identification information.";
    choice label-space {
        description
            "Designates the label space being used.";
        case context-label-space {
            uses rt-types:mpls-label-stack;
        }
        case platform-label-space {
            leaf label {
                type rt-types:mpls-label;
                description
                    "This is the case for Platform label space.";
            }
        }
    }
}

grouping data-flow-spec {
    description
        "app-flow identification.";
    choice data-flow-type {
        description
            "The Application flow type choices.";
        container tsn-app-flow {
            uses l2-header;
            description
                "The L2 header for application.";
        }
        container ip-app-flow {
            uses ip-flow-id;
            description
                "The IP header for application.";
        }
        container mpls-app-flow {
            uses mpls-flow-id;
            description
                "The MPLS header for application.";
        }
    }
}
```

```
grouping detnet-flow-spec {
  description
    "detnet-flow identification.";
  choice detnet-flow-type {
    description
      "The Detnet flow type choices.";
    case ip-detnet-flow {
      uses ip-flow-id;
    }
    case mpls-detnet-flow {
      uses mpls-flow-id;
    }
  }
}

grouping app-flows-group {
  description
    "Incoming or outgoing app-flow reference group.";
  leaf-list flow {
    type app-flow-ref;
    description
      "List of ingress or egress app-flows.";
  }
}

grouping service-sub-layer-group {
  description
    "Incoming or outgoing service sub-layer reference group.";
  leaf-list sub-layer {
    type service-sub-layer-ref;
    description
      "List of incoming or outgoing service sub-layers that have
      to aggregate or disaggregate.";
  }
}

grouping forwarding-sub-layer-group {
  description
    "Incoming or outgoing forwarding sub-layer reference group.";
  leaf-list sub-layer {
    type forwarding-sub-layer-ref;
    description
      "List of incoming or outgoing forwarding sub-layers that
      have to aggregate or disaggregate.";
  }
}

grouping detnet-header {
  description
    "DetNet header info for DetNet encapsulation or swap.";
  choice header-type {
    description
      "The choice of DetNet header type.";
    case mpls {
      description
        "MPLS label stack for DetNet MPLS encapsulation or
        forwarding.";
    }
  }
}
```

```
        uses rt-types:mpls-label-stack;
    }
    case ip {
        description
            "IPv4/IPv6 packet header for DetNet IP encapsulation.";
        uses ip-header;
    }
}

grouping detnet-app-next-hop-content {
    description
        "Generic parameters of DetNet next hops. This follows the
        principles for next hops in RFC 8349";
    choice next-hop-options {
        description
            "Options for next hops. It is expected that further cases
            will be added through
            augments from other modules, e.g., for recursive
            next hops.";
        case simple-next-hop {
            description
                "This case represents a simple next hop consisting of the
                next-hop address and/or outgoing interface.";
            leaf outgoing-interface {
                type if:interface-ref;
                description
                    "The outgoing interface, when matching all flows to
                    the interface.";
            }
            choice flow-type {
                description
                    "The flow type choices.";
                case ip {
                    leaf next-hop-address {
                        type inet:ip-address-no-zone;
                        description
                            "The IP next hop case.";
                    }
                }
                case mpls {
                    uses rt-types:mpls-label-stack;
                    description
                        "The MPLS Label stack next hop case.";
                }
            }
        }
    }
    case next-hop-list {
        description
            "Container for multiple next hops.";
        list next-hop {
            key "hop-index";
            description
                "An entry in a next-hop list.";
            leaf hop-index {
                type uint8;
                description
                    "A user-specified identifier utilized to uniquely
```

```
        reference the next-hop entry in the next-hop list.
        The value of this index has no semantic meaning other
        than for referencing the entry.";
    }
    leaf outgoing-interface {
        type if:interface-ref;
        description
            "The outgoing interface, when matching all flows to
            the interface.";
    }
    choice flow-type {
        description
            "The flow types supported.";
        case ip {
            leaf next-hop-address {
                type inet:ip-address-no-zone;
                description
                    "This is the IP flow type next hop.";
            }
        }
        case mpls {
            uses rt-types:mpls-label-stack;
        }
    }
}

grouping detnet-forwarding-next-hop-content {
    description
        "Generic parameters of DetNet next hops. This follows the
        principles for next hops in RFC 8349";
    choice next-hop-options {
        description
            "Options for next hops.
            It is expected that further cases will be added through
            augments from other modules, e.g., for recursive
            next hops.";
        case simple-next-hop {
            description
                "This case represents a simple next hop consisting of the
                next-hop address and/or outgoing interface.";
            leaf outgoing-interface {
                type if:interface-ref;
                description
                    "The outgoing interface, when matching all flows to
                    the interface.";
            }
            choice flow-type {
                description
                    "These are the flow type next hop choices.";
                case ip {
                    choice operation-type {
                        description
                            "This is the IP forwarding operation choices.";
                        case ip-forwarding {
                            leaf next-hop-address {
```

```
        type inet:ip-address-no-zone;
        description
            "This is an IP address as a next hop.";
    }
}
case mpls-over-ip-encapsulation {
    uses ip-header;
}
}
}
case mpls {
    uses rt-types:mpls-label-stack;
}
}
}
case next-hop-list {
    description
        "Container for multiple next hops.";
    list next-hop {
        key "hop-index";
        description
            "An entry in a next-hop list.";
        leaf hop-index {
            type uint8;
            description
                "The value of the index for a hop.";
        }
        leaf outgoing-interface {
            type if:interface-ref;
            description
                "The outgoing interface, when matching all flows to
                the interface.";
        }
        choice flow-type {
            description
                "These are the flow type next hop choices.";
            case ip {
                choice operation-type {
                    description
                        "These are the next hop choices.";
                    case ip-forwarding {
                        leaf next-hop-address {
                            type inet:ip-address-no-zone;
                            description
                                "This is an IP address as a next hop.";
                        }
                    }
                    case mpls-over-ip-encapsulation {
                        uses ip-header;
                    }
                }
            }
            case mpls {
                uses rt-types:mpls-label-stack;
            }
        }
    }
}
}
```

```
    }  
  }  
  
  container detnet {  
    description  
      "The top level DetNet container. This contains  
      applications, service sub-layers and forwarding sub-layers  
      as well as the traffic profiles.";  
    list traffic-profile {  
      key "name";  
      description  
        "A traffic profile.";  
      leaf name {  
        type string;  
        description  
          "An Aggregation group ID.";  
      }  
    }  
    container traffic-requirements {  
      description  
        "This defines the attributes of the App-flow  
        regarding bandwidth, latency, latency variation, loss, and  
        misordering tolerance.";  
      reference  
        "RFC 9016 Section 4.2";  
      leaf min-bandwidth {  
        type uint64;  
        units 'octets per second';  
        description  
          "This is the minimum bandwidth that has to be  
          guaranteed for the DetNet service. MinBandwidth is  
          specified in octets per second.";  
        reference  
          "RFC 9016 Section 4.2";  
      }  
      leaf max-latency {  
        type uint32;  
        units "nanoseconds";  
        description  
          "This is the maximum latency from Ingress to  
          Egress(es) for a single packet of the DetNet flow.  
          MaxLatency is specified as an integer number of  
          nanoseconds. The MAX value is 4,294,967,295  
          nanoseconds.";  
        reference  
          "RFC 9016 Section 4.2";  
      }  
      leaf max-latency-variation {  
        type uint32;  
        units "nanoseconds";  
        description  
          "This is the difference between the  
          minimum and the maximum end-to-end one-way latency.  
          MaxLatencyVariation is specified as an integer number of  
          nanoseconds.";  
        reference  
          "RFC 9016 Section 4.2";  
      }  
      leaf max-loss {
```

```
    type decimal64 {
      fraction-digits 10;
      range "0 .. 100";
    }
    units "percent";
    description
      "This defines the maximum Packet Loss Rate (PLR)
      parameter for the DetNet service between the Ingress and
      Egress(es) of the DetNet domain. Packet loss rate is
      calculated by the number of transmitted packets minus
      the number of received packets divided by the number
      transmitted packets expressed as a percent.";
    reference
      "RFC 9016 Section 4.2";
  }
  leaf max-consecutive-loss-tolerance {
    type uint32;
    units "packets";
    description
      "Some applications have special loss requirement, such
      as MaxConsecutiveLossTolerance. The maximum consecutive
      loss tolerance parameter describes the maximum number of
      consecutive packets whose loss can be tolerated. The
      maximum consecutive loss tolerance can be measured for
      example based on sequence number.";
    reference
      "RFC 9016 Section 4.2";
  }
  leaf max-misordering {
    type uint32;
    units "packets";
    description
      "This describes the tolerable maximum number
      of packets that can be received out of order. The
      maximum allowed misordering can be measured for example
      based on sequence number. The value zero for the
      maximum allowed misordering indicates that in order
      delivery is required, misordering cannot be tolerated.";
    reference
      "RFC 9016 Section 4.2";
  }
}
container traffic-spec {
  description
    "Traffic-specification specifies how the Source transmits
    packets for the flow. This is the promise/request of the
    Source to the network. The network uses this flow
    specification to allocate resources and adjust queue
    parameters in network nodes.";
  reference
    "RFC 9016 Section 5.5";
  leaf interval {
    type uint32;
    units "nanoseconds";
    description
      "The period of time in which the traffic
      specification should not be exceeded.";
    reference
```



```
        "RFC 9016 Section 5.5,
        IEEE802.1Q";
    }
    leaf max-pkts-per-interval {
        type uint32;
        description
            "The maximum number of packets that the
            source will transmit in one interval.";
        reference
            "RFC 9016 Section 5.5, IEEE802.1Q";
    }
    leaf max-payload-size {
        type uint32;
        description
            "The maximum payload size that the source
            will transmit.";
        reference
            "RFC 9016 Section 5.5, IEEE802.1Q";
    }
    leaf min-payload-size {
        type uint32;
        description
            "The minimum payload size that the source
            will transmit., IEEE802.1Q";
    }
    leaf min-pkts-per-interval {
        type uint32;
        description
            "The minimum number of packets that the
            source will transmit in one interval.";
        reference
            "RFC 9016 Section 5.5, IEEE802.1Q";
    }
}
leaf-list member-app {
    type app-flow-ref;
    config false;
    description
        "A list of Applications attached to this profile. Each
        application that uses a profile has an automatically
        populated reference.";
    reference
        "RFC XXXX: Deterministic Networking (DetNet) YANG Model
        Section 5";
}
leaf-list member-service {
    type service-sub-layer-ref;
    config false;
    description
        "A list of Service Sub-layers attached to this profile.
        Each Service Sub-layers that uses a profile has an
        automatically populated reference.";
    reference
        "RFC XXXX: Deterministic Networking (DetNet) YANG Model
        Section 5";
}
leaf-list member-fwd-sublayer {
    type forwarding-sub-layer-ref;
```

```
    config false;
    description
      "A list of Forwarding Sub-layers attached to this profile.
      Each Forwarding Sub-layers that uses a profile has an
      automatically populated reference.";
    reference
      "RFC XXXX: Deterministic Networking (DetNet) YANG Model
      Section 5";
  }
}
container app-flows {
  description
    "The DetNet app-flow configuration.";
  reference
    "RFC 9016 Section 4.1";
  list app-flow {
    key "name";
    description
      "A unique (management) identifier of the App-flow.";
    leaf name {
      type string;
      description
        "A unique (management) identifier of the App-flow.";
      reference
        "RFC 9016
        Sections 4.1, 5.1";
    }
    leaf bidir-congruent {
      type boolean;
      default false;
      description
        "Defines the data path requirement of the App-flow
        whether it must share the same data path and physical
        path for both directions through the network, e.g., to
        provide congruent paths in the two directions.";
      reference
        "RFC 9016
        Section 4.2";
    }
    leaf outgoing-service {
      type service-sub-layer-ref;
      config false;
      description
        "Binding to this applications outgoing
        service.";
    }
    leaf incoming-service {
      type service-sub-layer-ref;
      config false;
      description
        "Binding to this applications incoming service.";
    }
    leaf traffic-profile {
      type traffic-profile-ref;
      description
        "The Traffic Profile for this group.";
    }
  }
  container ingress {
```

```
    description
      "Ingress DetNet application flows or a compound flow.";
    leaf app-flow-status {
      type identityref {
        base app-status;
      }
      default none;
      config false;
      description
        "Status of ingress application flow. This is an
         operational status and defaults to none if
         incomplete.";
      reference
        "RFC 9016 Sections
         4.1, 5.8";
    }
    leaf interface {
      type if:interface-ref;
      description
        "Interface is used for any service type when
         matching all flows to the interface.";
    }
    uses data-flow-spec;
  } //End of app-ingress
  container egress {
    description
      "Route's next-hop attribute.";
    uses data-flow-spec;
    choice application-type {
      description
        "This is the application type choices.";
      container ethernet {
        description
          "This is TSN unaware traffic that maps to an
           interface.";
        leaf interface {
          type if:interface-ref;
          description
            "This is an Ethernet or TSN interfaces.";
        }
      }
      container ip-mpls {
        description
          "This is IP or MPLS DetNet application types.";
        uses detnet-app-next-hop-content;
      }
    }
  }
}

container service {
  description
    "The DetNet service sub-layer configuration.";
  list sub-layer {
    key "name";
    description
      "Services are indexed by name.";
    leaf name {
```

```
    type string;
    description
      "The name of the DetNet service sub-layer.";
  }
  leaf service-rank {
    type uint8;
    default 255;
    description
      "The DetNet rank for this service. Defaults to 255
      lowest rank if not specified.";
    reference
      "RFC 9016 Section 5.7.";
  }
  leaf traffic-profile {
    type traffic-profile-ref;
    description
      "The Traffic Profile for this service.";
  }
  container service-protection {
    description
      "This is the service protection type and sequence number
      options.";
    leaf protection {
      type service-protection;
      description
        "The DetNet service protection type such as
        Packet Replication Function (PRF),
        Packet Elimination Function (PEF),
        Packet Replication, Elimination, and Ordering Functions
        (PREOF).";
      reference
        "RFC 8938 Section 4.3";
    }
    leaf sequence-number-length {
      type sequence-number-field;
      default zero-sn;
      description
        "Sequence number field length can be one of 0 (none),
        16-bits or 28-bits. The default is none.";
    }
  }
  leaf operation {
    type operation;
    description
      "This is the service operation type for this service
      sub-layer;";
  }
  container incoming {
    description
      "The DetNet service sub-layer incoming configuration.";
    choice incoming {
      description
        "A service sub-layer may have App flows or other
        service sub-layers.";
      container app-flow {
        description
          "This service sub-layer is related to the app-flows
          of the upper layer and provide ingress proxy or
```

```
        ingress aggregation at the ingress node.";
    uses app-flows-group;
}
container service-aggregation {
    description
        "This service sub-layer is related to the service
        sub-layer of the upper layer and provide
        service-to-service aggregation at the ingress node
        or relay node.";
    uses service-sub-layer-group;
}
container forwarding-aggregation {
    description
        "This service sub-layer is related to the forwarding
        sub-layer of the upper layer and provide
        forwarding-to-service aggregation at the ingress
        node or relay node.";
    uses forwarding-sub-layer-group;
}
container service-id {
    description
        "This service sub-layer is related to the service or
        forwarding sub-layer of the lower layer and provide
        DetNet service relay or termination at the relay
        node or egress node.";
    uses detnet-flow-spec;
}
}
}
container outgoing {
    description
        "The DetNet service sub-layer outgoing configuration.";
    choice outgoing {
        description
            "The outgoing type may be a forwarding Sub-layer or a
            service sub-layer or aggregation type.";
        container forwarding-sub-layer {
            description
                "This service sub-layer is sent to the forwarding
                sub-layers of the lower layer for DetNet service
                forwarding or service-to-forwarding aggregation at
                the ingress node or relay node. When the operation
                type is service-initiation, The service sub-layer
                encapsulates the DetNet Control-Word and services
                label, which are for individual DetNet flow when the
                incoming type is app-flow and for aggregated DetNet
                flow when the incoming type is service or
                forwarding. The service sub-layer swaps the service
                label when the operation type is service-relay.";
            reference
                "RFC 8964 Section 4.2.1 and 4.2.2.";
            list service-outgoing {
                key "index";
                description
                    "List of the outgoing service
                    that separately for each node
                    where services will be eliminated.";
                leaf index {
```

```
        type uint8;
        description
            "This index allows a list of multiple outgoing
            forwarding sub-layers";
    }
    uses detnet-header;
    uses forwarding-sub-layer-group;
}
}
container service-sub-layer {
    description
        "This service sub-layer is sent to the service
        sub-layers of the lower layer for service-to-service
        aggregation at the ingress node or relay node. The
        service sub-layer encapsulates the DetNet
        Control-Word and S-label when the operation type is
        service-initiation, and swaps the S-label when the
        operation type is service-relay.";
    reference
        "RFC 8964 Section 4.2.1 and 4.2.2.";
    leaf aggregation-sub-layer {
        type service-sub-layer-ref;
        description
            "reference point of the service-sub-layer
            at which this service will be aggregated.";
    }
    container service-label {
        description
            "This is the MPLS service sub-layer label. This
            is optional and only used when the service
            sub-layer uses MPLS. It is an MPLS stack since
            more than a single label may be used.";
        uses rt-types:mpls-label-stack;
    }
}
}
container app-flow {
    description
        "This service sub-layer is sent to the app-flow of
        the upper layer for egress proxy at the egress node,
        and decapsulates the DetNet Control-Word and S-label
        for individual DetNet service. This outgoing type
        only can be chosen when the operation type is
        service-termination.";
    reference
        "RFC 8964 Section 4.2.1 and 4.2.2.";
    uses app-flows-group;
}
}
container service-disaggregation {
    description
        "This service sub-layer is sent to the service
        sub-layer of the upper layer for service-to-service
        disaggregation at the relay node or egress node, and
        decapsulates the DetNet Control-Word and A-label for
        aggregated DetNet service. This outgoing type only
        can be chosen when the operation type is
        service-termination.";
    reference
        "RFC 8964 Section 4.2.1 and 4.2.2.";
```

```

        uses service-sub-layer-group;
    }
    container forwarding-disaggregation {
        description
            "This service sub-layer is sent to the forwarding
            sub-layer of the upper layer for
            forwarding-to-service disaggregation at the relay
            node or egress node, and decapsulates the DetNet
            Control-Word and A-label for aggregated DetNet
            service. This outgoing type only can be chosen when
            the operation type is service-termination.";
        reference
            "RFC 8964 Section 4.2.1 and 4.2.2.";
        uses forwarding-sub-layer-group;
    }
}
}
}
}
container forwarding {
    description
        "The DetNet forwarding sub-layer configuration.";
    list sub-layer {
        key "name";
        description
            "The List is one or more DetNet Traffic types.";
        leaf name {
            type string;
            description
                "The name of the DetNet forwarding sub-layer.";
        }
        leaf traffic-profile {
            type traffic-profile-ref;
            description
                "The Traffic Profile for this group.";
        }
        leaf operation {
            type forwarding-operations;
            description
                "This is the forwarding operation types
                impose-and-forward, pop-and-forward,
                pop-impose-and-forward, forward, pop-and-lookup.";
        }
    }
    container incoming {
        description
            "The DetNet forwarding sub-layer incoming
            configuration.";
        choice incoming {
            description
                "Cases of incoming types.";
            container service-sub-layer {
                description
                    "This forwarding sub-layer is related to the service
                    sub-layers of the upper layer and provide DetNet
                    forwarding or service-to-forwarding aggregation at
                    the ingress node or relay node.";
                uses service-sub-layer-group;
            }
        }
    }
}

```

```
    container forwarding-aggregation {
      description
        "This forwarding sub-layer is related to the
        forwarding sub-layer of the upper layer and provide
        forwarding-to-forwarding aggregation at the ingress
        node or relay node or transit node.";
      uses forwarding-sub-layer-group;
    }
    container forwarding-id {
      description
        "This forwarding sub-layer is related to all of the
        lower layer and provide DetNet forwarding swap or
        termination at the transit node or relay node or
        egress node.";
      leaf interface {
        type if:interface-ref;
        description
          "This is the interface associated with the
          forwarding sub-layer.";
      }
      uses detnet-flow-spec;
    }
  }
}
container outgoing {
  description
    "The DetNet forwarding sub-layer outbound
    configuration.";
  choice outgoing {
    description
      "This is when a service connected directly to an
      interface with no forwarding sub-layer.";
    container
      interface {
        description
          "This forwarding sub-layer is sent to the interface
          for send to next-hop at the ingress node or relay
          node or transit node.";
        uses detnet-forwarding-next-hop-content;
      }
    container service-aggregation {
      description
        "This forwarding sub-layer is sent to the service
        sub-layers of the lower layer for
        forwarding-to-service aggregation at the ingress
        node or relay node.";
      leaf aggregation-sub-layer {
        type service-sub-layer-ref;
        description
          "This is a reference to the service sub-layer.";
      }
      container optional-forwarding-label {
        description
          "This is the optional forwarding label for service
          aggregation.";
        uses rt-types:mpls-label-stack;
      }
    }
  }
}
```



```

    container forwarding-sub-layer {
      description
        "This forwarding sub-layer is sent to the forwarding
          sub-layers of the lower layer for
            forwarding-to-forwarding aggregation at the ingress
              node or relay node or transit node.";
      leaf aggregation-sub-layer {
        type forwarding-sub-layer-ref;
        description
          "This is a reference to the forwarding sub-layer.";
      }
      container forwarding-label {
        description
          "This is the forwarding label for forwarding
            sub-layer aggregation.";
        uses rt-types:mpls-label-stack;
      }
    }
  container service-sub-layer {
    description
      "This forwarding sub-layer is sent to the service
        sub-layer of the upper layer and decapsulate the
          F-label for DetNet service or service-to-forwarding
            disaggregation at the relay node or egress node.
              This outgoing type only can be chosen when the
                operation type is pop-and-lookup.";
    uses service-sub-layer-group;
    reference
      "RFC 8964 Section 4.2.3";
  }
  container forwarding-disaggregation {
    description
      "This forwarding sub-layer is sent to the forwarding
        sub-layer of the upper layer and decapsulate the
          F-label for forwarding-to-forwarding disaggregation
            at the transit node or relay node or egress node.
              This outgoing type only can be chosen when the
                operation type is pop-and-lookup.";
    uses forwarding-sub-layer-group;
  }
}
}
}
}
}
}
}
<CODE ENDS>

```

9. IANA Considerations

This document registers a URI in the "IETF XML Registry" [RFC3688]. Following the format in [RFC3688], the following registration is requested to be made:

ID: yang:ietf-detnet
URI: urn:ietf:params:xml:ns:yang:ietf-detnet
Registrant Contact: The IESG.
XML: N/A, the requested URI is an XML namespace.

This document registers YANG modules in the "YANG Module Names" registry [[RFC6020](#)].

Name: ietf-detnet
Maintained by IANA: N
Namespace: urn:ietf:params:xml:ns:yang:ietf-detnet
Prefix: dnet
Reference: This RFC when published.

10. Security Considerations

Security considerations for DetNet are covered in the DetNet Architecture [[RFC8655](#)] and DetNet Security Considerations [[RFC9055](#)].

The YANG modules specified in this document define a schema for data that is designed to be accessed via network management protocols, such as NETCONF [[RFC6241](#)] or RESTCONF [[RFC8040](#)]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [[RFC6242](#)]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [[RFC8446](#)].

The Network Configuration Access Control Model (NACM) [[RFC8341](#)] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in the module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can break or incorrectly connect DetNet flows. Since this is a configured Data Plane any changes that are not coordinated with all devices along the path the whole DetNet module is considered vulnerable and should have authorized access only.

Similarly, the data nodes in these YANG modules may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or notification) to these data nodes. These are the subtrees and data node and their sensitivity/vulnerability:

/detnet/app-flows: This controls the application details so it could be considered sensitive.

/detnet/traffic-profile/member-app: This links traffic profiles to applications, o this also could be considered more sensitive. The traffic profiles linked to service sub-layer and forwarding sub-layer are less sensitive.

/detnet/service/sub-layer/incoming/app-flow: This links applications to services.

/detnet/service/sub-layer/outgoing/app-flow: This links applications to services.

11. Contributors

The editors of this document wish to thank and acknowledge the following people who contributed substantially to the content of this document and should be considered coauthors:

Mach(Guoyi) Chen

Huawei Technologies

Email: mach.chen@huawei.com

12. Acknowledgments

The editors of this document would like to thank Lou Berger, Tom Petch and Xufeng Lui for their detailed comments.

13. References

13.1. Normative References

- [RFC0791] Postel, J., "Internet Protocol", STD 5, RFC 791, DOI 10.17487/RFC0791, September 1981, <<https://www.rfc-editor.org/info/rfc791>>.
- [RFC4303] Kent, S., "IP Encapsulating Security Payload (ESP)", RFC 4303, DOI 10.17487/RFC4303, December 2005, <<https://www.rfc-editor.org/info/rfc4303>>.
- [RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <<https://www.rfc-editor.org/info/rfc6020>>.
- [RFC6991] Schoenwaelder, J., Ed., "Common YANG Data Types", RFC 6991, DOI 10.17487/RFC6991, July 2013, <<https://www.rfc-editor.org/info/rfc6991>>.
- [RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, DOI 10.17487/RFC7950, August 2016, <<https://www.rfc-editor.org/info/rfc7950>>.
- [RFC8200] Deering, S. and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification", STD 86, RFC 8200, DOI 10.17487/RFC8200, July 2017, <<https://www.rfc-editor.org/info/rfc8200>>.
- [RFC8294] Liu, X., Qu, Y., Lindem, A., Hopps, C., and L. Berger, "Common YANG Data Types for the Routing Area", RFC 8294, DOI 10.17487/RFC8294, December 2017, <<https://www.rfc-editor.org/info/rfc8294>>.
- [RFC8343] Bjorklund, M., "A YANG Data Model for Interface Management", RFC 8343, DOI 10.17487/RFC8343, March 2018, <<https://www.rfc-editor.org/info/rfc8343>>.

- [RFC8349] Lhotka, L., Lindem, A., and Y. Qu, "A YANG Data Model for Routing Management (NMDA Version)", RFC 8349, DOI 10.17487/RFC8349, March 2018, <<https://www.rfc-editor.org/info/rfc8349>>.
- [RFC8446] Rescorla, E., "The Transport Layer Security (TLS) Protocol Version 1.3", RFC 8446, DOI 10.17487/RFC8446, August 2018, <<https://www.rfc-editor.org/info/rfc8446>>.
- [RFC8519] Jethanandani, M., Agarwal, S., Huang, L., and D. Blair, "YANG Data Model for Network Access Control Lists (ACLs)", RFC 8519, DOI 10.17487/RFC8519, March 2019, <<https://www.rfc-editor.org/info/rfc8519>>.
- [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>>.
- [RFC8938] Varga, B., Ed., Farkas, J., Berger, L., Malis, A., and S. Bryant, "Deterministic Networking (DetNet) Data Plane Framework", RFC 8938, DOI 10.17487/RFC8938, November 2020, <<https://www.rfc-editor.org/info/rfc8938>>.
- [RFC8960] Saad, T., Raza, K., Gandhi, R., Liu, X., and V. Beeram, "A YANG Data Model for MPLS Base", RFC 8960, DOI 10.17487/RFC8960, December 2020, <<https://www.rfc-editor.org/info/rfc8960>>.
- [RFC8964] Varga, B., Ed., Farkas, J., Berger, L., Malis, A., Bryant, S., and J. Korhonen, "Deterministic Networking (DetNet) Data Plane: MPLS", RFC 8964, DOI 10.17487/RFC8964, January 2021, <<https://www.rfc-editor.org/info/rfc8964>>.
- [RFC9016] Varga, B., Farkas, J., Cummings, R., Jiang, Y., and D. Fedyk, "Flow and Service Information Model for Deterministic Networking (DetNet)", RFC 9016, DOI 10.17487/RFC9016, March 2021, <<https://www.rfc-editor.org/info/rfc9016>>.

13.2. Informative References

- [IEEE8021Q] IEEE, "IEEE Standard for Local and Metropolitan Area Networks--Bridges and Bridged Networks", DOI 10.1109/IEEESTD.2018.8403927, IEEE 802.1Q-2018, July 2018, <<https://ieeexplore.ieee.org/document/8403927>>.
- [IEEE8021QCX] IEEE, "IEEE Standard for Local and Metropolitan Area Networks--Bridges and Bridged Networks Amendment 33: YANG Data Model for Connectivity Fault Management", DOI 10.1109/IEEESTD.2020.9212765, IEEE 802.1Qcx-2020, October 2020, <<https://ieeexplore.ieee.org/document/9212765>>.
- [RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <<https://www.rfc-editor.org/info/rfc3688>>.
- [RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <<https://www.rfc-editor.org/info/rfc6241>>.

- [RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure Shell (SSH)", RFC 6242, DOI 10.17487/RFC6242, June 2011, <<https://www.rfc-editor.org/info/rfc6242>>.
- [RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <<https://www.rfc-editor.org/info/rfc8040>>.
- [RFC8340] Bjorklund, M. and L. Berger, Ed., "YANG Tree Diagrams", BCP 215, RFC 8340, DOI 10.17487/RFC8340, March 2018, <<https://www.rfc-editor.org/info/rfc8340>>.
- [RFC8341] Bierman, A. and M. Bjorklund, "Network Configuration Access Control Model", STD 91, RFC 8341, DOI 10.17487/RFC8341, March 2018, <<https://www.rfc-editor.org/info/rfc8341>>.
- [RFC9055] Grossman, E., Ed., Mizrahi, T., and A. Hacker, "Deterministic Networking (DetNet) Security Considerations", RFC 9055, DOI 10.17487/RFC9055, June 2021, <<https://www.rfc-editor.org/info/rfc9055>>.

Appendix A. DetNet Configuration YANG Tree

This is the full YANG tree as described in [RFC8340].

```

module: ietf-detnet
  +--rw detnet
    +--rw traffic-profile* [name]
      |   +--rw name string
      |   +--rw traffic-requirements
      |     |   +--rw min-bandwidth? uint64
      |     |   +--rw max-latency? uint32
      |     |   +--rw max-latency-variation? uint32
      |     |   +--rw max-loss? decimal64
      |     |   +--rw max-consecutive-loss-tolerance? uint32
      |     |   +--rw max-misordering? uint32
      |   +--rw traffic-spec
      |     |   +--rw interval? uint32
      |     |   +--rw max-pkts-per-interval? uint32
      |     |   +--rw max-payload-size? uint32
      |     |   +--rw min-payload-size? uint32
      |     |   +--rw min-pkts-per-interval? uint32
      |   +--ro member-app* app-flow-ref
      |   +--ro member-service* service-sub-layer-ref
      |   +--ro member-fwd-sublayer* forwarding-sub-layer-ref
    +--rw app-flows
      |   +--rw app-flow* [name]
      |     |   +--rw name string
      |     |   +--rw bidir-congruent? boolean
      |     |   +--ro outgoing-service? service-sub-layer-ref
      |     |   +--ro incoming-service? service-sub-layer-ref
      |     |   +--rw traffic-profile? traffic-profile-ref
      |     |   +--rw ingress
      |     |     |   +--ro app-flow-status? identityref
      |     |     |   +--rw interface? if:interface-ref
      |     |     |   +--rw (data-flow-type)?
      |     |     |     |   +--:(tsn-app-flow)
      |     |     |     |     |   +--rw tsn-app-flow
      |     |     |     |     |     |   +--rw source-mac-address?
      |     |     |     |     |     |     |   yang:mac-address
      |     |     |     |     |     |   +--rw destination-mac-address?
      |     |     |     |     |     |     |   yang:mac-address
      |     |     |     |     |     |   +--rw ethertype?
      |     |     |     |     |     |     |   ethertypes:ethertype
      |     |     |     |     |     |   +--rw vlan-id?
      |     |     |     |     |     |     |   dot1q-types:vlanid
      |     |     |     |     |     |   +--rw pcpc?
      |     |     |     |     |     |     |   dot1q-types:priority-type
      |     |     |     |   +--:(ip-app-flow)
      |     |     |     |     |   +--rw ip-app-flow
      |     |     |     |     |     |   +--rw src-ip-prefix? inet:ip-prefix
      |     |     |     |     |     |   +--rw dest-ip-prefix? inet:ip-prefix
      |     |     |     |     |     |   +--rw protocol-next-header? uint8
      |     |     |     |     |     |   +--rw dscp? inet:dscp
      |     |     |     |     |     |   +--rw flow-label?
      |     |     |     |     |     |     |   inet:ipv6-flow-label
      |     |     |     |     |   +--rw source-port
      |     |     |     |     |     |   +--rw (port-range-or-operator)?
      |     |     |     |     |     |     |   +--:(range)
      |     |     |     |     |     |     |     |   +--rw lower-port
      |     |     |     |     |     |     |     |     |   inet:port-number
      |     |     |     |     |     |     |   +--rw upper-port

```

```

|                               inet:port-number
|       +--:(operator)
|           +---rw operator?          operator
|           +---rw port                inet:port-number
+---rw destination-port
|   +---rw (port-range-or-operator)?
|       +--:(range)
|           | +---rw lower-port      inet:port-number
|           | |                     inet:port-number
|           | +---rw upper-port     inet:port-number
|           |                     inet:port-number
|       +--:(operator)
|           +---rw operator?          operator
|           +---rw port                inet:port-number
+---rw ipsec-spi?                    ipsec-spi
+--:(mpls-app-flow)
    +---rw mpls-app-flow
        +---rw (label-space)?
            +--:(context-label-space)
                +---rw mpls-label-stack
                    +---rw entry* [id]
                        +---rw id              uint8
                        +---rw label?
                            |               rt-types:mpls-label
                        +---rw ttl?             uint8
                        +---rw traffic-class?   uint8
            +--:(platform-label-space)
                +---rw label?
                    |               rt-types:mpls-label
+---rw egress
    +---rw (data-flow-type)?
        |   +--:(tsn-app-flow)
        |       +---rw tsn-app-flow
        |           +---rw source-mac-address? yang:mac-address
        |           +---rw destination-mac-address?
        |               |               yang:mac-address
        |           +---rw ethertype?         ethertypes:ethertype
        |           +---rw vlan-id?           dot1q-types:vlanid
        |           +---rw pcp?               dot1q-types:priority-type
    +--:(ip-app-flow)
        +---rw ip-app-flow
            +---rw src-ip-prefix?             inet:ip-prefix
            +---rw dest-ip-prefix?            inet:ip-prefix
            +---rw protocol-next-header?       uint8
            +---rw dscp?                       inet:dscp
            +---rw flow-label?                 inet:ipv6-flow-label
            +---rw source-port
                |   +---rw (port-range-or-operator)?
                |       +--:(range)
                |           | +---rw lower-port    inet:port-number
                |           | +---rw upper-port    inet:port-number
                |       +--:(operator)
                |           +---rw operator?        operator
                |           +---rw port              inet:port-number
            +---rw destination-port
                |   +---rw (port-range-or-operator)?
                |       +--:(range)
                |           | +---rw lower-port    inet:port-number

```

```

|         |         |         |         | +--rw upper-port      inet:port-number
|         |         |         |         | +--:(operator)
|         |         |         |         | +--rw operator?      operator
|         |         |         |         | +--rw port            inet:port-number
|         |         |         |         | +--rw ipsec-spi?       ipsec-spi
|         |         |         |         | +--:(mpls-app-flow)
|         |         |         |         | +--rw mpls-app-flow
|         |         |         |         | +--rw (label-space)?
|         |         |         |         | +--:(context-label-space)
|         |         |         |         | | +--rw mpls-label-stack
|         |         |         |         | | +--rw entry* [id]
|         |         |         |         | | | +--rw id                uint8
|         |         |         |         | | | +--rw label?          rt-types:mpls-label
|         |         |         |         | | | +--rw ttl?            uint8
|         |         |         |         | | | +--rw traffic-class?   uint8
|         |         |         |         | +--:(platform-label-space)
|         |         |         |         | +--rw label?              rt-types:mpls-label
+--rw (application-type)?
+--:(ethernet)
| +--rw ethernet
| +--rw interface?   if:interface-ref
+--:(ip-mpls)
+--rw ip-mpls
+--rw (next-hop-options)?
+--:(simple-next-hop)
| +--rw outgoing-interface?
| | if:interface-ref
| +--rw (flow-type)?
| +--:(ip)
| | +--rw next-hop-address?
| | | inet:ip-address-no-zone
| +--:(mpls)
| | +--rw mpls-label-stack
| | | +--rw entry* [id]
| | | | +--rw id                uint8
| | | | +--rw label?          rt-types:mpls-label
| | | | +--rw ttl?            uint8
| | | | +--rw traffic-class?   uint8
+--:(next-hop-list)
+--rw next-hop* [hop-index]
+--rw hop-index                uint8
+--rw outgoing-interface?
| if:interface-ref
+--rw (flow-type)?
+--:(ip)
| +--rw next-hop-address?
| | inet:ip-address-no-
| | zone
+--:(mpls)
| +--rw mpls-label-stack
| | +--rw entry* [id]
| | | +--rw id                uint8
| | | +--rw label?          rt-types:mpls-
| | | | label
| | | +--rw ttl?

```



```

|                                     |      uint8
|                                     +---rw traffic-class?
|                                     |      uint8
+---rw service
|   +---rw sub-layer* [name]
|       +---rw name                    string
|       +---rw service-rank?           uint8
|       +---rw traffic-profile?        traffic-profile-ref
|       +---rw service-protection
|           | +---rw protection?        service-protection
|           | +---rw sequence-number-length? sequence-number-field
+---rw operation?                      operation
+---rw incoming
|   +---rw (incoming)?
|       +---:(app-flow)
|           | +---rw app-flow
|           | +---rw flow*      app-flow-ref
+---:(service-aggregation)
|   +---rw service-aggregation
|       +---rw sub-layer*      service-sub-layer-ref
+---:(forwarding-aggregation)
|   +---rw forwarding-aggregation
|       +---rw sub-layer*      forwarding-sub-layer-ref
+---:(service-id)
|   +---rw service-id
|       +---rw (detnet-flow-type)?
|       +---:(ip-detnet-flow)
|           | +---rw src-ip-prefix?
|           | |      inet:ip-prefix
|           | +---rw dest-ip-prefix?
|           | |      inet:ip-prefix
|           | +---rw protocol-next-header? uint8
|           | +---rw dscp?                  inet:dscp
|           | +---rw flow-label?
|           | |      inet:ipv6-flow-label
|           | +---rw source-port
|           | |      +---rw (port-range-or-operator)?
|           | |      +---:(range)
|           | |          | +---rw lower-port
|           | |          | |      inet:port-number
|           | |          | +---rw upper-port
|           | |          | |      inet:port-number
|           | |          +---:(operator)
|           | |              +---rw operator?      operator
|           | |              +---rw port
|           | |                  inet:port-number
|           | +---rw destination-port
|           | |      +---rw (port-range-or-operator)?
|           | |      +---:(range)
|           | |          | +---rw lower-port
|           | |          | |      inet:port-number
|           | |          | +---rw upper-port
|           | |          | |      inet:port-number
|           | |          +---:(operator)
|           | |              +---rw operator?      operator
|           | |              +---rw port
|           | |                  inet:port-number
|           +---rw ipsec-spi?                  ipsec-spi

```

```

+---:(mpls-detnet-flow)
+---rw (label-space)?
+---:(context-label-space)
|   +---rw mpls-label-stack
|       +---rw entry* [id]
|           +---rw id                uint8
|           +---rw label?
|               |   rt-types:mpls-label
|           +---rw ttl?                uint8
|           +---rw traffic-class? uint8
+---:(platform-label-space)
|   +---rw label?
|       rt-types:mpls-label
+---rw outgoing
+---rw (outgoing)?
+---:(forwarding-sub-layer)
|   +---rw forwarding-sub-layer
|       +---rw service-outgoing* [index]
|           +---rw index                uint8
|       +---rw (header-type)?
|           +---:(mpls)
|           |   +---rw mpls-label-stack
|           |       +---rw entry* [id]
|           |           +---rw id                uint8
|           |           +---rw label?
|           |               |   rt-types:mpls-label
|           |           +---rw ttl?                uint8
|           |           +---rw traffic-class? uint8
|           +---:(ip)
|           |   +---rw src-ip-address?
|           |       |   inet:ip-address-no-zone
|           |   +---rw dest-ip-address?
|           |       |   inet:ip-address-no-zone
|           |   +---rw protocol-next-header? uint8
|           |   +---rw dscp?
|           |       |   inet:dscp
|           |   +---rw flow-label?
|           |       |   inet:ipv6-flow-label
|           |   +---rw source-port?
|           |       |   inet:port-number
|           |   +---rw destination-port?
|           |       |   inet:port-number
|           +---rw sub-layer*
|               forwarding-sub-layer-ref
+---:(service-sub-layer)
|   +---rw service-sub-layer
|       +---rw aggregation-sub-layer?
|           |   service-sub-layer-ref
|       +---rw service-label
|           +---rw mpls-label-stack
|               +---rw entry* [id]
|                   +---rw id                uint8
|                   +---rw label?
|                       |   rt-types:mpls-label
|                   +---rw ttl?                uint8
|                   +---rw traffic-class? uint8
+---:(app-flow)
|   +---rw app-flow

```

```

|         | +--rw flow*    app-flow-ref
|         | +---:(service-disaggregation)
|         | | +--rw service-disaggregation
|         | | +--rw sub-layer*    service-sub-layer-ref
|         | +---:(forwarding-disaggregation)
|         | | +--rw forwarding-disaggregation
|         | | +--rw sub-layer*    forwarding-sub-layer-ref
+--rw forwarding
+--rw sub-layer* [name]
+--rw name                string
+--rw traffic-profile?    traffic-profile-ref
+--rw operation?          forwarding-operations
+--rw incoming
| +--rw (incoming)?
| | +---:(service-sub-layer)
| | | +--rw service-sub-layer
| | | | +--rw sub-layer*    service-sub-layer-ref
| | | +---:(forwarding-aggregation)
| | | | +--rw forwarding-aggregation
| | | | +--rw sub-layer*    forwarding-sub-layer-ref
| | | +---:(forwarding-id)
| | | +--rw forwarding-id
| | | +--rw interface?
| | | | if:interface-ref
| | | +--rw (detnet-flow-type)?
| | | | +---:(ip-detnet-flow)
| | | | | +--rw src-ip-prefix?
| | | | | | inet:ip-prefix
| | | | | +--rw dest-ip-prefix?
| | | | | | inet:ip-prefix
| | | | | +--rw protocol-next-header?    uint8
| | | | | +--rw dscp?                    inet:dscp
| | | | | +--rw flow-label?
| | | | | | inet:ipv6-flow-label
| | | | +--rw source-port
| | | | | +--rw (port-range-or-operator)?
| | | | | | +---:(range)
| | | | | | | +--rw lower-port
| | | | | | | | inet:port-number
| | | | | | | +--rw upper-port
| | | | | | | | inet:port-number
| | | | | | +---:(operator)
| | | | | | +--rw operator?    operator
| | | | | | +--rw port
| | | | | | | inet:port-number
| | | | +--rw destination-port
| | | | | +--rw (port-range-or-operator)?
| | | | | | +---:(range)
| | | | | | | +--rw lower-port
| | | | | | | | inet:port-number
| | | | | | | +--rw upper-port
| | | | | | | | inet:port-number
| | | | | | +---:(operator)
| | | | | | +--rw operator?    operator
| | | | | | +--rw port
| | | | | | | inet:port-number
| | | | +--rw ipsec-spi?    ipsec-spi
| | | +---:(mpls-detnet-flow)

```

```

|               +---rw (label-space)?
|               +---:(context-label-space)
|               |   +---rw mpls-label-stack
|               |   |   +---rw entry* [id]
|               |   |   |   +---rw id                               uint8
|               |   |   |   +---rw label?
|               |   |   |   |   rt-types:mpls-label
|               |   |   |   +---rw ttl?                               uint8
|               |   |   |   +---rw traffic-class?   uint8
|               |   +---:(platform-label-space)
|               |   +---rw label?
|               |   |   rt-types:mpls-label
+---rw outgoing
+---rw (outgoing)?
+---:(interface)
|   +---rw interface
|   |   +---rw (next-hop-options)?
|   |   +---:(simple-next-hop)
|   |   |   +---rw outgoing-interface?
|   |   |   |   if:interface-ref
|   |   +---rw (flow-type)?
|   |   +---:(ip)
|   |   |   +---rw (operation-type)?
|   |   |   +---:(ip-forwarding)
|   |   |   |   +---rw next-hop-address?
|   |   |   |   |   inet:ip-address-no-zone
|   |   |   +---:(mpls-over-ip-encapsulation)
|   |   |   |   +---rw src-ip-address?
|   |   |   |   |   inet:ip-address-no-zone
|   |   |   |   +---rw dest-ip-address?
|   |   |   |   |   inet:ip-address-no-zone
|   |   |   |   +---rw protocol-next-header?
|   |   |   |   |   uint8
|   |   |   |   +---rw dscp?
|   |   |   |   |   inet:dscp
|   |   |   |   +---rw flow-label?
|   |   |   |   |   inet:ipv6-flow-label
|   |   |   |   +---rw source-port?
|   |   |   |   |   inet:port-number
|   |   |   |   +---rw destination-port?
|   |   |   |   |   inet:port-number
|   |   +---:(mpls)
|   |   |   +---rw mpls-label-stack
|   |   |   |   +---rw entry* [id]
|   |   |   |   |   +---rw id                               uint8
|   |   |   |   |   +---rw label?
|   |   |   |   |   |   rt-types:mpls-label
|   |   |   |   |   +---rw ttl?                               uint8
|   |   |   |   |   +---rw traffic-class?   uint8
|   |   +---:(next-hop-list)
|   |   |   +---rw next-hop* [hop-index]
|   |   |   |   +---rw hop-index
|   |   |   |   |   uint8
|   |   |   |   +---rw outgoing-interface?
|   |   |   |   |   if:interface-ref
|   |   |   +---rw (flow-type)?
|   |   |   +---:(ip)

```

```

+---rw (operation-type)?
+---:(ip-forwarding)
|   +---rw next-hop-address?
|       inet:ip-address-no-
|       zone
+---:(mpls-over-ip-encapsulation)
+---rw src-ip-address?
|   inet:ip-address-no-
|   zone
+---rw dest-ip-address?
|   inet:ip-address-no-
|   zone
+---rw protocol-next-header?
|   uint8
+---rw dscp?
|   inet:dscp
+---rw flow-label?
|   inet:ipv6-flow-label
+---rw source-port?
|   inet:port-number
+---rw destination-port?
|   inet:port-number
+---:(mpls)
+---rw mpls-label-stack
+---rw entry* [id]
+---rw id
|   uint8
+---rw label?
|   rt-types:mpls-label
+---rw ttl?
|   uint8
+---rw traffic-class?
|   uint8
+---:(service-aggregation)
+---rw service-aggregation
+---rw aggregation-sub-layer?
|   service-sub-layer-ref
+---rw optional-forwarding-label
+---rw mpls-label-stack
+---rw entry* [id]
+---rw id
|   uint8
+---rw label?
|   rt-types:mpls-label
+---rw ttl?
|   uint8
+---rw traffic-class?
|   uint8
+---:(forwarding-sub-layer)
+---rw forwarding-sub-layer
+---rw aggregation-sub-layer?
|   forwarding-sub-layer-ref
+---rw forwarding-label
+---rw mpls-label-stack
+---rw entry* [id]
+---rw id
|   uint8
+---rw label?

```

```

|           |           rt-types:mpls-label
|           +---rw ttl?           uint8
|           +---rw traffic-class?  uint8
+---:(service-sub-layer)
|   +---rw service-sub-layer
|       +---rw sub-layer*   service-sub-layer-ref
+---:(forwarding-disaggregation)
|   +---rw forwarding-disaggregation
|       +---rw sub-layer*   forwarding-sub-layer-ref

```

Appendix B. Examples

The following examples are provided. These examples are tested with Yanglint and use operational output to exercise both config true and config false objects. Note that IPv4 and IPv6 addresses are supported but for clarity in the examples and diagrams IPv4 has been used in most examples. The IP types are imported from [\[RFC6991\]](#) and these support both IPv4 and IPv6.

The following conventions are used in the diagrams.

- Replication and Elimination points are shown as an R in and E in circles respectively.
- Packet Headers including DetNet aggregation label or A-label, Service label or S-label and Forwarding label or F-label are illustrated at each hop as defined in [\[RFC8964\]](#).
- Aggregation/Disaggregation nodes are indicated by dashed line boxes.
- Since the model augments IETF interfaces, minimal interface YANG data is provided to validate the interface data as well. This shows up as a named value such as "eth0" etc. that is referenced by the configuration.

The following are examples of aggregation and disaggregation at various points in Detnet. Figures are provided in the PDF and HTML version of this document.

B.1. Example A-1 JSON Configuration/Operational

This illustrates that the multiple App flows with the same source, the same destination, and the same traffic specification are aggregated in a single DetNet flow service sub-layer. Ingress node 1 aggregates App flows 0 and 1 into a service sub-layer of DetNet flow 1. Two ways of illustrating this follow, then the JSON operational data model corresponding to the diagrams follows. This example uses IPv6 address format.

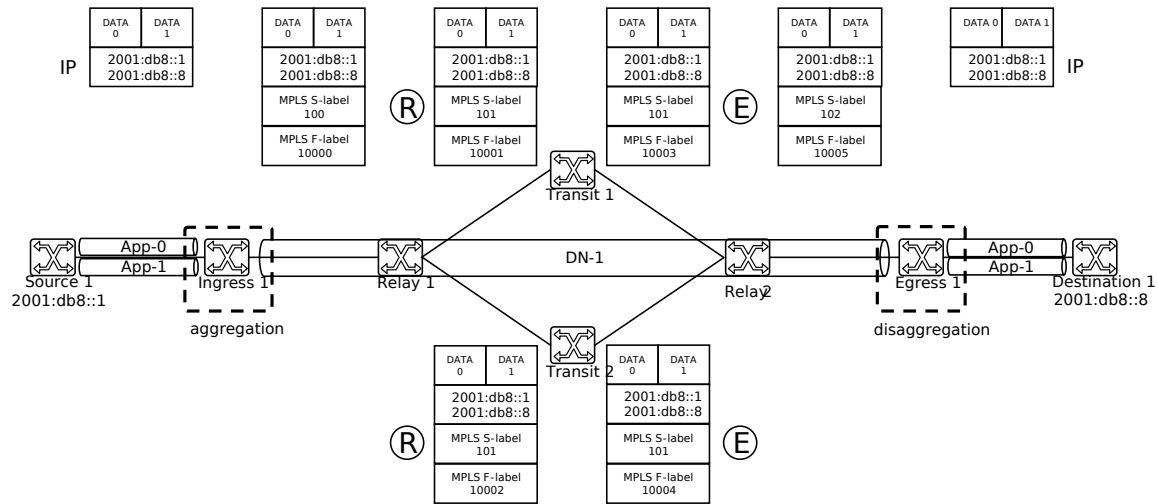


Figure 2: Case A-1 Application Aggregation

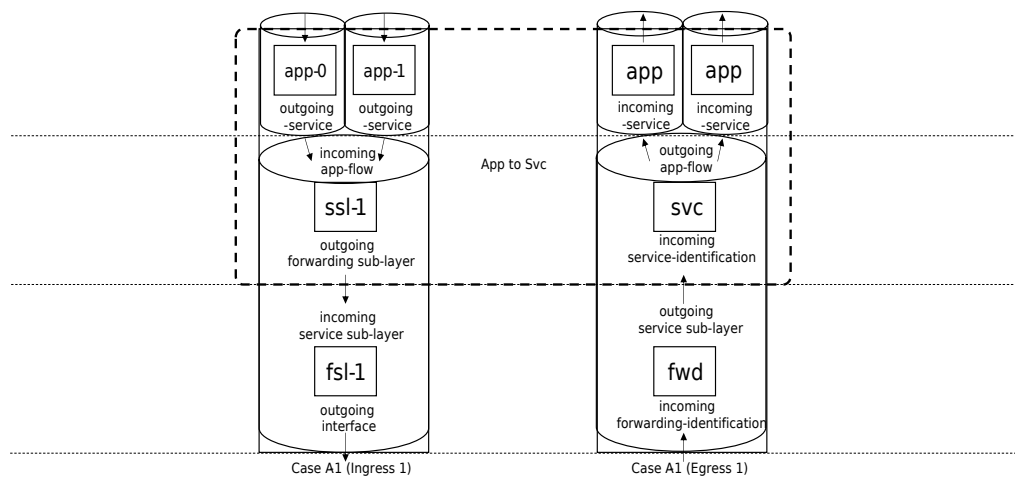


Figure 3: Case A-1 Application Aggregation Flow Stack Detail

The following figure contains the operational JSON configuration for the ingress aggregation node illustrated in Figure 2 and Figure 3. App-0 and app-1 are aggregated into Service Sub-layer ssl-1.

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 20000000,
          "max-loss": "0.000001",
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "traffic-spec": {
          "interval": 5,
          "max-pkts-per-interval": 10,
          "max-payload-size": 1500,
          "min-payload-size": 100,
          "min-pkts-per-interval": 1
        },
        "member-app": [
          "app-0",
          "app-1"
        ]
      },
      {
        "name": "pf-2",
        "traffic-requirements": {
          "min-bandwidth": "200000000",
          "max-latency": 100000000,
          "max-latency-variation": 20000000,
          "max-loss": "0.000001",
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 5,
          "max-pkts-per-interval": 20,
          "max-payload-size": 1500
        },
        "member-fwd-sublayer": [
          "fsl-1"
        ]
      }
    ],
    "app-flows": {
      "app-flow": [
        {
          "name": "app-0",
          "bidir-congruent": false,

```



```
    "outgoing-service": "ssl-1",
    "traffic-profile": "pf-1",
    "ingress": {
      "app-flow-status": "ietf-detnet:ready",
      "interface": "eth0",
      "ip-app-flow": {
        "src-ip-prefix": "2001:db8::1/128",
        "dest-ip-prefix": "2001:db8::8/128",
        "dscp": 6
      }
    }
  },
  {
    "name": "app-1",
    "bidir-congruent": false,
    "outgoing-service": "ssl-1",
    "traffic-profile": "pf-1",
    "ingress": {
      "app-flow-status": "ietf-detnet:ready",
      "interface": "eth0",
      "ip-app-flow": {
        "src-ip-prefix": "2001:db8::1/128",
        "dest-ip-prefix": "2001:db8::8/128",
        "dscp": 7
      }
    }
  }
]
},
"service": {
  "sub-layer": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-2",
      "service-protection": {
        "protection": "none",
        "sequence-number-length": "long-sn"
      },
      "operation": "initiation",
      "incoming": {
        "app-flow": {
          "flow": [
            "app-0",
            "app-1"
          ]
        }
      }
    },
    {
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 100
                  }
                ]
              }
            }
          ]
        }
      }
    }
  ]
}
```

```
    }
  ]
},
"sub-layer": [
  "fsl-1"
]
}
]
}
}
}
}
},
"forwarding": {
  "sub-layer": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-3",
      "operation": "impose-and-forward",
      "incoming": {
        "service-sub-layer": {
          "sub-layer": [
            "ssl-1"
          ]
        }
      },
      "outgoing": {
        "interface": {
          "outgoing-interface": "eth2",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10000
              }
            ]
          }
        }
      }
    }
  ]
}
}
}
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
```

```

    "discontinuity-time": "2020-12-18T18:59:00-05:00"
  }
}
]
}
}

```

Figure 4: Example A-1 DetNet configuration Application Aggregation

B.2. Example B-1 XML Config: Aggregation using a Forwarding Sub-layer

This illustrates that service sub-layers of DetNet flows 1 and 2 are aggregated into a single forwarding sub-layer. For the same destination multiple DetNet flows use a single forwarding path and service protection is performed by the corresponding service sub-layer of each flow. A diagram illustrating this case is shown and then the corresponding XML operational data for node Ingress 1 follows.

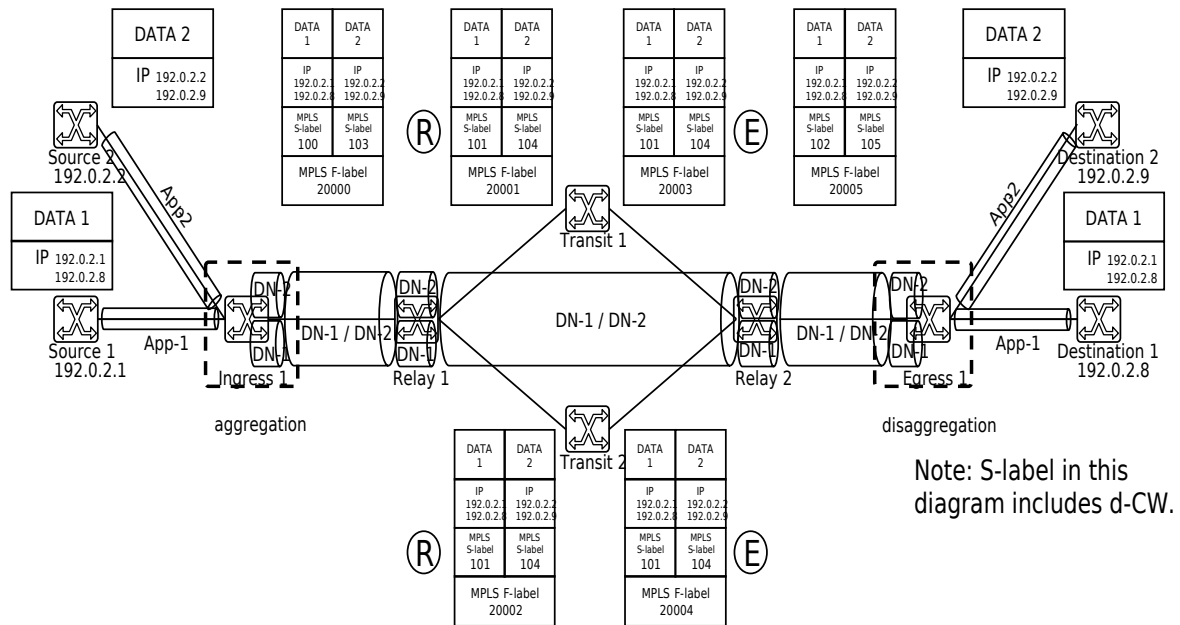


Figure 5: Case B-1 Example Config: Aggregation using a Forwarding Sub-layer

The following Figure 6 contains the operational XML configuration for the ingress aggregation node illustrated in Figure 5. In this example app-0 and app-1 are in separate service sub-layers with MPLS labels and the aggregation happens at the forwarding sub-layer afl-1 using MPLS labels.

```
<interfaces
  xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
  xmlns:ia="urn:ietf:params:xml:ns:yang:iana-if-type">
  <interface>
    <name>eth0</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>
        >2020-12-18T23:59:00Z</discontinuity-time>
      </statistics>
    </interface>
  <interface>
    <name>eth1</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>
        >2020-12-18T23:59:00Z</discontinuity-time>
      </statistics>
    </interface>
  <interface>
    <name>eth2</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>
        >2020-12-18T23:59:00Z</discontinuity-time>
      </statistics>
    </interface>
  </interfaces>
<detnet
  xmlns="urn:ietf:params:xml:ns:yang:ietf-detnet">
  <app-flows>
    <app-flow>
      <name>app-1</name>
      <bidir-congruent>false</bidir-congruent>
      <outgoing-service>ssl-1</outgoing-service>
      <traffic-profile>1</traffic-profile>
      <ingress>
        <app-flow-status>ready</app-flow-status>
        <interface>eth0</interface>
        <ip-app-flow>
          <src-ip-prefix>192.0.2.1/32</src-ip-prefix>
          <dest-ip-prefix>192.0.2.8/32</dest-ip-prefix>
          <dscp>6</dscp>
        </ip-app-flow>
      </ingress>
    </app-flow>
    <app-flow>
      <name>app-2</name>
      <bidir-congruent>false</bidir-congruent>
      <outgoing-service>ssl-2</outgoing-service>
      <traffic-profile>1</traffic-profile>
      <ingress>
        <app-flow-status>ready</app-flow-status>
```

```
<interface>eth1</interface>
  <ip-app-flow>
    <src-ip-prefix>192.0.2.2/32</src-ip-prefix>
    <dest-ip-prefix>192.0.2.9/32</dest-ip-prefix>
    <dscp>7</dscp>
  </ip-app-flow>
</ingress>
</app-flow>
</app-flows>
<traffic-profile>
  <name>1</name>
  <traffic-requirements>
    <min-bandwidth>100000000</min-bandwidth>
    <max-latency>100000000</max-latency>
    <max-latency-variation>20000000</max-latency-variation>
    <max-loss>0.0000001</max-loss>
    <max-consecutive-loss-tolerance>
      >5</max-consecutive-loss-tolerance>
    <max-misordering>0</max-misordering>
  </traffic-requirements>
  <traffic-spec>
    <interval>5</interval>
    <max-pkts-per-interval>10</max-pkts-per-interval>
    <max-payload-size>1500</max-payload-size>
  </traffic-spec>
  <member-app>app-1</member-app>
  <member-app>app-2</member-app>
</traffic-profile>
<traffic-profile>
  <name>2</name>
  <traffic-requirements>
    <min-bandwidth>100000000</min-bandwidth>
    <max-latency>100000000</max-latency>
    <max-latency-variation>20000000</max-latency-variation>
    <max-loss>0.0000001</max-loss>
    <max-consecutive-loss-tolerance>
      >5</max-consecutive-loss-tolerance>
    <max-misordering>0</max-misordering>
  </traffic-requirements>
  <member-service>ssl-1</member-service>
  <member-service>ssl-2</member-service>
</traffic-profile>
<traffic-profile>
  <name>3</name>
  <traffic-spec>
    <interval>5</interval>
    <max-pkts-per-interval>20</max-pkts-per-interval>
    <max-payload-size>1500</max-payload-size>
  </traffic-spec>
  <member-fwd-sublayer>afl-1</member-fwd-sublayer>
</traffic-profile>
<service>
  <sub-layer>
    <name>ssl-1</name>
    <service-rank>10</service-rank>
    <traffic-profile>2</traffic-profile>
    <operation>initiation</operation>
    <service-protection>
```

```
    <protection>none</protection>
    <sequence-number-length>long-sn</sequence-number-length>
  </service-protection>
</incoming>
  <app-flow>
    <flow>app-1</flow>
  </app-flow>
</incoming>
<outgoing>
  <forwarding-sub-layer>
    <service-outgoing>
      <index>0</index>
      <mpls-label-stack>
        <entry>
          <id>0</id>
          <label>100</label>
        </entry>
      </mpls-label-stack>
      <sub-layer>afl-1</sub-layer>
    </service-outgoing>
  </forwarding-sub-layer>
</outgoing>
</sub-layer>
<sub-layer>
  <name>ssl-2</name>
  <service-rank>10</service-rank>
  <traffic-profile>2</traffic-profile>
  <operation>initiation</operation>
  <service-protection>
    <protection>none</protection>
    <sequence-number-length>long-sn</sequence-number-length>
  </service-protection>
</incoming>
  <app-flow>
    <flow>app-2</flow>
  </app-flow>
</incoming>
<outgoing>
  <forwarding-sub-layer>
    <service-outgoing>
      <index>0</index>
      <mpls-label-stack>
        <entry>
          <id>0</id>
          <label>103</label>
        </entry>
      </mpls-label-stack>
      <sub-layer>afl-1</sub-layer>
    </service-outgoing>
  </forwarding-sub-layer>
</outgoing>
</sub-layer>
</service>
<forwarding>
  <sub-layer>
    <name>afl-1</name>
    <traffic-profile>3</traffic-profile>
    <operation>impose-and-forward</operation>
```

```
<incoming>
  <service-sub-layer>
    <sub-layer>ssl-1</sub-layer>
    <sub-layer>ssl-2</sub-layer>
  </service-sub-layer>
</incoming>
<outgoing>
  <interface>
    <outgoing-interface>eth2</outgoing-interface>
    <mpls-label-stack>
      <entry>
        <id>0</id>
        <label>10000</label>
      </entry>
    </mpls-label-stack>
  </interface>
</outgoing>
</sub-layer>
</forwarding>
</detnet>
```

Figure 6: Example B-1 DetNet configuration Forwarding Layer Aggregation

B.3. Example B-2 JSON Service Aggregation Configuration

Figure 7 illustrates that DetNet flows 1 and 2 service sub-layers are aggregated into a service sub-layer of an aggregated flow. Multiple DetNet flows with the same requirements for the same destination are aggregated into a single aggregated DetNet flow, and service protection and resource allocation are performed by aggregated DetNet flow service sub-layer and forwarding sub-layer. A diagram illustrating this case is shown and then the corresponding JSON operational data for node Ingress 1 follows.

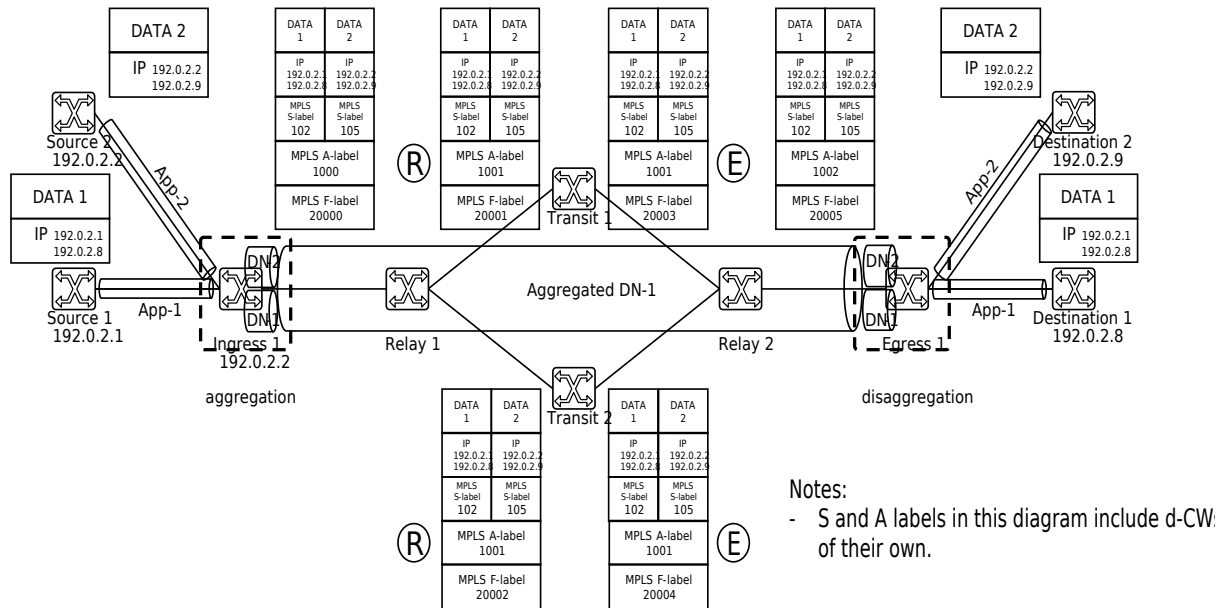


Figure 7: Case B-2 Example Service Aggregation

The following Figure 8 contains the operational JSON configuration for the ingress aggregation node illustrated in Figure 7. In this example, service sub-layer ssl-1 for DetNet flow DN1 and ssl-2 for flow DN2 aggregate at service sub-layer Detet flow asl-1. In this example an aggregation service sub-layer asl-1 is created to aggregated ssl-1 and ssl2 and that label is encapsulated in a separate forwarding sub-layer afl-1 with MPLS labels.


```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 20000000,
          "max-loss": 0.000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 10,
          "max-payload-size": 1500
        },
        "member-app": [
          "app-1",
          "app-2"
        ]
      },
      {
        "name": "2",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 20000000,
          "max-loss": 0.000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "3",
        "traffic-requirements": {
          "min-bandwidth": "200000000",
          "max-latency": 100000000,
          "max-latency-variation": 20000000,
          "max-loss": 0.000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "asl-1"
        ]
      },
      {
        "name": "4",
        "traffic-spec": {
          "interval": 125,
```

```
        "max-pkts-per-interval": 20,
        "max-payload-size": 1500
      },
      "member-fwd-sublayer": [
        "afl-1"
      ]
    }
  ],
  "app-flows": {
    "app-flow": [
      {
        "name": "app-1",
        "bidir-congruent": false,
        "outgoing-service": "ssl-1",
        "traffic-profile": "1",
        "ingress": {
          "app-flow-status": "ietf-detnet:ready",
          "interface": "eth0",
          "ip-app-flow": {
            "src-ip-prefix": "192.0.2.1/32",
            "dest-ip-prefix": "192.0.2.8/32",
            "dscp": 6
          }
        }
      },
      {
        "name": "app-2",
        "bidir-congruent": false,
        "outgoing-service": "ssl-2",
        "traffic-profile": "1",
        "ingress": {
          "app-flow-status": "ietf-detnet:ready",
          "interface": "eth0",
          "ip-app-flow": {
            "src-ip-prefix": "192.0.2.2/32",
            "dest-ip-prefix": "192.0.2.9/32",
            "dscp": 7
          }
        }
      }
    ]
  },
  "service": {
    "sub-layer": [
      {
        "name": "ssl-1",
        "service-rank": 10,
        "traffic-profile": "2",
        "service-protection": {
          "protection": "none",
          "sequence-number-length": "long-sn"
        },
        "operation": "initiation",
        "incoming": {
          "app-flow": {
            "flow": [
              "app-1"
            ]
          }
        }
      }
    ]
  }
}
```

```
    }
  },
  "outgoing": {
    "service-sub-layer": {
      "aggregation-sub-layer": "asl-1",
      "service-label": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 102
            }
          ]
        }
      }
    }
  },
  },
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "2",
    "service-protection": {
      "protection": "none",
      "sequence-number-length": "long-sn"
    },
    "operation": "initiation",
    "incoming": {
      "app-flow": {
        "flow": [
          "app-2"
        ]
      }
    },
    "outgoing": {
      "service-sub-layer": {
        "aggregation-sub-layer": "asl-1",
        "service-label": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 105
              }
            ]
          }
        }
      }
    }
  },
  },
  {
    "name": "asl-1",
    "service-rank": 10,
    "traffic-profile": "3",
    "service-protection": {
      "protection": "none",
      "sequence-number-length": "long-sn"
    },
  },
}
```

```
    "operation": "initiation",
    "incoming": {
      "service-aggregation": {
        "sub-layer": [
          "ssl-1",
          "ssl-2"
        ]
      }
    },
    "outgoing": {
      "forwarding-sub-layer": {
        "service-outgoing": [
          {
            "index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 1000
                }
              ]
            }
          },
          {
            "sub-layer": [
              "afl-1"
            ]
          }
        ]
      }
    }
  ],
  "forwarding": {
    "sub-layer": [
      {
        "name": "afl-1",
        "traffic-profile": "4",
        "operation": "impose-and-forward",
        "incoming": {
          "service-sub-layer": {
            "sub-layer": [
              "asl-1"
            ]
          }
        },
        "outgoing": {
          "interface": {
            "outgoing-interface": "eth2",
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 20000
                }
              ]
            }
          }
        }
      }
    ]
  }
}
```

```
    }  
  ]  
}  
},  
"ietf-interfaces:interfaces": {  
  "interface": [  
    {  
      "name": "eth0",  
      "type": "iana-if-type:ethernetCsmacd",  
      "oper-status": "up",  
      "statistics": {  
        "discontinuity-time": "2020-10-02T19:59:00-04:00"  
      }  
    },  
    {  
      "name": "eth2",  
      "type": "iana-if-type:ethernetCsmacd",  
      "oper-status": "up",  
      "statistics": {  
        "discontinuity-time": "2020-10-02T19:59:00-04:00"  
      }  
    }  
  ]  
}  
}
```

Figure 8: Example B-2 DetNet Service Aggregation

B.4. Example C-1 JSON Relay Aggregation/Disaggregation Configuration

Figure 9 illustrates the relay node's forwarding sub-layer flows 1 and 2 are aggregated into a single forwarding sub-layer. Service protection and resource allocation are performed by the corresponding service sub-layer and forwarding sub-layer of each flow. A diagram illustrating both aggregation and disaggregation is shown and then the corresponding JSON operational data follows.

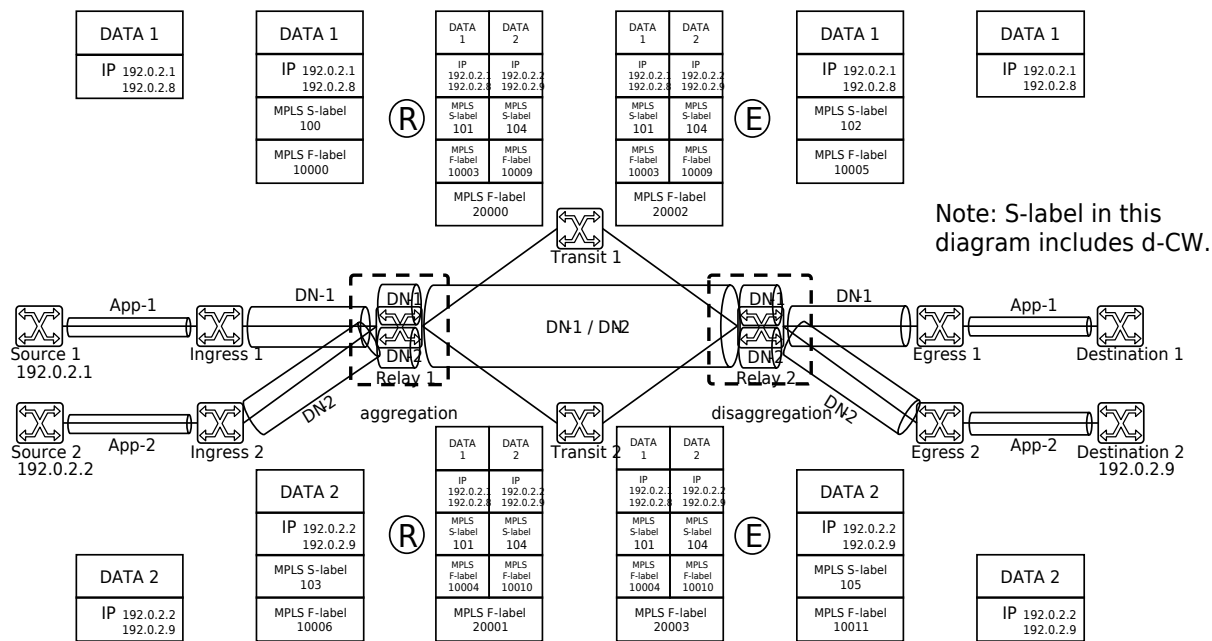


Figure 9: Case C-1 Example Service Aggregation/Disaggregation

The following Figure 10 contains the operational JSON configuration for the ingress aggregation node illustrated in Figure 9. In this example a relay performing aggregation at the forwarding sub-layer is illustrated. Two DetNet flows DN1 and DN2 are replicated at each service sub-layer. The two forwarding sub-layers for the upside path are aggregated at the forwarding sub-layer with label 20000 and the two forwarding sub-layers for the downside path are aggregated at the forwarding sub-layer with label 20001. The Figure 11 contains the operational JSON configuration for the egress disaggregation node illustrated in Figure 9.

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "afl-1",
          "afl-2"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2",
          "fsl-3",
          "fsl-4",
          "fsl-5",
          "fsl-6"
        ]
      }
    ],
    "service": {
      "sub-layer": [
        {
          "name": "ssl-1",
          "service-rank": 10,
          "traffic-profile": "pf-1",
          "service-protection": {
            "protection": "replication",
            "sequence-number-length": "long-sn"
          }
        }
      ]
    }
  }
}
```

```
    },
    "operation": "relay",
    "incoming": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 100
            }
          ]
        }
      }
    },
    "outgoing": {
      "forwarding-sub-layer": {
        "service-outgoing": [
          {
            "index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 101
                }
              ]
            },
            "sub-layer": [
              "fsl-2",
              "fsl-3"
            ]
          }
        ]
      }
    },
    {
      "name": "ssl-2",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "protection": "replication",
        "sequence-number-length": "long-sn"
      },
      "operation": "relay",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 103
              }
            ]
          }
        }
      },
      "outgoing": {
```



```

        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 104
                  }
                ]
              },
              "sub-layer": [
                "fsl-5",
                "fsl-6"
              ]
            }
          ]
        },
      ],
    },
    "forwarding": {
      "sub-layer": [
        {
          "name": "fsl-1",
          "traffic-profile": "pf-3",
          "operation": "pop-and-lookup",
          "incoming": {
            "forwarding-id": {
              "interface": "eth0",
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 10000
                  }
                ]
              }
            }
          },
          "outgoing": {
            "service-sub-layer": {
              "sub-layer": [
                "ssl-1"
              ]
            }
          }
        },
        {
          "name": "fsl-2",
          "traffic-profile": "pf-3",
          "operation": "impose-and-forward",
          "incoming": {
            "service-sub-layer": {
              "sub-layer": [
                "ssl-1"
              ]
            }
          }
        }
      ]
    }
  }

```

```
    ]
  }
},
"outgoing": {
  "forwarding-sub-layer": {
    "aggregation-sub-layer": "af1-1",
    "forwarding-label": {
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10003
          }
        ]
      }
    }
  }
},
{
  "name": "fsl-3",
  "traffic-profile": "pf-3",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-1"
      ]
    }
  },
  "outgoing": {
    "forwarding-sub-layer": {
      "aggregation-sub-layer": "af1-2",
      "forwarding-label": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10004
            }
          ]
        }
      }
    }
  }
},
{
  "name": "fsl-4",
  "traffic-profile": "pf-3",
  "operation": "pop-and-lookup",
  "incoming": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10006
          }
        ]
      }
    }
  }
}
```

```

    }
  ]
}
}
},
"outgoing": {
  "service-sub-layer": {
    "sub-layer": [
      "ssl-2"
    ]
  }
}
},
{
  "name": "fsl-5",
  "traffic-profile": "pf-3",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-2"
      ]
    }
  },
  "outgoing": {
    "forwarding-sub-layer": {
      "aggregation-sub-layer": "af1-1",
      "forwarding-label": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10009
            }
          ]
        }
      }
    }
  }
},
{
  "name": "fsl-6",
  "traffic-profile": "pf-3",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-2"
      ]
    }
  },
  "outgoing": {
    "forwarding-sub-layer": {
      "aggregation-sub-layer": "af1-2",
      "forwarding-label": {
        "mpls-label-stack": {
          "entry": [
            {

```

```
        "id": 0,
        "label": 10010
      }
    ]
  }
}
},
{
  "name": "af1-1",
  "traffic-profile": "pf-2",
  "operation": "impose-and-forward",
  "incoming": {
    "forwarding-aggregation": {
      "sub-layer": [
        "fsl-2",
        "fsl-5"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth2",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 20000
          }
        ]
      }
    }
  }
},
{
  "name": "af1-2",
  "traffic-profile": "pf-2",
  "operation": "impose-and-forward",
  "incoming": {
    "forwarding-aggregation": {
      "sub-layer": [
        "fsl-3",
        "fsl-6"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth3",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 20001
          }
        ]
      }
    }
  }
}
```

```
    }
  }
]
}
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
}
```

Figure 10: Example C-1 DetNet Relay Service Aggregation

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "afl-1",
          "afl-2"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2",
          "fsl-3",
          "fsl-4",
          "fsl-5",
          "fsl-6"
        ]
      }
    ],
    "service": {
      "sub-layer": [
        {
          "name": "ssl-1",
          "service-rank": 10,
          "traffic-profile": "pf-1",
          "service-protection": {
            "protection": "elimination",
            "sequence-number-length": "long-sn"
          }
        }
      ]
    }
  }
}
```

```
    },
    "operation": "relay",
    "incoming": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 101
            }
          ]
        }
      }
    },
    "outgoing": {
      "forwarding-sub-layer": {
        "service-outgoing": [
          {
            "index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 102
                }
              ]
            },
            "sub-layer": [
              "fsl-3"
            ]
          }
        ]
      }
    },
    {
      "name": "ssl-2",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "protection": "elimination",
        "sequence-number-length": "long-sn"
      },
      "operation": "relay",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 104
              }
            ]
          }
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
```

```
        "service-outgoing": [
          {
            "index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 105
                }
              ]
            },
            "sub-layer": [
              "fsl-6"
            ]
          }
        ]
      },
      "forwarding": {
        "sub-layer": [
          {
            "name": "afl-1",
            "traffic-profile": "pf-2",
            "operation": "pop-and-lookup",
            "incoming": {
              "forwarding-id": {
                "interface": "eth0",
                "mpls-label-stack": {
                  "entry": [
                    {
                      "id": 0,
                      "label": 20002
                    }
                  ]
                }
              }
            },
            "outgoing": {
              "forwarding-disaggregation": {
                "sub-layer": [
                  "fsl-1",
                  "fsl-4"
                ]
              }
            }
          }
        ],
        {
          "name": "afl-2",
          "traffic-profile": "pf-2",
          "operation": "pop-and-lookup",
          "incoming": {
            "forwarding-id": {
              "interface": "eth1",
              "mpls-label-stack": {
                "entry": [
```



```
        {
          "id": 0,
          "label": 20003
        }
      ]
    }
  },
  "outgoing": {
    "forwarding-disaggregation": {
      "sub-layer": [
        "fsl-2",
        "fsl-5"
      ]
    }
  }
},
{
  "name": "fsl-1",
  "traffic-profile": "pf-3",
  "operation": "pop-and-lookup",
  "incoming": {
    "forwarding-id": {
      "interface": "eth0",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10003
          }
        ]
      }
    }
  },
  "outgoing": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-1"
      ]
    }
  }
},
{
  "name": "fsl-2",
  "traffic-profile": "pf-3",
  "operation": "pop-and-lookup",
  "incoming": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10004
          }
        ]
      }
    }
  }
}
```

```
    },
    "outgoing": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-1"
        ]
      }
    }
  },
  {
    "name": "fsl-3",
    "traffic-profile": "pf-3",
    "operation": "impose-and-forward",
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-1"
        ]
      }
    },
    "outgoing": {
      "interface": {
        "outgoing-interface": "eth2",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10005
            }
          ]
        }
      }
    }
  },
  {
    "name": "fsl-4",
    "traffic-profile": "pf-3",
    "operation": "pop-and-lookup",
    "incoming": {
      "forwarding-id": {
        "interface": "eth0",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10009
            }
          ]
        }
      }
    },
    "outgoing": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-2"
        ]
      }
    }
  }
}
```

```
    },
    {
      "name": "fsl-5",
      "traffic-profile": "pf-3",
      "operation": "pop-and-lookup",
      "incoming": {
        "forwarding-id": {
          "interface": "eth1",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10010
              }
            ]
          }
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "ssl-2"
          ]
        }
      }
    },
  ],
  {
    "name": "fsl-6",
    "traffic-profile": "pf-3",
    "operation": "impose-and-forward",
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-2"
        ]
      }
    },
    "outgoing": {
      "interface": {
        "outgoing-interface": "eth3",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10011
            }
          ]
        }
      }
    }
  }
],
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
```

```

    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  },
  {
    "name": "eth1",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  },
  {
    "name": "eth2",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  },
  {
    "name": "eth3",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  }
]
}

```

Figure 11: Example C-1 DetNet Relay Service Disaggregation

B.5. Example C-2 JSON Relay Aggregation/Disaggregation Service Sub-Layer

[Figure 12](#) This illustrates that at the relay node service sub-layers flows 1 and 2 are aggregated into a single forwarding sub-layer. Service protection is performed by the corresponding service sub-layer of each flow and resource allocation is performed by aggregated forwarding sub-layer for all aggregated flows. A diagram illustrating both aggregation and disaggregation is shown and then the corresponding JSON operational data follows.

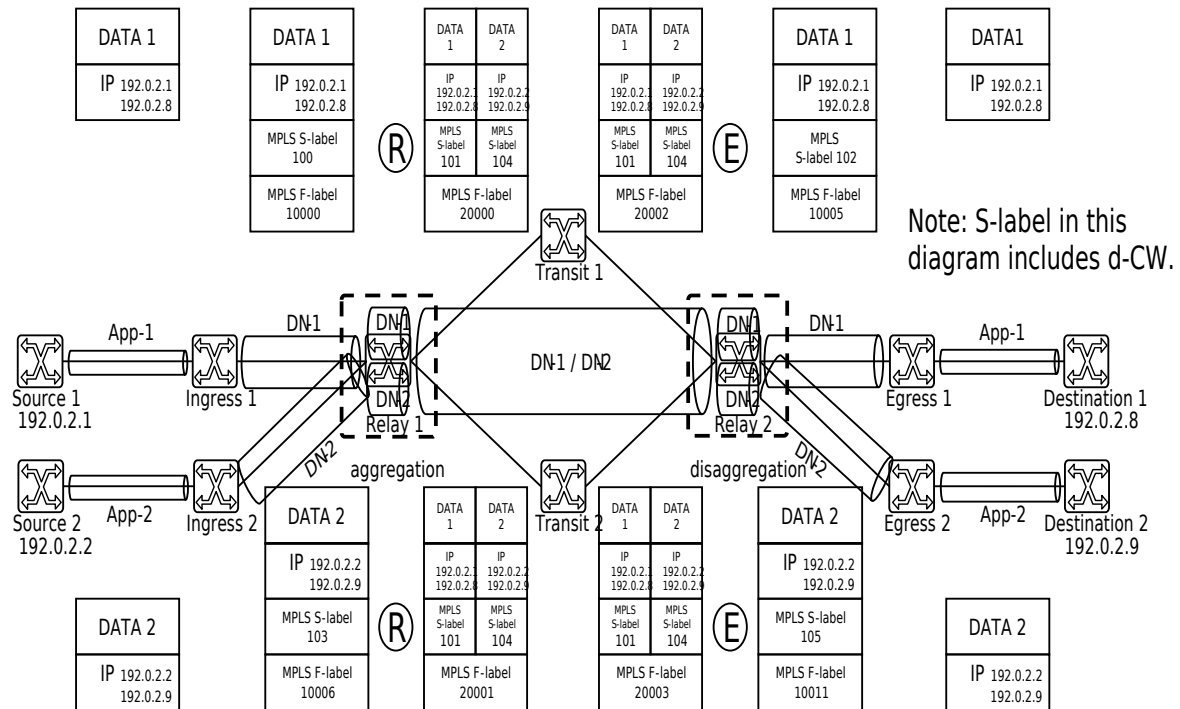


Figure 12: Case C-2 Example Service Aggregation/Disaggregation

The following Figure 13 contains the operational JSON configuration for the ingress aggregation node illustrated in Figure 12. In this example, a relay performing aggregation at the forwarding sub-layer is illustrated. Two DetNet flows DN1 and DN2 are replicated at each service sub-layer, and the replicated each service sub-layer for the upside path is aggregated at the single forwarding sub-layer with MPLS label 20000, and the replicated each service sub-layer for the downside path is aggregated at the forwarding sub-layer with MPLS label 20001. Figure 14 contains the operational JSON configuration for the egress disaggregation node illustrated in Figure 12.

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "afl-1",
          "afl-2"
        ]
      }
    ],
    "service": {
      "sub-layer": [
        {
          "name": "ssl-1",
          "service-rank": 10,
          "traffic-profile": "pf-1",
          "service-protection": {
            "protection": "replication",
            "sequence-number-length": "long-sn"
          },
          "operation": "relay",
          "incoming": {
            "service-id": {
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 100
            }
          ]
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 101
                  }
                ]
              },
              "sub-layer": [
                "afl-1",
                "afl-2"
              ]
            }
          ]
        }
      },
      {
        "name": "ssl-2",
        "service-rank": 10,
        "traffic-profile": "pf-1",
        "service-protection": {
          "protection": "replication",
          "sequence-number-length": "long-sn"
        },
        "operation": "relay",
        "incoming": {
          "service-id": {
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 103
                }
              ]
            }
          }
        },
        "outgoing": {
          "forwarding-sub-layer": {
            "service-outgoing": [
              {
                "index": 0,
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 104
            }
          ]
        },
        "sub-layer": [
          "afl-1",
          "afl-2"
        ]
      }
    ]
  },
  "forwarding": {
    "sub-layer": [
      {
        "name": "fsl-1",
        "traffic-profile": "pf-2",
        "operation": "pop-and-lookup",
        "incoming": {
          "forwarding-id": {
            "interface": "eth0",
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 10000
                }
              ]
            }
          }
        },
        "outgoing": {
          "service-sub-layer": {
            "sub-layer": [
              "ssl-1"
            ]
          }
        }
      }
    ],
    {
      "name": "fsl-2",
      "traffic-profile": "pf-2",
      "operation": "pop-and-lookup",
      "incoming": {
        "forwarding-id": {
          "interface": "eth1",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10006
              }
            ]
          }
        }
      }
    }
  ]
}
```



```

    }
  ]
}
},
{
  "outgoing": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-2"
      ]
    }
  }
},
{
  "name": "afl-1",
  "traffic-profile": "pf-3",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-1",
        "ssl-2"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth2",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 20000
          }
        ]
      }
    }
  }
},
{
  "name": "afl-2",
  "traffic-profile": "pf-3",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-1",
        "ssl-2"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth3",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,

```

```
        "label": 20001
      }
    ]
  }
}
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
```

Figure 13: Example C-2 DetNet Relay Aggregation Service Sub-Layer

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "afl-1",
          "afl-2"
        ]
      }
    ],
    "service": {
      "sub-layer": [
        {
          "name": "ssl-1",
          "service-rank": 10,
          "traffic-profile": "pf-1",
          "service-protection": {
            "protection": "elimination",
            "sequence-number-length": "long-sn"
          },
          "operation": "relay",
          "incoming": {
            "service-id": {
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": "101"
            }
          ]
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": "102"
                  }
                ]
              }
            }
          ],
          "sub-layer": [
            "fsl-1"
          ]
        }
      }
    },
    {
      "name": "ssl-2",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "protection": "elimination",
        "sequence-number-length": "long-sn"
      },
      "operation": "relay",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": "104"
              }
            ]
          }
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
```

```
        "entry": [
          {
            "id": 0,
            "label": "105"
          }
        ]
      },
      "sub-layer": [
        "fsl-2"
      ]
    }
  ]
},
"forwarding": {
  "sub-layer": [
    {
      "name": "afl-1",
      "traffic-profile": "pf-3",
      "operation": "pop-and-lookup",
      "incoming": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 20002
              }
            ]
          }
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "ssl-1",
            "ssl-2"
          ]
        }
      }
    }
  ],
  {
    "name": "afl-2",
    "traffic-profile": "pf-3",
    "operation": "pop-and-lookup",
    "incoming": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20003
            }
          ]
        }
      }
    }
  }
}
```

```
    ]
  }
}
},
"outgoing": {
  "service-sub-layer": {
    "sub-layer": [
      "ssl-1",
      "ssl-2"
    ]
  }
}
},
{
  "name": "fsl-1",
  "traffic-profile": "pf-2",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-1"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth2",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10005
          }
        ]
      }
    }
  }
},
{
  "name": "fsl-2",
  "traffic-profile": "pf-2",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-2"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth3",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10011
          }
        ]
      }
    }
  }
}
```

```

    }
  }
}
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
}

```

Figure 14: Example C-2 DetNet Relay Disaggregation Service Sub-Layer

B.6. Example C-3 JSON Relay Service Sub-Layer Aggregation/Disaggregation

Figure 15 illustrates that at the relay node service sub-layer flows 1 and 2 are aggregated into a service sub-layer DetNet flow. Multiple DetNet flows with the same requirements which can use the same path are aggregated into a single aggregated DetNet flow, and service protection and resource allocation are performed by the service sub-layer and forwarding sub-layer of aggregated DetNet flow. A diagram illustrating both aggregation and disaggregation is shown and then the corresponding JSON operational data follows.

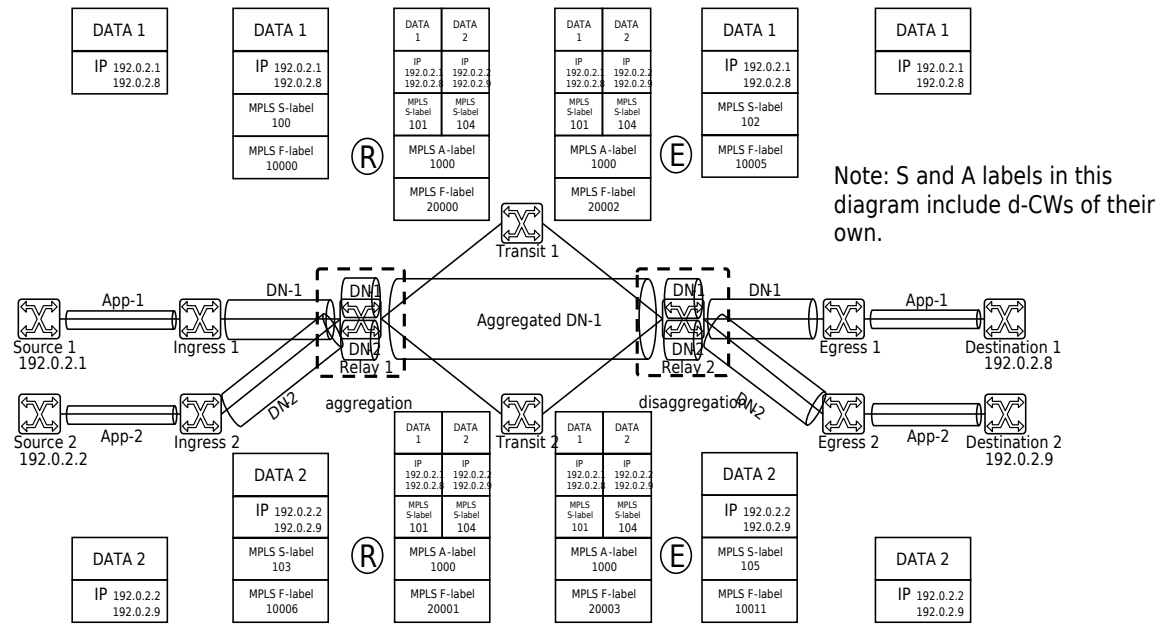


Figure 15: Case C-3 Example Service Aggregation/Disaggregation

The following Figure 16 contains the operational JSON configuration for the ingress aggregation node illustrated in Figure 15. In this example a relay performing aggregation at the service sub-layer is illustrated. Two DetNet flows DN1 and DN2 are relayed at each service sub-layer with MPLS labels 101 and 104 respectively, and each service sub-layer is aggregated at a single service sub-layer flow and replicated. The Figure 17 contains the operational JSON configuration for the egress disaggregation node illustrated in Figure 15.


```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-requirements": {
          "min-bandwidth": "200000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "asl-1"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2"
        ]
      },
      {
        "name": "pf-4",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-3",
          "fsl-4"
        ]
      }
    ]
  }
}
```

```
],
"service": {
  "sub-layer": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "protection": "none",
        "sequence-number-length": "long-sn"
      },
      "operation": "relay",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 100
              }
            ]
          }
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "aggregation-sub-layer": "asl-1",
          "service-label": {
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 101
                }
              ]
            }
          }
        }
      }
    }
  ],
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "protection": "none",
      "sequence-number-length": "long-sn"
    },
    "operation": "relay",
    "incoming": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 103
            }
          ]
        }
      }
    }
  }
]
```

```
    }
  },
  "outgoing": {
    "service-sub-layer": {
      "aggregation-sub-layer": "asl-1",
      "service-label": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 104
            }
          ]
        }
      }
    }
  },
  {
    "name": "asl-1",
    "service-rank": 10,
    "traffic-profile": "pf-2",
    "service-protection": {
      "protection": "replication",
      "sequence-number-length": "long-sn"
    },
    "operation": "initiation",
    "incoming": {
      "service-aggregation": {
        "sub-layer": [
          "ssl-1",
          "ssl-2"
        ]
      }
    },
    "outgoing": {
      "forwarding-sub-layer": {
        "service-outgoing": [
          {
            "index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 1000
                }
              ]
            }
          },
          {
            "sub-layer": [
              "fsl-3",
              "fsl-4"
            ]
          }
        ]
      }
    }
  }
}
```

```
]
},
"forwarding": {
  "sub-layer": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-3",
      "operation": "pop-and-lookup",
      "incoming": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10000
              }
            ]
          }
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "ssl-1"
          ]
        }
      }
    }
  ],
  {
    "name": "fsl-2",
    "traffic-profile": "pf-3",
    "operation": "pop-and-lookup",
    "incoming": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10006
            }
          ]
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "ssl-2"
          ]
        }
      }
    },
    {
      "name": "fsl-3",
      "traffic-profile": "pf-4",
      "operation": "impose-and-forward",
```

```
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "asl-1"
        ]
      }
    },
    "outgoing": {
      "interface": {
        "outgoing-interface": "eth2",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20000
            }
          ]
        }
      }
    }
  },
  {
    "name": "fsl-4",
    "traffic-profile": "pf-4",
    "operation": "impose-and-forward",
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "asl-1"
        ]
      }
    },
    "outgoing": {
      "interface": {
        "outgoing-interface": "eth3",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20001
            }
          ]
        }
      }
    }
  }
],
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
```

```
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
```

Figure 16: Example C-3 DetNet Relay Service Sub-Layer Aggregation

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-requirements": {
          "min-bandwidth": "200000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "asl-1"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-3",
          "fsl-4"
        ]
      },
      {
        "name": "pf-4",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2"
        ]
      }
    ]
  }
}
```

```
],
"service": {
  "sub-layer": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "protection": "none",
        "sequence-number-length": "long-sn"
      },
      "operation": "relay",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 101
              }
            ]
          }
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 102
                  }
                ]
              },
              "sub-layer": [
                "fsl-3"
              ]
            }
          ]
        }
      }
    }
  ],
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "protection": "none",
      "sequence-number-length": "long-sn"
    },
    "operation": "relay",
    "incoming": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
```



```
        {
          "id": 0,
          "label": 104
        }
      ]
    }
  },
  "outgoing": {
    "forwarding-sub-layer": {
      "service-outgoing": [
        {
          "index": 0,
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 105
              }
            ]
          },
          "sub-layer": [
            "fsl-4"
          ]
        }
      ]
    }
  },
  {
    "name": "asl-1",
    "service-rank": 10,
    "traffic-profile": "pf-2",
    "service-protection": {
      "protection": "elimination",
      "sequence-number-length": "long-sn"
    },
    "operation": "termination",
    "incoming": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 1000
            }
          ]
        }
      }
    },
    "outgoing": {
      "service-disaggregation": {
        "sub-layer": [
          "ssl-1",
          "ssl-2"
        ]
      }
    }
  }
}
```

```
    }
  ]
},
"forwarding": {
  "sub-layer": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-4",
      "operation": "pop-and-lookup",
      "incoming": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 20002
              }
            ]
          }
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "asl-1"
          ]
        }
      }
    }
  ],
  {
    "name": "fsl-2",
    "traffic-profile": "pf-4",
    "operation": "pop-and-lookup",
    "incoming": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20003
            }
          ]
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "asl-1"
          ]
        }
      }
    }
  ],
  {
    "name": "fsl-3",
    "traffic-profile": "pf-3",
```

```
    "operation": "impose-and-forward",
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-1"
        ]
      }
    },
    "outgoing": {
      "interface": {
        "outgoing-interface": "eth2",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10005
            }
          ]
        }
      }
    }
  },
  {
    "name": "fsl-4",
    "traffic-profile": "pf-3",
    "operation": "impose-and-forward",
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-2"
        ]
      }
    },
    "outgoing": {
      "interface": {
        "outgoing-interface": "eth3",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10011
            }
          ]
        }
      }
    }
  }
],
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
```

```

    }
  },
  {
    "name": "eth1",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  },
  {
    "name": "eth2",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  },
  {
    "name": "eth3",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  },
  {
    "name": "eth4",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  }
]
}

```

Figure 17: Example C-3 DetNet Relay Service Sub-Layer Disaggregation

B.7. Example C-4 JSON Relay Service Sub-Layer Aggregation/Disaggregation

Figure 18 illustrates the relay node forwarding sub-layers of DetNet flows 1 and 2 are aggregated into a service sub-layer DetNet flow. Multiple DetNet flows with the same requirements which can use the same path are aggregated into a single aggregated DetNet flow. Service protection is performed by the service sub-layer of the aggregated DetNet flow and resource allocation is performed by the forwarding sub-layer of each aggregated DetNet flow. A diagram illustrating both aggregation and disaggregation is shown and then the corresponding JSON operational data follows.

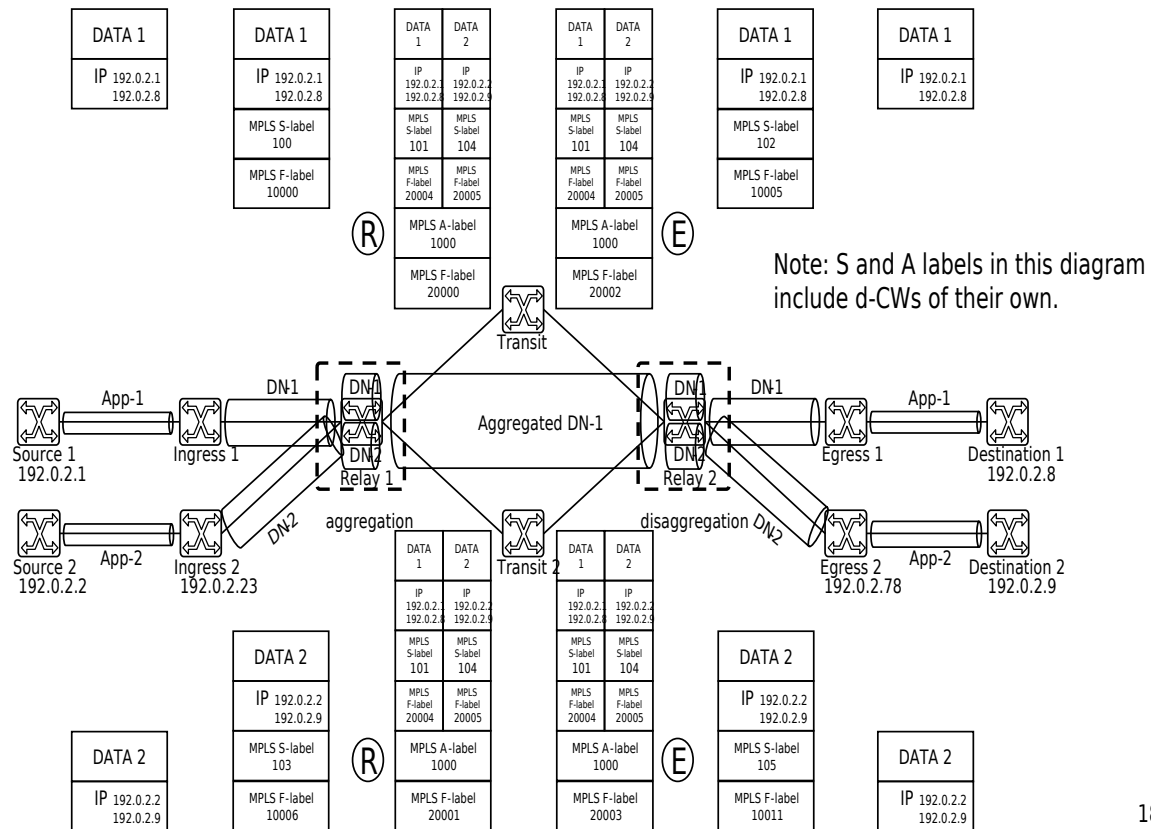


Figure 18: Case C-4 Example Service Aggregation/Disaggregation

The following [Figure 19](#) contains the operational JSON configuration for the ingress aggregation node illustrated in [Figure 18](#). In this example, a relay performing aggregation at the service sub-layer is illustrated. Two DetNet flows DN1 and DN2 are relayed at each service sub-layer. The two DetNet forwarding sub-layer flows with MPLS labels 20004 and 20005 are aggregated at the single service sub-layer DetNet flow and then replicated. The [Figure 20](#) contains the operational JSON configuration for the egress disaggregation node illustrated in [Figure 18](#).

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-requirements": {
          "min-bandwidth": "200000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "asl-1"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2",
          "fsl-3",
          "fsl-4"
        ]
      },
      {
        "name": "pf-4",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-5",
          "fsl-6"
        ]
      }
    ]
  }
}
```

```
    ]
  }
],
"service": {
  "sub-layer": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "protection": "none",
        "sequence-number-length": "long-sn"
      },
      "operation": "relay",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 100
              }
            ]
          }
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 101
                  }
                ]
              }
            }
          ],
          "sub-layer": [
            "fsl-3"
          ]
        }
      }
    }
  ],
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "protection": "none",
      "sequence-number-length": "long-sn"
    },
    "operation": "relay",
    "incoming": {
      "service-id": {
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 103
            }
          ]
        }
      },
    },
    "outgoing": {
      "forwarding-sub-layer": {
        "service-outgoing": [
          {
            "index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 104
                }
              ]
            }
          },
          "sub-layer": [
            "fsl-4"
          ]
        }
      ]
    },
    {
      "name": "asl-1",
      "service-rank": 10,
      "traffic-profile": "pf-2",
      "service-protection": {
        "protection": "replication",
        "sequence-number-length": "long-sn"
      },
      "operation": "initiation",
      "incoming": {
        "forwarding-aggregation": {
          "sub-layer": [
            "fsl-3",
            "fsl-4"
          ]
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 1000
                  }
                ]
              }
            }
          ]
        }
      }
    }
  ]
}
```



```
    }
  ]
},
"sub-layer": [
  "fsl-5",
  "fsl-6"
]
}
]
}
}
}
},
"forwarding": {
  "sub-layer": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-3",
      "operation": "pop-and-lookup",
      "incoming": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10000
              }
            ]
          }
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "ssl-1"
          ]
        }
      }
    }
  ],
  {
    "name": "fsl-2",
    "traffic-profile": "pf-3",
    "operation": "pop-and-lookup",
    "incoming": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10006
            }
          ]
        }
      }
    }
  }
],
},
```

```
    "outgoing": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-2"
        ]
      }
    },
  },
  {
    "name": "fsl-3",
    "traffic-profile": "pf-3",
    "operation": "impose-and-forward",
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-1"
        ]
      }
    },
    "outgoing": {
      "service-aggregation": {
        "aggregation-sub-layer": "asl-1",
        "optional-forwarding-label": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 20004
              }
            ]
          }
        }
      }
    }
  },
  {
    "name": "fsl-4",
    "traffic-profile": "pf-3",
    "operation": "impose-and-forward",
    "incoming": {
      "service-sub-layer": {
        "sub-layer": [
          "ssl-2"
        ]
      }
    },
    "outgoing": {
      "service-aggregation": {
        "aggregation-sub-layer": "asl-1",
        "optional-forwarding-label": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 20005
              }
            ]
          }
        }
      }
    }
  }
}
```

```
    }  
  }  
},  
{  
  "name": "fsl-5",  
  "traffic-profile": "pf-4",  
  "operation": "impose-and-forward",  
  "incoming": {  
    "service-sub-layer": {  
      "sub-layer": [  
        "asl-1"  
      ]  
    }  
  },  
  "outgoing": {  
    "interface": {  
      "outgoing-interface": "eth2",  
      "mpls-label-stack": {  
        "entry": [  
          {  
            "id": 0,  
            "label": 20000  
          }  
        ]  
      }  
    }  
  }  
},  
{  
  "name": "fsl-6",  
  "traffic-profile": "pf-4",  
  "operation": "impose-and-forward",  
  "incoming": {  
    "service-sub-layer": {  
      "sub-layer": [  
        "asl-1"  
      ]  
    }  
  },  
  "outgoing": {  
    "interface": {  
      "outgoing-interface": "eth3",  
      "mpls-label-stack": {  
        "entry": [  
          {  
            "id": 0,  
            "label": 20001  
          }  
        ]  
      }  
    }  
  }  
},  
]  
},  
},  
],  
"ietf-interfaces:interfaces": {
```

```
"interface": [  
  {  
    "name": "eth0",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2020-12-18T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth1",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2020-12-18T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth2",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2020-12-18T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth3",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2020-12-18T18:59:00-05:00"  
    }  
  }  
]
```

Figure 19: Example C-4 DetNet Relay Service Sub-Layer Aggregation

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-requirements": {
          "min-bandwidth": "200000000",
          "max-latency": 100000000,
          "max-latency-variation": 10000000,
          "max-loss": 0.0000001,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-service": [
          "asl-1"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-3",
          "fsl-4",
          "fsl-5",
          "fsl-6"
        ]
      },
      {
        "name": "pf-4",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2"
        ]
      }
    ]
  }
}
```

```
    ]
  }
],
"service": {
  "sub-layer": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "protection": "none",
        "sequence-number-length": "long-sn"
      },
      "operation": "relay",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": "101"
              }
            ]
          }
        }
      },
      "outgoing": {
        "forwarding-sub-layer": {
          "service-outgoing": [
            {
              "index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": "102"
                  }
                ]
              }
            }
          ],
          "sub-layer": [
            "fsl-5"
          ]
        }
      }
    }
  ],
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "protection": "none",
      "sequence-number-length": "long-sn"
    },
    "operation": "relay",
    "incoming": {
      "service-id": {
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": "104"
            }
          ]
        }
      },
    },
    "outgoing": {
      "forwarding-sub-layer": {
        "service-outgoing": [
          {
            "index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": "105"
                }
              ]
            }
          },
          "sub-layer": [
            "fsl-6"
          ]
        ]
      }
    },
    {
      "name": "asl-1",
      "service-rank": 10,
      "traffic-profile": "pf-2",
      "service-protection": {
        "protection": "elimination",
        "sequence-number-length": "long-sn"
      },
      "operation": "termination",
      "incoming": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": "1000"
              }
            ]
          }
        }
      },
      "outgoing": {
        "forwarding-disaggregation": {
          "sub-layer": [
            "fsl-3",
            "fsl-4"
          ]
        }
      }
    }
  ],
}
```

```

    }
  }
]
},
"forwarding": {
  "sub-layer": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-4",
      "operation": "pop-and-lookup",
      "incoming": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 20002
              }
            ]
          }
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "asl-1"
          ]
        }
      }
    }
  ],
  {
    "name": "fsl-2",
    "traffic-profile": "pf-4",
    "operation": "pop-and-lookup",
    "incoming": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20003
            }
          ]
        }
      },
      "outgoing": {
        "service-sub-layer": {
          "sub-layer": [
            "asl-1"
          ]
        }
      }
    }
  ],
  {

```



```
"name": "fsl-3",
"traffic-profile": "pf-3",
"operation": "pop-and-lookup",
"incoming": {
  "forwarding-id": {
    "interface": "eth0",
    "mpls-label-stack": {
      "entry": [
        {
          "id": 0,
          "label": 20004
        }
      ]
    }
  }
},
"outgoing": {
  "service-sub-layer": {
    "sub-layer": [
      "ssl-1"
    ]
  }
},
},
{
  "name": "fsl-4",
  "traffic-profile": "pf-3",
  "operation": "pop-and-lookup",
  "incoming": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 20005
          }
        ]
      }
    }
  },
  "outgoing": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-2"
      ]
    }
  }
},
},
{
  "name": "fsl-5",
  "traffic-profile": "pf-3",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-1"
      ]
    }
  }
}
```

```
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth2",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10005
          }
        ]
      }
    }
  }
},
{
  "name": "fsl-6",
  "traffic-profile": "pf-3",
  "operation": "impose-and-forward",
  "incoming": {
    "service-sub-layer": {
      "sub-layer": [
        "ssl-2"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth3",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10011
          }
        ]
      }
    }
  }
}
],
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
    }
  ]
}
```

```
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    },
  },
  {
    "name": "eth2",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  },
  {
    "name": "eth3",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2020-12-18T18:59:00-05:00"
    }
  }
]
}
```

Figure 20: Example C-4 DetNet Relay Service Sub-Layer Disaggregation

B.8. Example D-1 JSON Transit Forwarding Sub-Layer Aggregation/Disaggregation

Figure 21 illustrates at the transit node, forwarding sub-layers flows 1 and 2 are aggregated into a single forwarding sub-layer. Resource allocation is performed by the corresponding forwarding sub-layer for all aggregated flows. Figure 21 illustrating both aggregation and disaggregation is shown and then the corresponding JSON operational data follows.

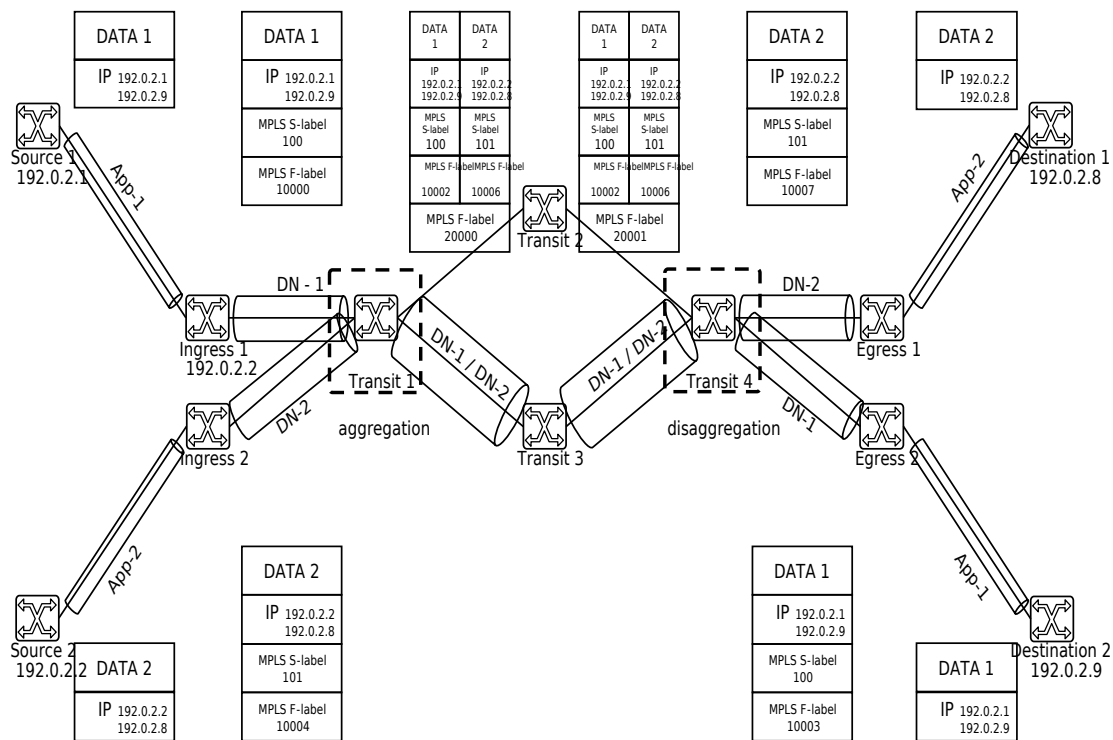


Figure 21: Case D-1 Example Transit Node Forwarding Aggregation/Disaggregation

The following Figure 22 contains the operational JSON configuration for the ingress aggregation node illustrated in Figure 21. In this example, a transit node performing aggregation at the forwarding sub-layer is illustrated. Two DetNet flows DN1 and DN2 are transmitted at each forwarding sub-layer. The DetNet forwarding sub-layer flows with MPLS labels 10002 and 10006 are aggregated at the single forwarding sub-layer. The resulting aggregated DetNet flow has MPLS label 20000. The Figure 23 contains the operational JSON configuration for the egress disaggregation transit node illustrated in Figure 21.

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "afl-1"
        ]
      }
    ],
    "forwarding": {
      "sub-layer": [
        {
          "name": "fsl-1",
          "traffic-profile": "pf-1",
          "operation": "pop-impose-and-forward",
          "incoming": {
            "forwarding-id": {
              "interface": "eth0",
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": "10000"
                  }
                ]
              }
            }
          },
          "outgoing": {
            "forwarding-sub-layer": {
              "aggregation-sub-layer": "afl-1",
              "forwarding-label": {
                "mpls-label-stack": {
                  "entry": [
                    {
                      "id": 0,
                      "label": "10002"
                    }
                  ]
                }
              }
            }
          }
        ]
      }
    }
  }
}
```

```
    ]
  }
}
},
{
  "name": "fsl-2",
  "traffic-profile": "pf-1",
  "operation": "pop-impose-and-forward",
  "incoming": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": "10004"
          }
        ]
      }
    }
  },
  "outgoing": {
    "forwarding-sub-layer": {
      "aggregation-sub-layer": "afl-1",
      "forwarding-label": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": "10006"
            }
          ]
        }
      }
    }
  }
},
{
  "name": "afl-1",
  "traffic-profile": "pf-2",
  "operation": "impose-and-forward",
  "incoming": {
    "forwarding-aggregation": {
      "sub-layer": [
        "fsl-1",
        "fsl-2"
      ]
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth3",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
```

```

        "label": "20000"
      }
    ]
  }
}
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth0",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
}

```

Figure 22: Example D-1 Transit Node Forwarding Aggregation

```
{
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "name": "pf-1",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "fsl-1",
          "fsl-2"
        ]
      },
      {
        "name": "pf-2",
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 2,
          "max-payload-size": 1518
        },
        "member-fwd-sublayer": [
          "afl-1"
        ]
      }
    ],
    "forwarding": {
      "sub-layer": [
        {
          "name": "fsl-1",
          "traffic-profile": "pf-1",
          "operation": "swap-and-forward",
          "incoming": {
            "forwarding-id": {
              "interface": "eth1",
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 10002
                  }
                ]
              }
            }
          },
          "outgoing": {
            "interface": {
              "outgoing-interface": "eth3",
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 10003
                  }
                ]
              }
            }
          }
        ]
      }
    }
  }
}
```



```
    }
  }
},
{
  "name": "fsl-2",
  "traffic-profile": "pf-1",
  "operation": "swap-and-forward",
  "incoming": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10006
          }
        ]
      }
    }
  },
  "outgoing": {
    "interface": {
      "outgoing-interface": "eth2",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10007
          }
        ]
      }
    }
  }
},
{
  "name": "af1-1",
  "traffic-profile": "pf-2",
  "operation": "pop-and-lookup",
  "incoming": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 20001
          }
        ]
      }
    }
  },
  "outgoing": {
    "forwarding-disaggregation": {
      "sub-layer": [
        "fsl-1",
        "fsl-2"
      ]
    }
  }
}
```

```
    }
  }
]
},
"ietf-interfaces:interfaces": {
  "interface": [
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2020-12-18T18:59:00-05:00"
      }
    }
  ]
}
```

Figure 23: Example D-1 Transit Node Forwarding Disaggregation

Authors' Addresses

Xuesong Geng

Huawei Technologies

Email: gengxuesong@huawei.com

Yeoncheol Ryoo

ETRI

Email: dbduscjf@etri.re.kr

Don Fedyk

LabN Consulting, L.L.C.

Email: dfedyk@labn.net

Reshad Rahman

Individual

Email: reshad@yahoo.com

Zhenqiang Li

China Mobile

Email: lizhenqiang@chinamobile.com