

---

Workgroup: Network Working Group  
Internet-Draft: draft-ietf-detnet-yang-20  
Published: 22 February 2024  
Intended Status: Standards Track  
Expires: 25 August 2024  
Authors: X. Geng Y. Ryoo D. Fedyk R. Rahman  
Huawei Technologies ETRI LabN Consulting, L.L.C. Equinix  
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 25 August 2024.

## Copyright Notice

Copyright (c) 2024 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.

This Yang model is scoped to the description of the aggregation/disaggregation and data plane capabilities of the DetNet data planes defined in the DetNet Architecture [\[RFC8655\]](#) and DetNet Framework [\[RFC8938\]](#). DetNet operates at the IP layer and delivers service over lower-layer technologies such as MPLS and IEEE 802.1 Time-Sensitive Networking (TSN).

## 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 4.1](#) , [Section 4.2](#) , [Section 4.3](#) 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.

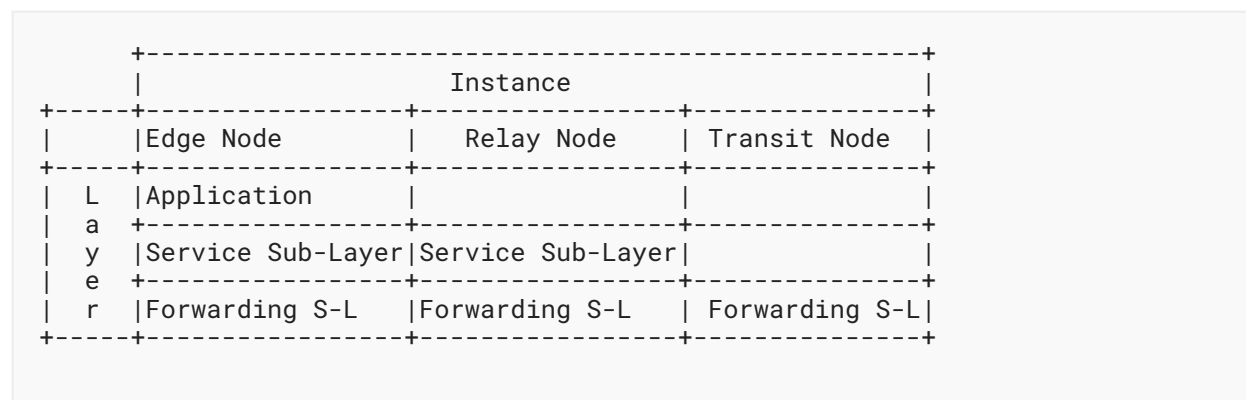


Figure 1: DetNet Layers and Node Types

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, see [RFC8938](#), 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, or 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

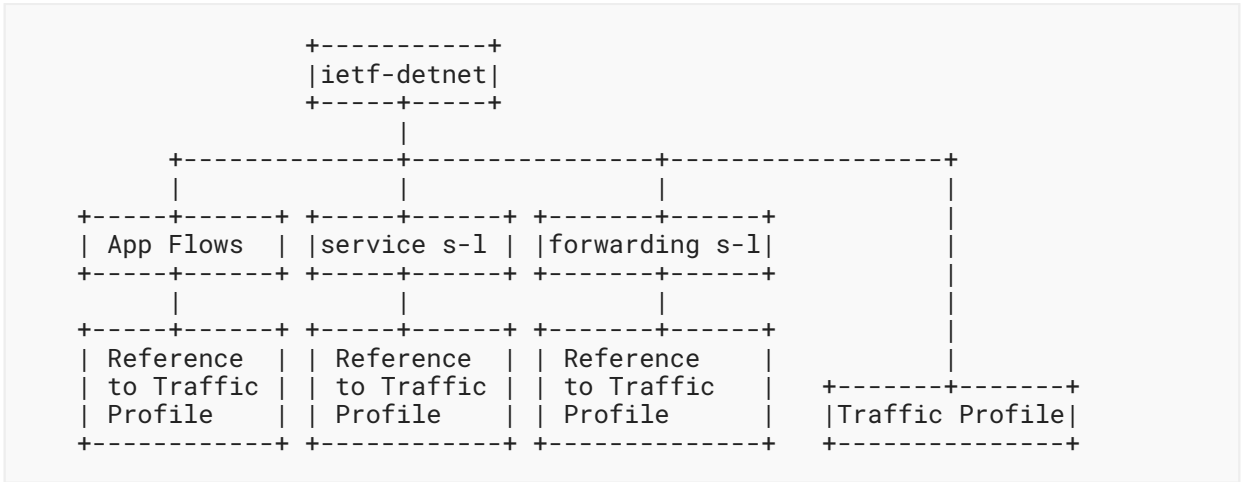
The following cases of DetNet aggregation are supported:

- 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-flow* app-flow-ref
      | +--ro member-svc-sublayer* 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? mpls-fwd-operation
      |   +--rw incoming
      |   | ...
      |   +--rw outgoing
      |   | ...

```

## 8. DetNet Configuration YANG Model

This YANG model imports typedefs from [\[RFC6991\]](#), [\[RFC8519\]](#), [\[RFC8294\]](#), [\[RFC8343\]](#), and [\[IEEE8021Q\]](#). 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 802.1Q-2022 - IEEE Standard for Local and Metropolitan
      Area Networks--Bridges and Bridged Networks Clause 48: YANG
      Data Models.";
}

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) 2024 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 '2024-02-21' with the module publication date
// the format is (year-month-day)

revision 2024-02-21 {
  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 some values are 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 mpls-fwd-operation {
    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 used 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
      "In IPv4 refers to the protocol of the
      payload. In IPv6, this field is known as 'next-header',
      and Identifies the type of header immediately following
      the IPv6 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 802.1Q-2022.";
      }
      leaf pcps {
        type dot1q-types:priority-type;
        description
          "The priority value of the Ethernet header.";
        reference
          "IEEE 802.1Q-2022.";
      }
    }

    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;
                        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;
                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 {
                    description
                        "Use IP data plane for forwarding.";
                    leaf next-hop-address {
                        type inet:ip-address;
                        description

```

```
        "This is an IP address as a next hop.";
    }
    uses ip-header;
}
case mpls {
    description
        "Use MPLS data plane for forwarding.";
    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 {
                description
                    "Use IP data plane for forwarding.";
                leaf next-hop-address {
                    type inet:ip-address;
                    description
                        "This is an IP address as a next hop.";
                }
                uses ip-header;
            }
            case mpls {
                description
                    "Use MPLS data plane for forwarding.";
                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
      "The name of the traffic profile which is used as a
       reference to this profile.";
  }
  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 5.9";
    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 5.9.1";
    }
    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 5.9.2";
    }
    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 5.9.3";
    }
    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 5.9.4";
}
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 5.9.5";
}
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 5.9.6";
}
}
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-flow {
    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-svc-sublayer {
    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-list interface {
    type if:interface-ref;
    description
        "Interface is optional for a service type. When matching a flow to a single interface one interface is specified. The list allows for matching a subset of interfaces. When more than one interfaces is specified, these flows are simply aggregated and the service sub-layer is unaware of the aggregation.";
}
uses data-flow-spec;
} //End of app-ingress
container egress {
    description
        "Egress DetNet application flows or a compound flow.";
    uses data-flow-spec;
    choice application-type {
        description
            "This is the application type choices.";
        container ethernet {
            description
                "This is Ethernet or TSN traffic that maps to an interface.";
            leaf-list interface {
                type if:interface-ref;
                description
                    "This is one or more Ethernet or TSN interfaces. If multiple interfaces are specified, this application flow is replicated to those interfaces. DetNet application Flow filtering applies to the whole list of interfaces. For fine grain flow filtering, use a single interface per application.";
            }
        }
        container ip-mpls {
            description
                "This is IP or MPLS DetNet application types.";
            uses detnet-app-next-hop-content;
        }
    }
}
}
}
}
}
}
}
}
}
}
```

```
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 forwarding-sub-layer {
      description
        "This entry specifies one or more forwarding
        sub-layers. No or minimal service sub-layer
        encapsulation is allowed.";
      leaf-list sub-layer {
        type forwarding-sub-layer-ref;
        config false;
        description
          "List of outgoing forwarding sub-layers.";
      }
    }
  }
}

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 sending 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 sending 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 sending 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 sending 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 sending 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 service/forwarding 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 mpls-fwd-operation;
            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 sending 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 sending 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 sending 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 sending 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 sending 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. Unauthorized write operations (e.g., edit-config) to any elements of this module can break or incorrectly connect DetNet flows. Since DetNet is a configured Data Plane, any changes that are not coordinated with all devices along the path will create a denial of service. In addition, arbitrary write operations could also enable an attacker to

modify a network path to enable select traffic to avoid inspection or treatment by security controls, or route traffic in a way that it would be subject to inspect/modification by an adversary node.

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-flow: This links traffic profiles to applications, service sub-layers and/or and forwarding sub-layers so this also could be considered more 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.

The above nodes can reveal identifiable characteristics of the application flows.

/detnet/service/sub-layer: This defines the service and forwarding operations.

/detnet/fowarding/sub-layer: This defines the forwarding operations.

The above nodes can reveal some aspects of the network topology of there is unauthorized access to this configuration.

## 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](mailto:mach.chen@huawei.com)

## 12. Acknowledgments

The editors of this document would like to thank Lou Berger, Tom Petch Xufeng Lui, Julien Meuric, John Scudder` and Florian Kauer 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.2022.10004498, IEEE 802.1Q-2022, July 2022, <<https://ieeexplore.ieee.org/document/8403927>>.
- [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-flow* app-flow-ref
      |   +--ro member-svc-sublayer* 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 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 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
|       +--:(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
+--:(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
+--:(forwarding-sub-layer)
+---rw forwarding-sub-layer
+---ro sub-layer*    forwarding-sub-layer-ref
+---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? mpls-fwd-operation
|     +---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 next-hop-address?
| | | | |      inet:ip-address
| | | | +--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 next-hop-address?
|      |      inet:ip-address
|      +---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 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.

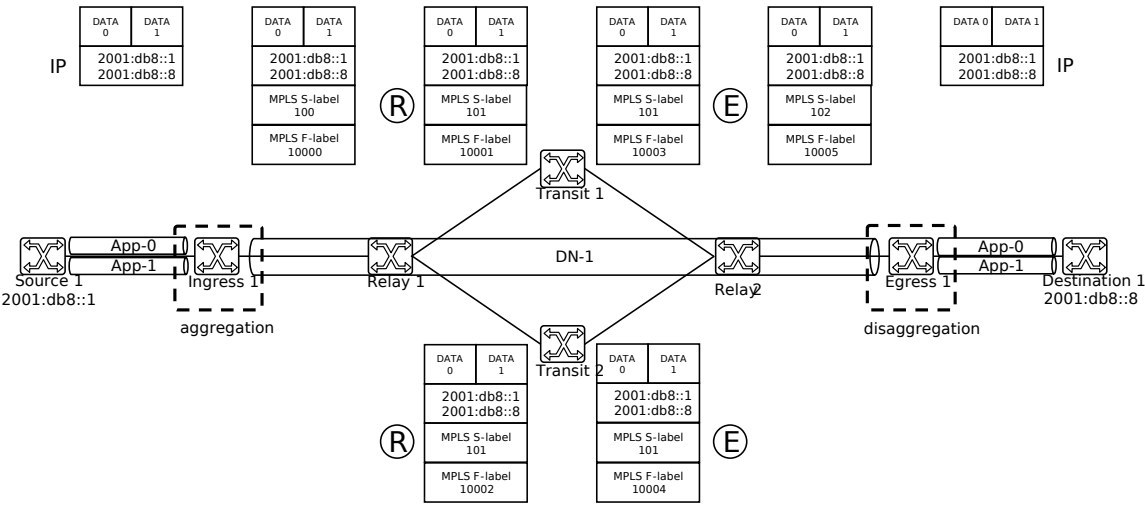


Figure 2: Case A-1 Application Aggregation

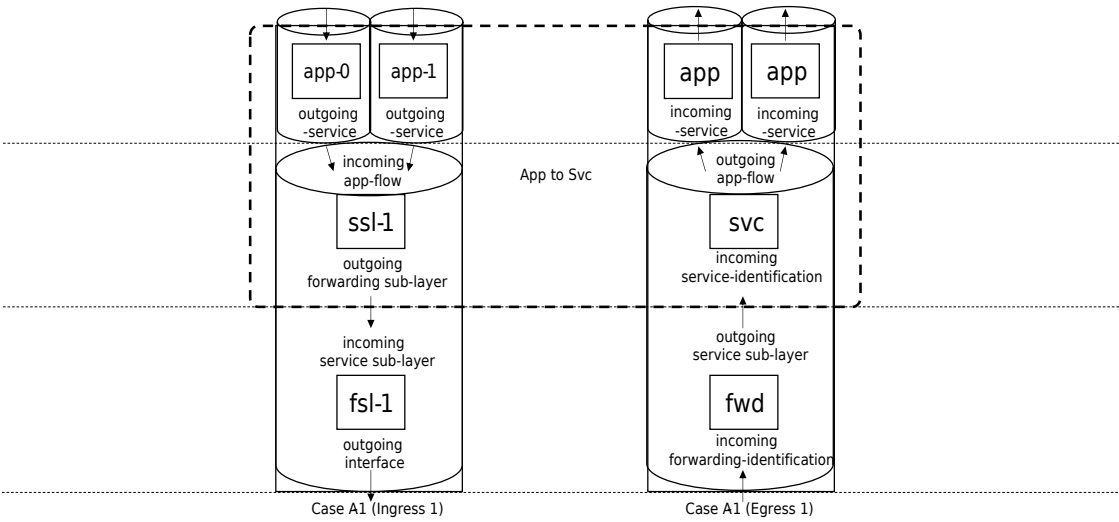


Figure 3: Case A-1 Application Aggregation Flow Stack Detail

Figure 4 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": "0.0000001",
          "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-flow": [
          "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
        },
        "traffic-spec": {
          "interval": 5,
          "max-pkts-per-interval": 20,
          "max-payload-size": 1500,
          "min-payload-size": 100,
          "min-pkts-per-interval": 1
        },
        "member-svc-sublayer": [
          "ssl-1"
        ]
      },
      {
        "name": "pf-3",
        "traffic-spec": {
          "interval": 5,
          "max-pkts-per-interval": 10,
          "max-payload-size": 1500
        },
        "member-fwd-sublayers": [
          "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": "2024-02-21T18:59:00-05:00"
    }
  },
  {
    "name": "eth2",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2024-02-21T18:59:00-05:00"
    }
  }
]
}
```

Figure 4: Example A-1 DetNet configuration Application Aggregation

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

Figure 5 illustrates the DetNet service sub-layer 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.

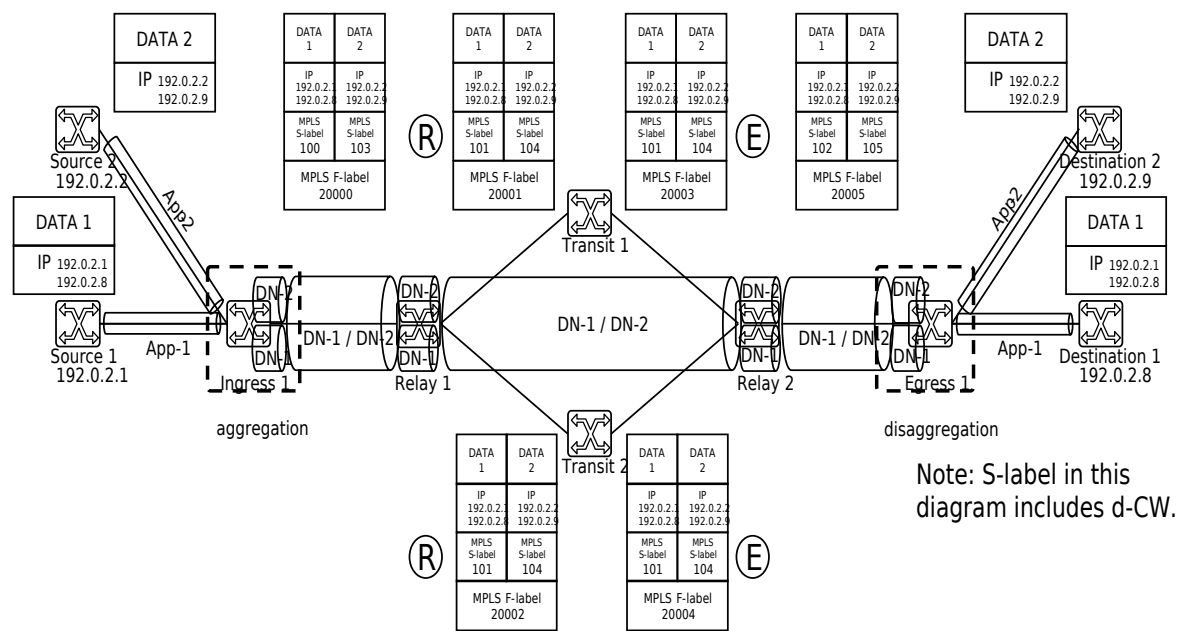


Figure 5: Case B-1 Example Config: Aggregation using a Forwarding Sub-layer

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>2024-02-21T23:59:00Z</discontinuity-time>
    </statistics>
  </interface>
  <interface>
    <name>eth1</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>2024-02-21T23:59:00Z</discontinuity-time>
    </statistics>
  </interface>
  <interface>
    <name>eth2</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>2024-02-21T23:59:00Z</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-flow>app-1</member-app-flow>
  <member-app-flow>app-2</member-app-flow>
</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-svc-sublayer>ssl-1</member-svc-sublayer>
  <member-svc-sublayer>ssl-2</member-svc-sublayer>
</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>
      </service-sub-layer>
    </incoming>
  </sub-layer>
</forwarding>
</sub-layer>
</detnet>
```



```
    <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 DetNet service sub-layer flows 1 and 2 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 an 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.

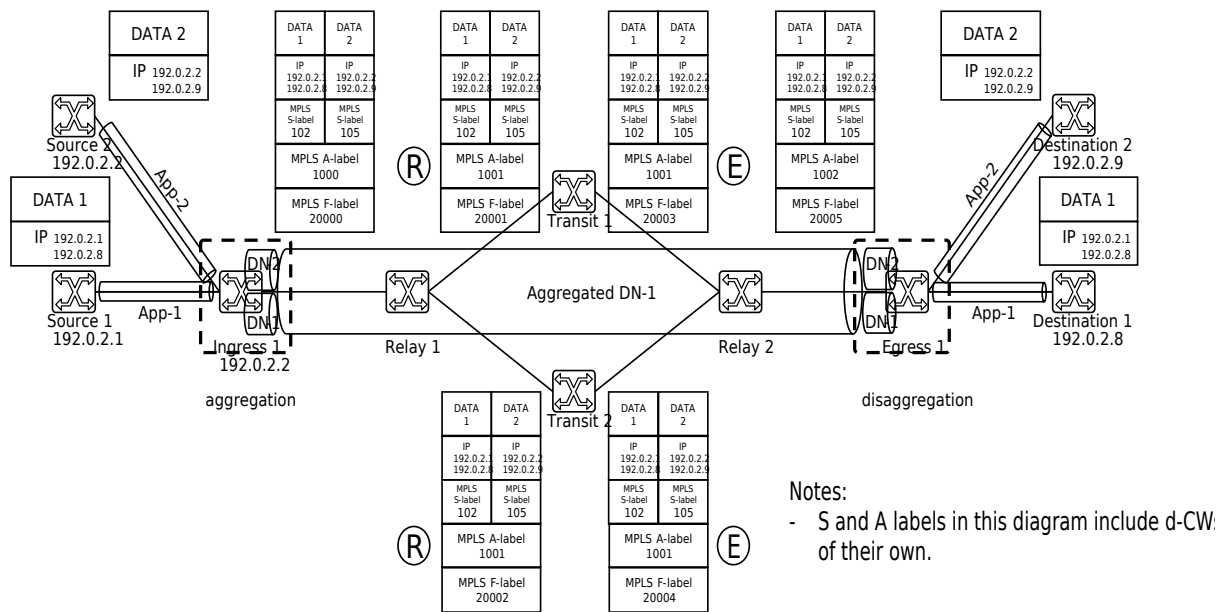


Figure 7: Case B-2 Example Service Aggregation

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": "0.0000001",
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "traffic-spec": {
          "interval": 125,
          "max-pkts-per-interval": 10,
          "max-payload-size": 1500
        },
        "member-app-flow": [
          "app-1",
          "app-2"
        ]
      },
      {
        "name": "2",
        "traffic-requirements": {
          "min-bandwidth": "100000000",
          "max-latency": 100000000,
          "max-latency-variation": 20000000,
          "max-loss": "0.0000001",
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-svc-sublayer": [
          "ssl-1",
          "ssl-2"
        ]
      },
      {
        "name": "3",
        "traffic-requirements": {
          "min-bandwidth": "200000000",
          "max-latency": 100000000,
          "max-latency-variation": 20000000,
          "max-loss": "0.0000001",
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        },
        "member-svc-sublayer": [
          "asl-1"
        ]
      },
      {
        "name": "4",
        "traffic-spec": {
          "interval": 125,
```

```
        "max-pkts-per-interval": 20,
        "max-payload-size": 1500
      },
      "member-fwd-sublayer": [
        "af1-1"
      ]
    }
  ],
  "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": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
}
```

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 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.

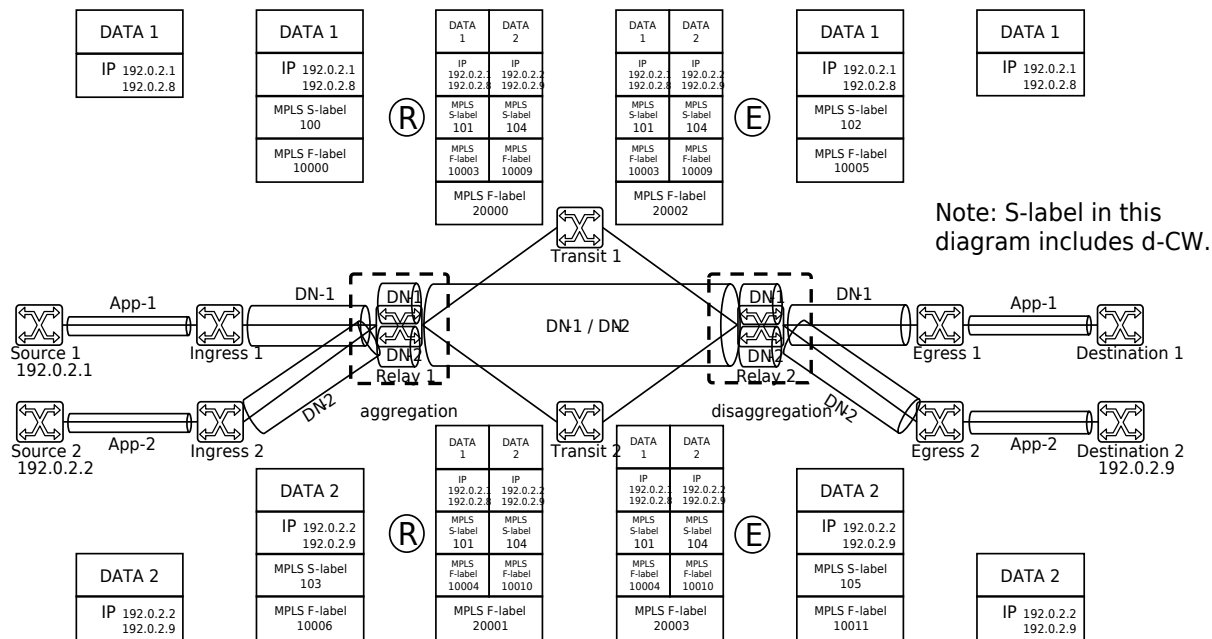


Figure 9: Case C-1 Example Service Aggregation/Disaggregation

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. 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-svc-sublayer": [
          "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": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
}
```

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-svc-sublayer": [
          "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": "2024-02-21T18:59:00-05:00"
    }
  },
  {
    "name": "eth1",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2024-02-21T18:59:00-05:00"
    }
  },
  {
    "name": "eth2",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2024-02-21T18:59:00-05:00"
    }
  },
  {
    "name": "eth3",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2024-02-21T18:59:00-05:00"
    }
  }
]
}

```

Figure 11: Example C-1 DetNet Relay Service Disaggregation

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

Figure 12 illustrates the DetNet relay node service sub-layer flows 1 and 2 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 an 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.

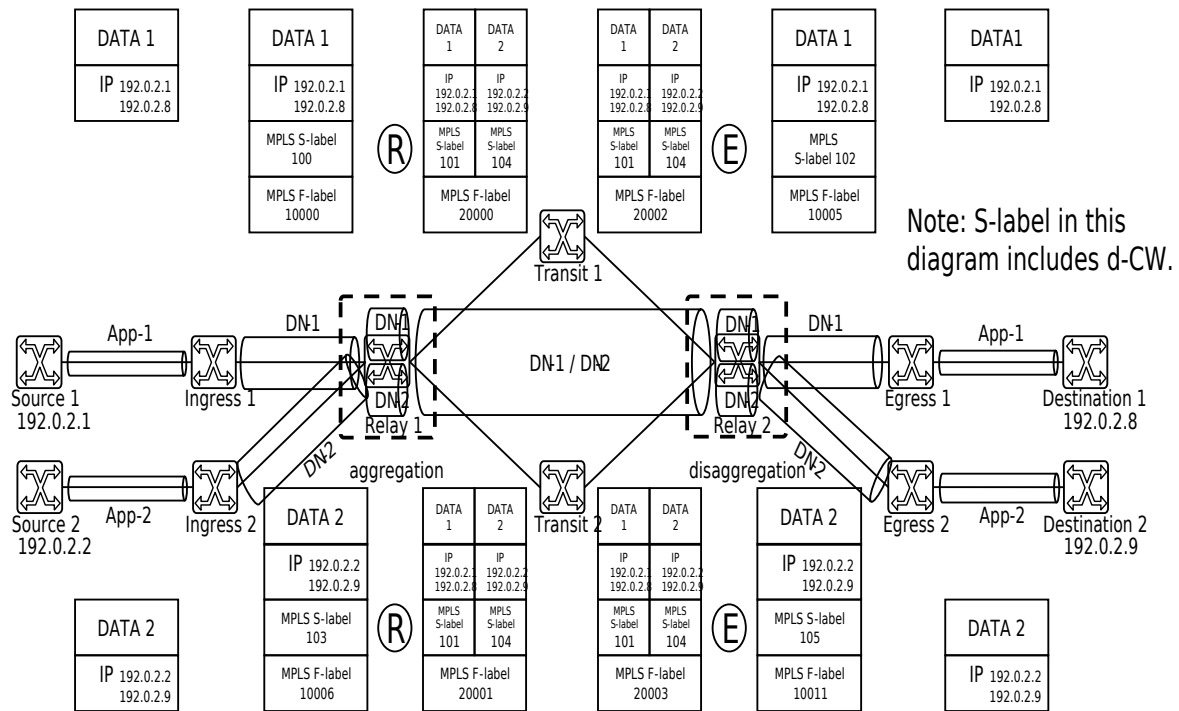


Figure 12: Case C-2 Example Service Aggregation/Disaggregation

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-svc-sublayer": [
          "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": [
          "af1-1",
          "af1-2"
        ]
      }
    ],
    "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": "af1-1",
  "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": "af1-2",
  "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": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
```

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-svc-sublayer": [
          "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": "2024-02-21T18:59:00-05:00"
          }
        },
        {
          "name": "eth1",
          "type": "iana-if-type:ethernetCsmacd",
          "oper-status": "up",
          "statistics": {
            "discontinuity-time": "2024-02-21T18:59:00-05:00"
          }
        },
        {
          "name": "eth2",
          "type": "iana-if-type:ethernetCsmacd",
          "oper-status": "up",
          "statistics": {
            "discontinuity-time": "2024-02-21T18:59:00-05:00"
          }
        },
        {
          "name": "eth3",
          "type": "iana-if-type:ethernetCsmacd",
          "oper-status": "up",
          "statistics": {
            "discontinuity-time": "2024-02-21T18:59:00-05:00"
          }
        }
      ]
    }
  }
}

```

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 the DetNet relay node service sub-layer flows 1 and 2 aggregated into a service sub-layer 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.

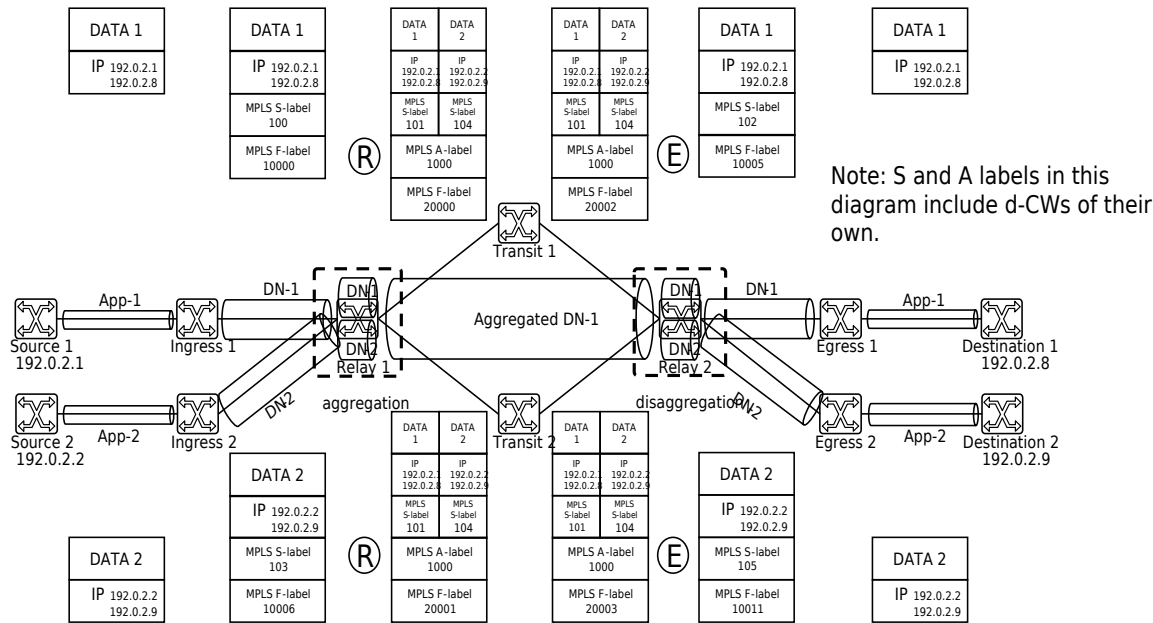


Figure 15: Case C-3 Example Service Aggregation/Disaggregation

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. 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-svc-sublayer": [
          "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-svc-sublayer": [
          "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": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
```

```
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
```

*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-svc-sublayer": [
          "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-svc-sublayer": [
          "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": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
```

```
    }  
  },  
  {  
    "name": "eth1",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2024-02-21T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth2",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2024-02-21T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth3",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2024-02-21T18:59:00-05:00"  
    }  
  }  
]  
}
```

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 DetNet forwarding sub-layer flows 1 and 2 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.

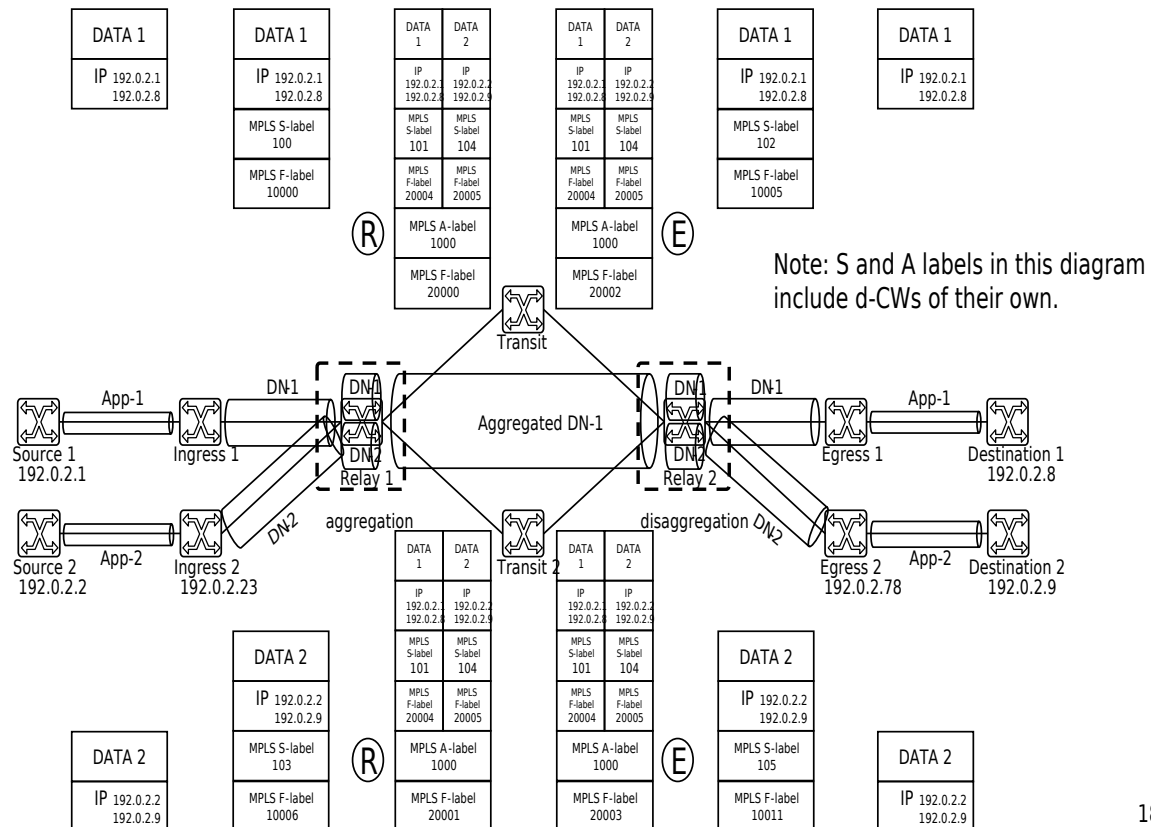


Figure 18: Case C-4 Example Service Aggregation/Disaggregation

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. 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-svc-sublayer": [
          "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-svc-sublayer": [
          "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": "2024-02-21T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth1",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2024-02-21T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth2",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2024-02-21T18:59:00-05:00"  
    }  
  },  
  {  
    "name": "eth3",  
    "type": "iana-if-type:ethernetCsmacd",  
    "oper-status": "up",  
    "statistics": {  
      "discontinuity-time": "2024-02-21T18:59:00-05:00"  
    }  
  }  
]
```

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-svc-sublayer": [
          "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-svc-sublayer": [
          "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": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
    }
  ]
}
```

```
    "statistics": {
      "discontinuity-time": "2024-02-21T18:59:00-05:00"
    },
  },
  {
    "name": "eth2",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2024-02-21T18:59:00-05:00"
    }
  },
  {
    "name": "eth3",
    "type": "iana-if-type:ethernetCsmacd",
    "oper-status": "up",
    "statistics": {
      "discontinuity-time": "2024-02-21T18:59:00-05:00"
    }
  }
]
}
```

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-layer 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.

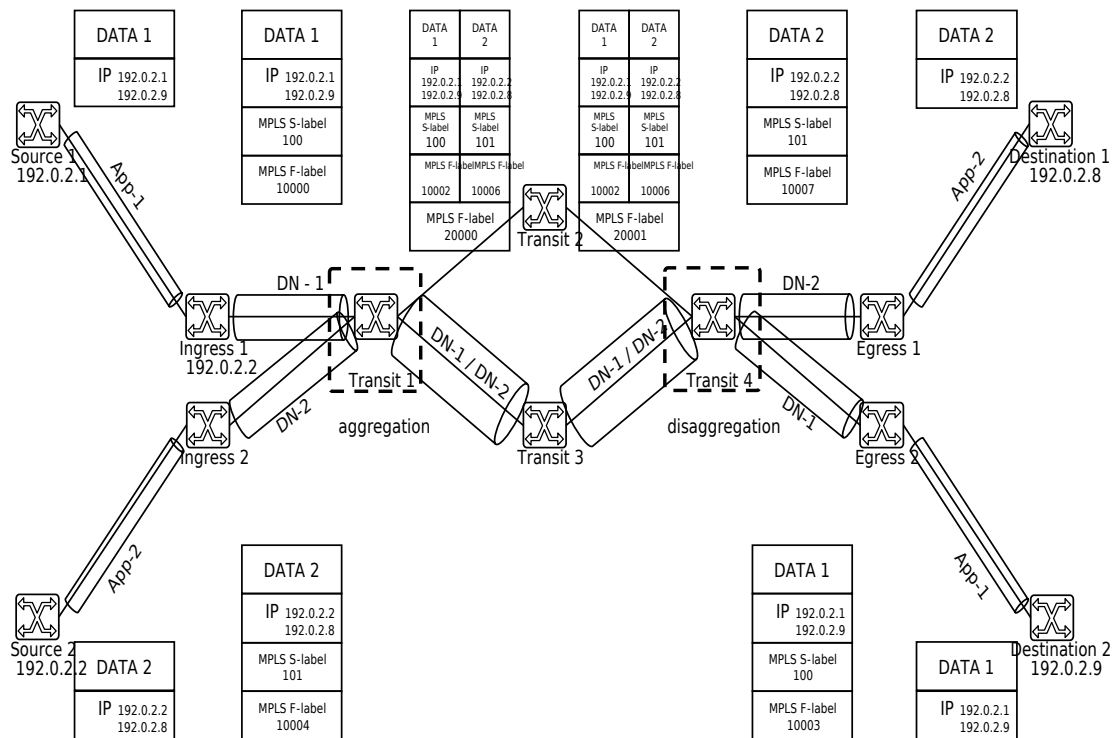


Figure 21: Case D-1 Example Transit Node Forwarding Aggregation/Disaggregation

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. 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": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth1",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
}
```

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": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth2",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    },
    {
      "name": "eth3",
      "type": "iana-if-type:ethernetCsmacd",
      "oper-status": "up",
      "statistics": {
        "discontinuity-time": "2024-02-21T18:59:00-05:00"
      }
    }
  ]
}
```

Figure 23: Example D-1 Transit Node Forwarding Disaggregation

## Authors' Addresses

### Xuesong Geng

Huawei Technologies

Email: [gengxuesong@huawei.com](mailto:gengxuesong@huawei.com)

### Yeoncheol Ryoo

ETRI

Email: [dbduscjf@etri.re.kr](mailto:dbduscjf@etri.re.kr)

### Don Fedyk

LabN Consulting, L.L.C.

Email: [dfedyk@labn.net](mailto:dfedyk@labn.net)

**Reshad Rahman**

Equinix

Email: [reshad@yahoo.com](mailto:reshad@yahoo.com)**Zhenqiang Li**

China Mobile

Email: [lizhenqiang@chinamobile.com](mailto:lizhenqiang@chinamobile.com)