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Authors:

X. Geng	M. Chen	Y. Ryoo	D. Fedyk	R. Rahman
<i>Huawei Technologies</i>	<i>Huawei Technologies</i>	<i>ETRI</i>	<i>LabN Consulting, L.L.C.</i>	<i>Individual</i>
Z. Li				
<i>China Mobile</i>				

Deterministic Networking (DetNet) YANG Model

Abstract

This document contains the specification for the Deterministic Networking YANG Model for configuration and operational data for DetNet Flows. The model allows for provisioning of end-to-end DetNet service 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).

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [RFC2119].

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Table of Contents

- 1. Introduction
- 2. Terminology
- 3. DetNet YANG Module
 - 3.1. DetNet Application Flow YANG Attributes
 - 3.2. DetNet Service Sub-layer YANG Attributes
 - 3.3. DetNet Forwarding Sub-layer YANG Attributes
- 4. DetNet Flow Aggregation
- 5. DetNet YANG Structure Considerations
- 6. DetNet Configuration YANG Structures
- 7. DetNet Configuration YANG Model
- 8. Open Issues
- 9. IANA Considerations
- 10. Security Considerations
- 11. Acknowledgements
- 12. References
 - 12.1. Normative References
 - 12.2. Informative References
- Appendix A. Examples
 - A.1. Example JSON Configuration/Operational
 - A.2. Example B1 XML Config: Aggregation using a Forwarding Sub-layer

- [A.3. Example B2 JSON Service Aggregation Configuration](#)
- [A.4. Example C1 JSON Relay Aggregation Configuration](#)
- [A.5. Example C1 JSON Relay Dissaggregation Configuration](#)
- [A.6. Example C2 JSON Relay Aggregation Service Sub-Layer](#)
- [A.7. Example C3 JSON Relay Disaggregation Service Sub-Layer](#)
- [A.8. Example C3 JSON Relay Service Sub-Layer Aggregation](#)
- [A.9. Example C3 JSON Relay Service Sub-Layer Disaggregation](#)
- [A.10. Example C4 JSON Relay Forwarding Sub-Layer Aggregation](#)
- [A.11. Example C4 JSON Relay Service Sub-Layer Disaggregation](#)
- [A.12. Example D1 JSON Transit Forwarding Sub-Layer Aggregation](#)
- [A.13. Example D1 JSON Transit Forwarding Sub-Layer Disaggregation](#)

[Authors' Addresses](#)

1. Introduction

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

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

2. Terminology

This document uses the terminology defined in [\[RFC8655\]](#).

3. DetNet YANG Module

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

3.1. 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 [\[I-D.ietf-detnet-flow-information-model\]](#).

3.2. 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 DetNet service layer, so there is no need for explicit indication). The corresponding arguments for service functions also need to be defined.

3.3. 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, refers to [\[I-D.ietf-detnet-flow-information-model\]](#). 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 need 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 mapping or other aspects.

4. 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 the 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:

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

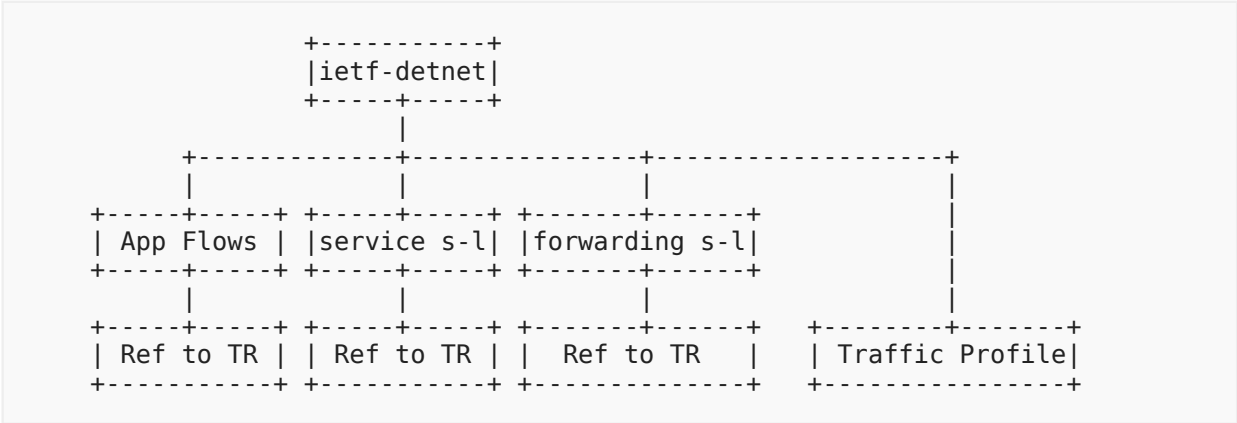
The following cases of DetNet aggregation are supported:

- 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.

5. DetNet YANG Structure Considerations

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



There are three instances in DetNet YANG Model: App-flow instance, service sub-layer instance and forwarding sub-layer instance, respectively corresponding to four parts of DetNet functions defined in section 3.

6. DetNet Configuration YANG Structures

```

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

```



```

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

```

```

    +--rw (port-range-or-operator)?
    +--:(range)
    |   +--rw lower-port
    |   |   inet:port-number
    |   +--rw upper-port
    |   |   inet:port-number
    +--:(operator)
    |   +--rw operator?      operator
    |   +--rw port
    |   |   inet:port-number
    +--rw ipsec-spi?          ipsec-spi
+--:(mpls-detnet-flow)
+--rw (label-space)?
+--:(context-label-space)
|   +--rw mpls-label-stack
|   |   +--rw entry* [id]
|   |   |   +--rw id          uint8
|   |   |   +--rw label?
|   |   |   |   rt-types:mpls-label
|   |   +--rw ttl?          uint8
|   |   +--rw traffic-class? uint8
+--:(platform-label-space)
|   +--rw label?
|   |   rt-types:mpls-label
+--rw outgoing-type
+--rw (outgoing-type)
+--:(forwarding-sub-layer)
|   +--rw forwarding-sub-layer
|   |   +--rw service-outgoing-list*
|   |   |   [service-outgoing-index]
|   |   +--rw service-outgoing-index      uint8
|   +--rw (header-type)?
|   |   +--:(detnet-mpls-header)
|   |   |   +--rw mpls-label-stack
|   |   |   |   +--rw entry* [id]
|   |   |   |   |   +--rw id          uint8
|   |   |   |   |   +--rw label?
|   |   |   |   |   |   rt-types:mpls-label
|   |   |   +--rw ttl?          uint8
|   |   |   +--rw traffic-class? uint8
|   |   +--:(detnet-ip-header)
|   |   |   +--rw src-ip-address?
|   |   |   |   inet:ip-address
|   |   |   +--rw dest-ip-address?
|   |   |   |   inet:ip-address
|   |   |   +--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 forwarding-sub-layer*
|   |   forwarding-sub-layer-ref
+--:(service-sub-layer)
|   +--rw service-sub-layer

```

```

    +--rw aggregation-service-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 app-flow-list* app-flow-ref
    +--:(service-disaggregation)
    |   +--rw service-disaggregation
    |   |   +--rw service-sub-layer*
    |   |   |   service-sub-layer-ref
    +--:(forwarding-disaggregation)
    |   +--rw forwarding-disaggregation
    |   |   +--rw forwarding-sub-layer*
    |   |   |   forwarding-sub-layer-ref
+--rw forwarding-sub-layer
+--rw forwarding-sub-layer-list* [name]
+--rw name                string
+--rw traffic-profile?    traffic-profile-ref
+--rw forwarding-operation-type?
|   forwarding-operations-type
+--rw incoming-type
|   +--rw (incoming-type)
|   |   +--:(service-sub-layer)
|   |   |   +--rw service-sub-layer
|   |   |   |   +--rw service-sub-layer*
|   |   |   |   |   service-sub-layer-ref
|   |   +--:(forwarding-aggregation)
|   |   |   +--rw forwarding-aggregation
|   |   |   |   +--rw forwarding-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-type
+---rw (outgoing-type)
+---:(interface)
|       +---rw interface
|       |       +---rw (next-hop-options)
|       |       +---:(simple-next-hop)
|       |       |       +---rw outgoing-interface?
|       |       |       |       if:interface-ref
|       |       +---rw (flow-type)?
|       |       +---:(ip)
|       |       |       +---rw (operation-type)?
|       |       |       +---:(ip-forwarding)
|       |       |       |       +---rw next-hop-address?
|       |       |       |       |       inet:ip-address
|       |       +---:(mpls-over-ip-encapsulation)
|       |       |       +---rw src-ip-address?
|       |       |       |       inet:ip-address
|       |       |       +---rw dest-ip-address?
|       |       |       |       inet:ip-address
|       |       |       +---rw protocol-next-header?
|       |       |       |       uint8
|       |       |       +---rw dscp?
|       |       |       |       inet:dscp
|       |       |       +---rw flow-label?
|       |       |       |       inet:ipv6-flow-label
|       |       |       +---rw source-port?
|       |       |       |       inet:port-number
|       |       +---rw destination-port?
|       |       |       inet:port-number

```

```

+---:(mpls)
+---rw mpls-label-stack
+---rw entry* [id]
+---rw id                               uint8
+---rw label?
|   rt-types:mpls-label
+---rw ttl?                             uint8
+---rw traffic-class?                   uint8
+---:(next-hop-list)
+---rw next-hop* [hop-index]
+---rw hop-index
|   uint8
+---rw outgoing-interface?
|   if:interface-ref
+---rw (flow-type)?
+---:(ip)
+---rw (operation-type)?
+---:(ip-forwarding)
|   +---rw next-hop-address?
|   |   inet:ip-address
+---:(mpls-over-ip-encapsulation)
+---rw src-ip-address?
|   inet:ip-address
+---rw dest-ip-address?
|   inet:ip-address
+---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-service-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-forwarding-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 service-sub-layer*
|   |   |   service-sub-layer-ref
+---:(forwarding-disaggregation)
|   +--rw forwarding-disaggregation
|   |   +--rw forwarding-sub-layer*
|   |   |   forwarding-sub-layer-ref
```

7. DetNet Configuration YANG Model


```
<CODE BEGINS>
module ietf-detnet {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-detnet";
  prefix ietf-detnet;

  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6021 - Common YANG Data Types.";
  }
  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991 - Common YANG Data Types.";
  }
  import ietf-ethertypes {
    prefix ethertypes;
    reference
      "RFC 8519 - YANG Data Model for Network Access Control
        Lists (ACLs).";
  }
  import ietf-routing-types {
    prefix rt-types;
    reference
      "RFC 8294 - Common YANG Data Types for the Routing Area.";
  }
  import ietf-packet-fields {
    prefix packet-fields;
    reference
      "RFC 8519 - YANG Data Model for Network Access Control Lists
        (ACLs).";
  }
  import ietf-interfaces {
    prefix if;
    reference
      "RFC 8343 - A YANG Data Model for Interface Management.";
  }
  import ieee802-dot1q-types {
    prefix dot1q-types;
    reference
      "IEEE 802.1Qcx-2020 - IEEE Standard for Local and Metropolitan
        Area Networks--Bridges and Bridged Networks Amendment 33: YANG
        Data Model for Connectivity Fault Management.";
  }

  organization
    "IETF DetNet Working Group";
  contact
    "WG Web:  <http://tools.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: Mach Chen
       <mailto:mach.chen@huawei.com>

Editor: Zhenqiang Li
       <mailto:lizhenqiang@chinamobile.com>;
description
  "This YANG module describes the parameters needed
  for DetNet flow configuration and flow status
  reporting.

  Copyright (c) 2021 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
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  (https://trustee.ietf.org/license-info).

  This version of this YANG module is part of RFC XXXX
  (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
  for full legal notices.

  The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL', 'SHALL
  NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED', 'NOT RECOMMENDED',
  'MAY', and 'OPTIONAL' in this document are to be interpreted as
  described in BCP 14 (RFC 2119) (RFC 8174) when, and only when,
  they appear in all capitals, as shown here. ";

revision 2021-02-17 {
  description
    "initial revision";
  reference
    "RFC XXXX: draft-ietf-detnet-yang-10";
}

identity app-status {
  description
    "Base identity from which all application-status
    status types are derived.";
  reference
    "draft-ietf-detnet-flow-information-model Section 5.8";
}

identity none {
  base app-status;
  description
    "This Application has no status. This type of status is
    expected when the configuration is incomplete.";
```

```
    reference
      "draft-ietf-detnet-flow-information-model Section 5.8";
  }

  identity ready {
    base app-status;
    description
      "Application ingress/egress ready.";
    reference
      "draft-ietf-detnet-flow-information-model Section 5.8";
  }

  identity failed {
    base app-status;
    description
      "Application ingres/egresss failed.";
    reference
      "draft-ietf-detnet-flow-information-model Section 5.8";
  }

  identity out-of-service {
    base app-status;
    description
      "Application Administratively blocked.";
    reference
      "draft-ietf-detnet-flow-information-model 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
      "draft-ietf-detnet-flow-information-model Section 5.8";
  }

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

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

```
}

typedef forwarding-sub-layer-ref {
  type leafref {
    path "/ietf-detnet:detnet"
      + "/ietf-detnet:forwarding-sub-layer"
      + "/ietf-detnet:forwarding-sub-layer-list"
      + "/ietf-detnet:name";
  }
  description
    "This is a Forwarding sub-layer Reference.";
}

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

typedef ipsec-spi {
  type uint32 {
    range "1..max";
  }
  description
    "IPsec Security Parameters Index.";
  reference
    "IETF RFC 6071";
}

typedef service-operation-type {
  type enumeration {
    enum service-initiation {
      description
        "This is an initiating service sub-layer encapsulation.";
    }
    enum service-termination {
      description
        "Operation for DetNet service sub-layer decapsulation.";
    }
    enum service-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 instance. Operations are described as unidirectional
    but a service sub-layer may combine operation types.";
}
```

```
typedef forwarding-operations-type {
  type enumeration {
    enum impose-and-forward {
      description
        "This operation impose outgoing label(s) and forward to
        next-hop.";
      reference
        " A YANG Data Model for MPLS Base
        draft-ietf-mpls-base-yang.";
    }
    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
        draft-ietf-mpls-base-yang.";
    }
    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
        draft-ietf-mpls-base-yang.";
    }
    enum swap-and-forward {
      description
        "This operation swaps incoming label, with an outgoing
        label and forwards to the next-hop.";
      reference
        " A YANG Data Model for MPLS Base
        draft-ietf-mpls-base-yang.";
    }
    enum forward {
      description
        "This operation forward to next-hop.";
    }
    enum pop-and-lookup {
      description
        "This operation pops incoming label and performs a
        lookup.";
    }
  }
  description
    "MPLS operations types. This is an enum modeled after the
    MPLS enum. The first 4 enums are the same as A YANG Data
    Model for MPLS Base. draft-ietf-mpls-base-yang.";
}

typedef service-protection-type {
  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-replicaiton {
        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 types.";
}

typedef sequence-number-generation-type {
    type enumeration {
        enum copy-from-app-flow {
            description
            "This type means copy the app-flow sequence number to the
            DetNet-flow.";
        }
        enum generate-by-detnet-flow {
            description
            "This type means generate the sequence number by the
            DetNet flow.";
        }
    }
}
description
"An enumeration for the sequence number behaviors supported.";
}
```

```
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 type captures 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;
    description
      "The source IP address in the header.";
    reference
      "RFC 6021 Common YANG Data Types";
  }
  leaf dest-ip-address {
    type inet:ip-address;
    description
      "The destination IP address in the header.";
    reference
      "RFC 6021 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 6021 Common YANG Data Types";
  }
}
```

```
}
leaf flow-label {
  type inet:ipv6-flow-label;
  description
    "The flow label value of the header.IPV6 only.";
  reference
    "RFC 6021 Common YANG Data Types";
}
leaf source-port {
  type inet:port-number;
  description
    "The source port number.";
  reference
    "RFC 6021 Common YANG Data Types";
}
leaf destination-port {
  type inet:port-number;
  description
    "The destination port number.";
  reference
    "RFC 6021 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 ethernet-types:ethertype;
    description
      "The Ethernet packet type value of the Ethernet header.";
  }
  leaf vlan-id {
    type dot1q-types:vlanid;
    description
      "The VLAN value of the Ethernet header.";
    reference
      "IEEE 802.1Qcx-2020.";
  }
  leaf pcps {
    type dot1q-types:priority-type;
    description
      "The priority value of the Ethernet header.";
    reference
      "IEEE 802.1Qcx-2020.";
  }
}
```



```
grouping destination-ip-port-id {
  description
    "The TCP/UDP port(source/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/destination) 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 6021 Common YANG Data Types";
  }
  leaf dest-ip-prefix {
    type inet:ip-prefix;
    description
      "The destination IP prefix.";
    reference
      "RFC 6021 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 6021 Common YANG Data Types";
  }
}
```

```
    leaf flow-label {
      type inet:ipv6-flow-label;
      description
        "The flow label value of the header.";
      reference
        "RFC 6021 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 6071 IP Security (IPsec) and Internet Key Exchange
        (IKE) Document Roadmap.";
    }
  }
}

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 app-flow-list {
        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 service-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 forwarding-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 detnet-mpls-header {
      description
        "MPLS label stack for DetNet MPLS encapsulation or
        forwarding.";
      uses rt-types:mpls-label-stack;
    }
    case detnet-ip-header {
      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.";
  choice next-hop-options {
    mandatory true;
    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.
        Modules for address families MUST augment this case with a
        leaf containing a next-hop address of that address
        family.";
      leaf outgoing-interface {
        type if:interface-ref;
        description
          "The outgoing interface, if this is a whole 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. Modules for address
      families MUST augment this list with a leaf containing a
      next-hop address of that address family.";
    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
        "Name of the outgoing 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.";
  choice next-hop-options {
    mandatory true;
    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.
        Modules for address families MUST augment this case with a
        leaf containing a next-hop address of that address
        family.";
      leaf outgoing-interface {
        type if:interface-ref;
        description
          "This is the interface as an outgoing type.";
      }
    }
  }
}
```

```
choice flow-type {
  description
    "These are the flow type next hop choices.";
  case ip {
    choice operation-type {
      description
        "This is the IP forwarding operation choices.";
      case ip-forwarding {
        leaf next-hop-address {
          type inet:ip-address;
          description
            "This is an IP address as a next hop.";
        }
      }
      case mpls-over-ip-encapsulation {
        uses ip-header;
      }
    }
  }
  case mpls {
    uses rt-types:mpls-label-stack;
  }
}
}
case next-hop-list {
  description
    "Container for multiple next hops.";
  list next-hop {
    key "hop-index";
    description
      "An entry in a next-hop list. Modules for address
      families MUST augment this list with a leaf containing a
      next-hop address of that address family.";
    leaf hop-index {
      type uint8;
      description
        "The value of the index for a hop.";
    }
    leaf outgoing-interface {
      type if:interface-ref;
      description
        "This is a whole interface as the next hop.";
    }
    choice flow-type {
      description
        "These are the flow type next hop choices.";
      case ip {
        choice operation-type {
          description
            "These are the next hop choices.";
          case ip-forwarding {
            leaf next-hop-address {
              type inet:ip-address;
              description
                "This is an IP address as a next hop.";
            }
          }
        }
      }
      case mpls-over-ip-encapsulation {
```

```
        uses ip-header;
      }
    }
  }
  case mpls {
    uses rt-types:mpls-label-stack;
  }
}
}
}
}
}

container detnet {
  description
    "The top level DetNet container. This contains
    applications, service sub-layers and forwarding sub-layers
    as well as the traffic profiles.";
  list traffic-profile {
    key "profile-name";
    description
      "A traffic profile.";
    leaf profile-name {
      type string;
      description
        "An Aggregation group ID. Zero means the service is not
        part of a group.";
    }
    container traffic-requirements {
      description
        "This defines the attributes of the App-flow
        regarding bandwidth, latency, latency variation, loss, and
        misordering tolerance.";
      reference
        "draft-ietf-detnet-flow-information-model Section 4.2";
      leaf min-bandwidth {
        type uint64;
        units "bps";
        description
          "This is the minimum bandwidth that has to be
          guaranteed for the DetNet service. MinBandwidth is
          specified in octets per second.";
      }
      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.";
      }
      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.";
    }
    leaf max-loss {
        type uint32;
        description
            "This defines the maximum Packet Loss Ratio (PLR)
            parameter for the DetNet service between the Ingress and
            Egress(es) of the DetNet domain.";
    }
    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.";
    }
    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.";
    }
}
container flow-spec {
    description
        "Flow-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
        "draft-ietf-detnet-flow-information-model Section 5.5";
    leaf interval {
        type uint32;
        units "nanoseconds";
        description
            "The period of time in which the traffic
            specification cannot be exceeded.";
    }
    leaf max-pkts-per-interval {
        type uint32;
        description
            "The maximum number of packets that the
            source will transmit in one interval.";
    }
    leaf max-payload-size {
        type uint32;
        description
```



```
        "The maximum payload size that the source
        will transmit.";
    }
    leaf min-payload-size {
        type uint32;
        description
            "The minimum payload size that the source
            will transmit.";
    }
    leaf min-pkts-per-interval {
        type uint32;
        description
            "The minimum number of packets that the
            source will transmit in one interval.";
    }
}
leaf-list member-apps {
    type app-flow-ref;
    config false;
    description
        "Applications attached to this profile.";
}
leaf-list member-services {
    type service-sub-layer-ref;
    config false;
    description
        "Services attached to this profile.";
}
leaf-list member-fwd-sublayers {
    type forwarding-sub-layer-ref;
    config false;
    description
        "Forwarding sub-layer attached to this profile.";
}
}
container app-flows {
    description
        "The DetNet app-flow configuration.";
    reference
        "draft-ietf-detnet-flow-information-model 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
                "draft-ietf-detnet-flow-information-model
                Sections 4.1, 5.1";
        }
        leaf app-flow-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
        "draft-ietf-detnet-flow-information-model
        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 name {
        type string;
        description
            "Ingress DetNet application.";
    }
    leaf app-flow-status {
        type identityref {
            base app-status;
        }
        config false;
        description
            "Status of ingress application flow.";
        reference
            "draft-ietf-detnet-flow-information-model Sections
            4.1, 5.8";
    }
    leaf interface {
        type if:interface-ref;
        description
            "Interface is used for any service type where a whole
            interface is mapped to the applications. It may be
            further filtered by type.";
    }
    uses data-flow-spec;
} //End of app-ingress
container egress {
    description
        "Route's next-hop attribute.";
    leaf name {
        type string;
        description
```

```

    "Egress DetNet application.";
  }
  choice application-type {
    description
      "This is the application type choices.";
    container ethernet {
      description
        "This is TSN unaware traffic that maps to an
        interface.";
      leaf interface {
        type if:interface-ref;
        description
          "This is an Ethernet or TSN interfaces.";
      }
    }
    container ip-mpls {
      description
        "This is IP or MPLS DetNet application types.";
      uses detnet-app-next-hop-content;
    }
  }
}

container service-sub-layer {
  description
    "The DetNet service sub-layer configuration.";
  list service-sub-layer-list {
    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;
      description
        "The DetNet rank for this service.";
      reference
        "draft-ietf-detnet-flow-information-model 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 an sequence number
      options.";
    leaf service-protection-type {
      type service-protection-type;
      description
        "The DetNet service protection type such as PRF, PEF,
        PE0F,PERF, and PEORF.";
      reference

```

```
        "draft-ietf-detnet-data-plane-framework Section 4.3";
    }
    leaf sequence-number-length {
        type sequence-number-field;
        description
            "Sequence number field length can be one of 0 (none),
             16-bits or 28-bits.";
    }
}
leaf service-operation-type {
    type service-operation-type;
    description
        "This is the service operation type for this service
         sub-layer;";
}
container incoming-type {
    description
        "The DetNet service sub-layer incoming configuration.";
    choice incoming-type {
        mandatory true;
        description
            "A service sub-layer may have App flows or other
             service sub-layers.";
        container app-flow {
            description
                "This service sub-layer is related to the app-flows
                 of the upper layer and provide ingress proxy or
                 ingress aggregation at the ingress node.";
            uses app-flows-group;
        }
        container service-aggregation {
            description
                "This service sub-layer is related to the service
                 sub-layer of the upper layer and provide
                 service-to-service aggregation at the ingress node
                 or relay node.";
            uses service-sub-layer-group;
        }
        container forwarding-aggregation {
            description
                "This service sub-layer is related to the forwarding
                 sub-layer of the upper layer and provide
                 forwarding-to-service aggregation at the ingress
                 node or relay node.";
            uses forwarding-sub-layer-group;
        }
        container service-id {
            description
                "This service sub-layer is related to the service or
                 forwarding sub-layer of the lower layer and provide
                 DetNet service relay or termination at the relay
                 node or egress node.";
            uses detnet-flow-spec;
        }
    }
}
container outgoing-type {
    description
```

```
"The DetNet service sub-layer outgoing configuration.";
choice outgoing-type {
  mandatory true;
  description
    "The out-going type may be a forwarding Sub-layer or a
    service sub-layer or ? types need to be named.";
  container forwarding-sub-layer {
    description
      "This service sub-layer is sent to the forwarding
      sub-layers of the lower layer for DetNet service
      forwarding or service-to-forwarding aggregation at
      the ingress node or relay node. When the operation
      type is service-initiation, The service sub-layer
      encapsulates the DetNet Control-Word and services
      label, which are for individual DetNet flow when the
      incoming type is app-flow and for aggregated DetNet
      flow when the incoming type is service or
      forwarding. The service sub-layer swaps the service
      label when the operation type is service-relay.";
    list service-outgoing-list {
      key "service-outgoing-index";
      description
        "List of the outgoing service
        that separately for each node
        where services will be eliminated.";
      leaf service-outgoing-index {
        type uint8;
        description
          "This index allows a list of multiple outgoing
          forwarding sub-layers";
      }
      uses detnet-header;
      uses forwarding-sub-layer-group;
    }
  }
  container service-sub-layer {
    description
      "This service sub-layer is sent to the service
      sub-layers of the lower layer for service-to-service
      aggregation at the ingress node or relay node. The
      service sub-layer encapsulates the DetNet
      Control-Word and S-label when the operation type is
      service-initiation, and swaps the S-label when the
      operation type is service-relay.";
    leaf aggregation-service-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.";
      uses rt-types:mpls-label-stack;
    }
  }
  container app-flow {
    description
```

[illegible]

```
    container incoming-type {
      description
        "The DetNet forwarding sub-layer incoming
        configuration.";
      choice incoming-type {
        mandatory true;
        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-type {
    description
      "The DetNet forwarding sub-layer outbound
      configuration.";
    choice outgoing-type {
      mandatory true;
      description
        "This is when a service connected directly to an
        interface with no forwarding sub-layer.";
      container
        interface {
          description
            "This forwarding sub-layer is sent to the interface
            for send to next-hop at the ingress node or relay
            node or transit node.";
          uses detnet-forwarding-next-hop-content;
        }
      container service-aggregation {
```

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



```
}  
}  
}  
  
<CODE ENDS>
```

8. Open Issues

There are some open issues that are still under discussion:

- Terminology.
- Security Considerations.

These issues will be resolved in the following versions of the draft.

9. IANA Considerations

This document makes no request of IANA.

Note to RFC Editor: this section may be removed on publication as an RFC.

10. Security Considerations

<TBD>

11. Acknowledgements

12. References

12.1. Normative References

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- [RFC6991] Schoenwaelder, J., Ed., "Common YANG Data Types", RFC 6991, DOI 10.17487/RFC6991, July 2013, <<https://www.rfc-editor.org/info/rfc6991>>.
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- [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>>.

12.2. Informative References

[I-D.ietf-detnet-flow-information-model] Varga, B., Farkas, J., Cummings, R., Jiang, Y., and D. Fedyk, "DetNet Flow and Service Information Model", Work in Progress, Internet-Draft, draft-ietf-detnet-flow-information-model-14, 24 January 2021, <<http://www.ietf.org/internet-drafts/draft-ietf-detnet-flow-information-model-14.txt>>.

Appendix A. 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.

- A simple DetNet application illustrating multiplexing of Application Flows.
- A case of Forwarding sub-layer aggregation using a single forwarding sublayer.
- A case of Service sub-layer aggregation with and aggregation label.

A.1. Example JSON Configuration/Operational

Reference Case A-1. This illustrates aggregation Ingress node 1 aggregates App flows 0 and 1 into a service sub-layer of DetNet flow 1.

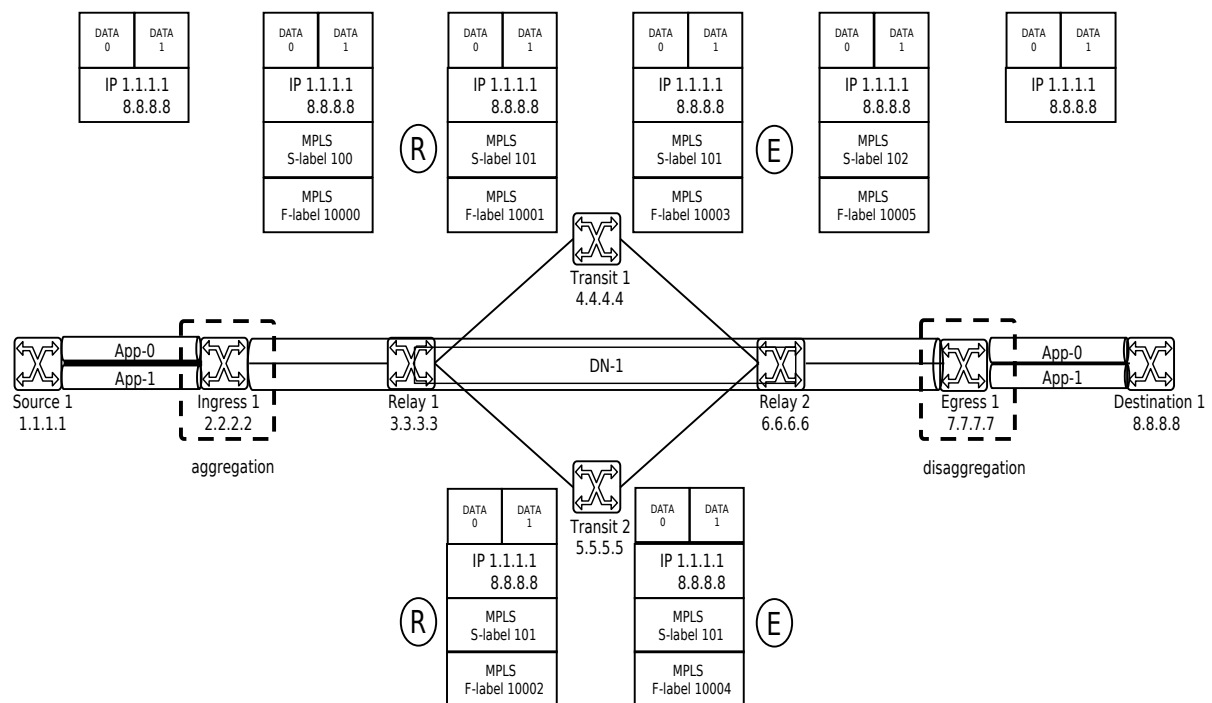


Figure 1: Case A1 Example JSON Operational/Configuration

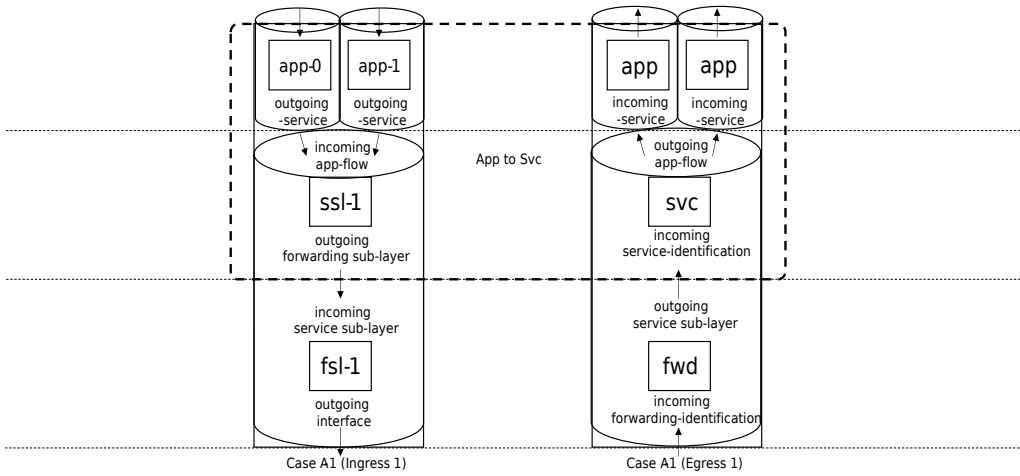


Figure 2: Case 1 Example JSON Operational/Configuration


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "app-flows": {
      "app-flow": [
        {
          "name": "app-0",
          "app-flow-bidir-congruent": false,
          "outgoing-service": "ssl-1",
          "traffic-profile": "pf-1",
          "ingress": {
            "app-flow-status": "ready",
            "interface": "eth0",
            "ip-app-flow": {
```

```
        "src-ip-prefix": "1.1.1.1/32",
        "dest-ip-prefix": "8.8.8.8/32",
        "dscp": 6
      }
    },
    {
      "name": "app-1",
      "app-flow-bidir-congruent": false,
      "outgoing-service": "ssl-1",
      "traffic-profile": "pf-1",
      "ingress": {
        "app-flow-status": "ready",
        "interface": "eth0",
        "ip-app-flow": {
          "src-ip-prefix": "2.1.1.1/32",
          "dest-ip-prefix": "9.8.8.8/32",
          "dscp": 7
        }
      }
    }
  ]
},
"traffic-profile": [
  {
    "profile-name": "pf-1",
    "traffic-requirements": {
      "min-bandwidth": "1000000000",
      "max-latency": 1000000000,
      "max-latency-variation": 2000000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "flow-spec": {
      "interval": 5,
      "max-pkts-per-interval": 10,
      "max-payload-size": 1500,
      "min-payload-size": 100,
      "min-pkts-per-interval": 1
    },
    "member-apps": [
      "app-0",
      "app-1"
    ]
  },
  {
    "profile-name": "pf-2",
    "traffic-requirements": {
      "min-bandwidth": "2000000000",
      "max-latency": 1000000000,
      "max-latency-variation": 2000000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "flow-spec": {
      "interval": 5,
```

```
        "max-pkts-per-interval": 10,
        "max-payload-size": 1500,
        "min-payload-size": 100,
        "min-pkts-per-interval": 1
      },
      "member-services": [
        "ssl-1"
      ]
    },
    {
      "profile-name": "pf-3",
      "flow-spec": {
        "interval": 5,
        "max-pkts-per-interval": 10,
        "max-payload-size": 1500
      },
      "member-fwd-sublayers": [
        "fsl-1"
      ]
    }
  ],
  "service-sub-layer": {
    "service-sub-layer-list": [
      {
        "name": "ssl-1",
        "service-rank": 10,
        "traffic-profile": "pf-2",
        "service-operation-type": "service-initiation",
        "service-protection": {
          "service-protection-type": "none",
          "sequence-number-length": "long-sn"
        },
        "incoming-type": {
          "app-flow": {
            "app-flow-list": [
              "app-0",
              "app-1"
            ]
          }
        },
        "outgoing-type": {
          "forwarding-sub-layer": {
            "service-outgoing-list": [
              {
                "service-outgoing-index": 0,
                "mpls-label-stack": {
                  "entry": [
                    {
                      "id": 0,
                      "label": 100
                    }
                  ]
                }
              },
              "forwarding-sub-layer": [
                "fsl-1"
              ]
            ]
          }
        }
      ]
    }
  ]
}
```

```
    }
  }
}
],
"forwarding-sub-layer": {
  "forwarding-sub-layer-list": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-3",
      "forwarding-operation-type": "impose-and-forward",
      "incoming-type": {
        "service-sub-layer": {
          "service-sub-layer": [
            "ssl-1"
          ]
        }
      },
      "outgoing-type": {
        "interface": {
          "outgoing-interface": "eth2",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10000
              }
            ]
          }
        }
      }
    }
  ]
}
}
```

Figure 3: Example A1 DetNet JSON configuration

A.2. Example B1 XML Config: Aggregation using a Forwarding Sub-layer

Reference Case B-1. This illustrates the service sub-layers of DetNet flows 1 and 2 are aggregated into a forwarding sub-layer.

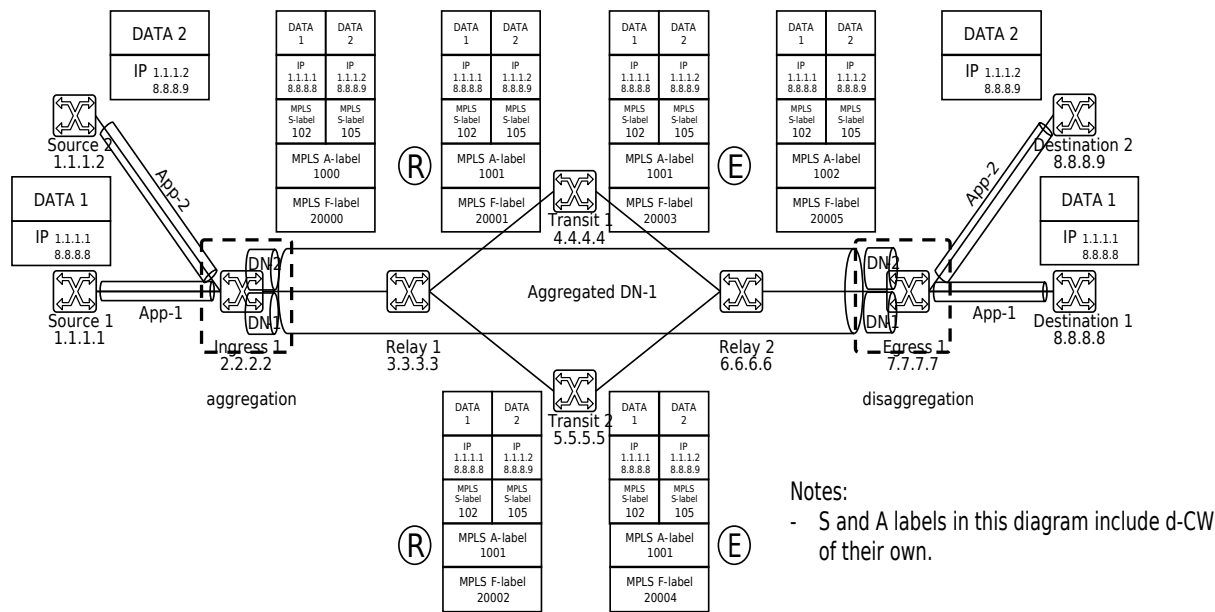


Figure 4: Case 2 Example XML Config: Aggregation using a Forwarding Sub-layer


```
<interfaces
  xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
  xmlns:ia="urn:ietf:params:xml:ns:yang:iana-if-type">
  <interface>
    <name>eth0</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>2020-12-18T23:59:00Z</discontinuity-time>
    </statistics>
  </interface>
  <interface>
    <name>eth1</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>2020-12-18T23:59:00Z</discontinuity-time>
    </statistics>
  </interface>
  <interface>
    <name>eth2</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>2020-12-18T23:59:00Z</discontinuity-time>
    </statistics>
  </interface>
  <interface>
    <name>eth3</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>2020-12-18T23:59:00Z</discontinuity-time>
    </statistics>
  </interface>
  <interface>
    <name>eth4</name>
    <type>ia:ethernetCsmacd</type>
    <oper-status>up</oper-status>
    <statistics>
      <discontinuity-time>2020-12-18T23:59:00Z</discontinuity-time>
    </statistics>
  </interface>
</interfaces>
<detnet
  xmlns="urn:ietf:params:xml:ns:yang:ietf-detnet">
  <app-flows>
    <app-flow>
      <name>app-1</name>
      <app-flow-bidir-congruent>false</app-flow-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>1.1.1.1/32</src-ip-prefix>
        </ip-app-flow>
      </ingress>
    </app-flow>
  </app-flows>
</detnet>
```

```

        <dest-ip-prefix>8.8.8.8/32</dest-ip-prefix>
        <dscp>6</dscp>
      </ip-app-flow>
    </ingress>
  </app-flow>
  <app-flow>
    <name>app-2</name>
    <app-flow-bidir-congruent>false</app-flow-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>2.1.1.1/32</src-ip-prefix>
        <dest-ip-prefix>9.8.8.8/32</dest-ip-prefix>
        <dscp>7</dscp>
      </ip-app-flow>
      <dscp>7</dscp>
    </ingress>
  </app-flow>
</app-flows>
<traffic-profile>
  <profile-name>1</profile-name>
  <traffic-requirements>
    <min-bandwidth>1000000000</min-bandwidth>
    <max-latency>1000000000</max-latency>
    <max-latency-variation>2000000000</max-latency-variation>
    <max-loss>2</max-loss>
    <max-consecutive-loss-tolerance>5</max-consecutive-loss-tolerance>
    <max-misordering>0</max-misordering>
  </traffic-requirements>
  <member-apps>app-1</member-apps>
  <member-apps>app-2</member-apps>
</traffic-profile>
<traffic-profile>
  <profile-name>2</profile-name>
  <traffic-requirements>
    <min-bandwidth>1000000000</min-bandwidth>
    <max-latency>1000000000</max-latency>
    <max-latency-variation>2000000000</max-latency-variation>
    <max-loss>2</max-loss>
    <max-consecutive-loss-tolerance>5</max-consecutive-loss-tolerance>
    <max-misordering>0</max-misordering>
  </traffic-requirements>
  <member-services>ssl-1</member-services>
  <member-services>ssl-2</member-services>
</traffic-profile>
<traffic-profile>
  <profile-name>3</profile-name>
  <flow-spec>
    <interval>5</interval>
    <max-pkts-per-interval>10</max-pkts-per-interval>
    <max-payload-size>1500</max-payload-size>
  </flow-spec>
  <member-fwd-sublayers>afl-1</member-fwd-sublayers>
</traffic-profile>
<service-sub-layer>

```

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

```
</outgoing-type>
</service-sub-layer-list>
</service-sub-layer>
<forwarding-sub-layer>
<forwarding-sub-layer-list>
  <name>afl-1</name>
  <traffic-profile>3</traffic-profile>
  <forwarding-operation-type>impose-and-forward
</forwarding-operation-type>
  <incoming-type>
    <service-sub-layer>
      <service-sub-layer>ssl-1</service-sub-layer>
      <service-sub-layer>ssl-2</service-sub-layer>
    </service-sub-layer>
  </incoming-type>
  <outgoing-type>
    <interface>
      <outgoing-interface>eth2</outgoing-interface>
      <mpls-label-stack>
        <entry>
          <id>0</id>
          <label>10000</label>
        </entry>
      </mpls-label-stack>
    </interface>
  </outgoing-type>
</forwarding-sub-layer-list>
</forwarding-sub-layer>
</detnet>
```

Figure 5: Example DetNet XML configuration

A.3. Example B2 JSON Service Aggregation Configuration

Reference Case B-2. This illustrates the service sub-layers of DetNet flows 1 and 2 are aggregated into a service sub-layer of aggregated DetNet flow 1.

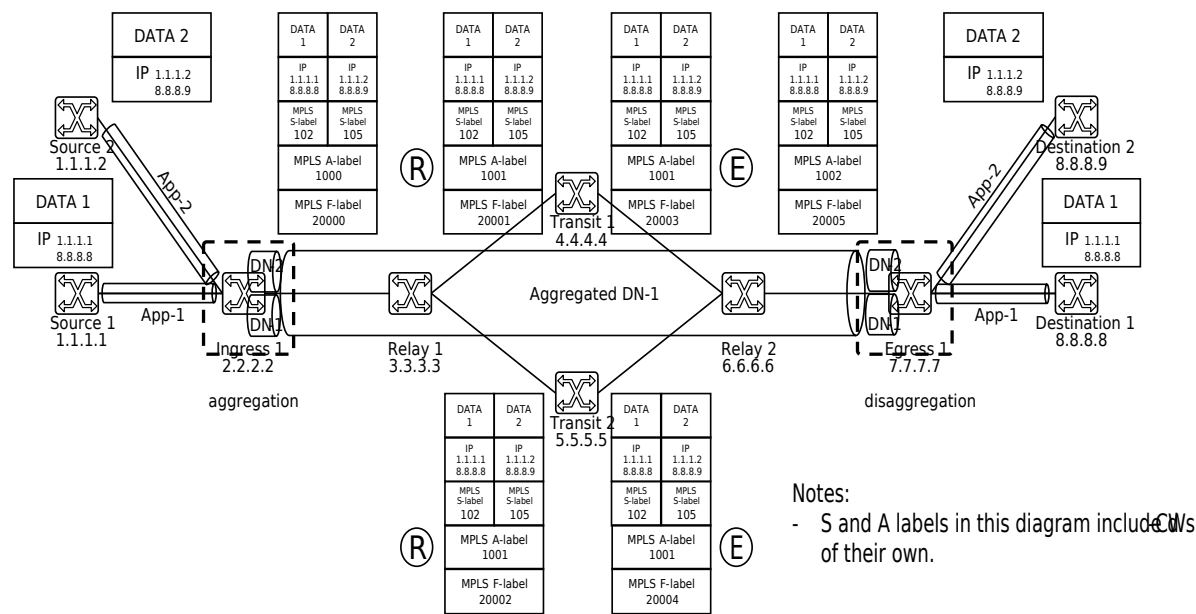


Figure 6: Case B2 Example JSON Service Aggregation


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-10-02T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-10-02T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-10-02T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-10-02T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-10-02T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "app-flows": {
      "app-flow": [
        {
          "name": "app-1",
          "app-flow-bidir-congruent": false,
          "outgoing-service": "ssl-1",
          "traffic-profile": "1",
          "ingress": {
            "app-flow-status": "ready",
            "interface": "eth0",
            "ip-app-flow": {
```

```
        "src-ip-prefix": "1.1.1.1/32",
        "dest-ip-prefix": "8.8.8.8/32",
        "dscp": 6
      }
    },
    {
      "name": "app-2",
      "app-flow-bidir-congruent": false,
      "outgoing-service": "ssl-2",
      "traffic-profile": "1",
      "ingress": {
        "app-flow-status": "ready",
        "interface": "eth0",
        "ip-app-flow": {
          "src-ip-prefix": "2.1.1.1/32",
          "dest-ip-prefix": "9.8.8.8/32",
          "dscp": 7
        }
      }
    }
  ]
},
"traffic-profile": [
  {
    "profile-name": "1",
    "traffic-requirements": {
      "min-bandwidth": "100000000",
      "max-latency": 100000000,
      "max-latency-variation": 200000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "member-apps": [
      "app-1",
      "app-2"
    ]
  },
  {
    "profile-name": "2",
    "traffic-requirements": {
      "min-bandwidth": "100000000",
      "max-latency": 100000000,
      "max-latency-variation": 200000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "3",
    "flow-spec": {
      "interval": 5,
```

```
        "max-pkts-per-interval": 10,
        "max-payload-size": 1500
      },
      "member-fwd-sublayers": [
        "afl-1"
      ]
    }
  ],
  "service-sub-layer": {
    "service-sub-layer-list": [
      {
        "name": "ssl-1",
        "service-rank": 10,
        "traffic-profile": "2",
        "service-protection": {
          "service-protection-type": "none",
          "sequence-number-length": "long-sn"
        },
        "service-operation-type": "service-initiation",
        "incoming-type": {
          "app-flow": {
            "app-flow-list": [
              "app-1"
            ]
          }
        }
      },
      {
        "outgoing-type": {
          "service-sub-layer": {
            "aggregation-service-sub-layer": "asl-1",
            "service-label": {
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 102
                  }
                ]
              }
            }
          }
        }
      }
    ]
  },
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "2",
    "service-operation-type": "service-initiation",
    "service-protection": {
      "service-protection-type": "none",
      "sequence-number-length": "long-sn"
    },
    "incoming-type": {
      "app-flow": {
        "app-flow-list": [
          "app-2"
        ]
      }
    }
  }
],
```

```
    "outgoing-type": {
      "service-sub-layer": {
        "aggregation-service-sub-layer": "asl-1",
        "service-label": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 105
              }
            ]
          }
        }
      }
    },
    {
      "name": "asl-1",
      "service-rank": 10,
      "service-protection": {
        "service-protection-type": "none",
        "sequence-number-length": "long-sn"
      },
      "incoming-type": {
        "service-aggregation": {
          "service-sub-layer": [
            "ssl-1",
            "ssl-2"
          ]
        }
      },
      "outgoing-type": {
        "forwarding-sub-layer": {
          "service-outgoing-list": [
            {
              "service-outgoing-index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 1000
                  }
                ]
              }
            }
          ],
          "forwarding-sub-layer": [
            "afl-1"
          ]
        }
      }
    }
  ],
  "forwarding-sub-layer": {
    "forwarding-sub-layer-list": [
      {
        "name": "afl-1",
```

```
"traffic-profile": "3",
"forwarding-operation-type": "impose-and-forward",
"incoming-type": {
  "service-sub-layer": {
    "service-sub-layer": [
      "asl-1"
    ]
  }
},
"outgoing-type": {
  "interface": {
    "outgoing-interface": "eth2",
    "mpls-label-stack": {
      "entry": [
        {
          "id": 0,
          "label": 20000
        }
      ]
    }
  }
}
}
```

Figure 7: Example DetNet JSON Service Aggregation

A.4. Example C1 JSON Relay Aggregation Configuration

Reference Case C-1. This illustrates where Relay node 1 aggregates the forwarding sub-layers of DetNet flows 1 and 2 into a forwarding sub-layer.


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },
    ],
  },
}
```

```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "pf-2",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "afl-1",
      "afl-2"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2",
      "fsl-3",
      "fsl-4",
      "fsl-5",
      "fsl-6"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "replication",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 100
              }
            ]
          }
        }
      }
    },
    {
      "outgoing-type": {
```



```
    "forwarding-sub-layer": {
      "service-outgoing-list": [
        {
          "service-outgoing-index": 0,
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 101
              }
            ]
          },
          "forwarding-sub-layer": [
            "fsl-2",
            "fsl-3"
          ]
        }
      ]
    }
  },
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "service-protection-type": "replication",
      "sequence-number-length": "long-sn"
    },
    "service-operation-type": "service-relay",
    "incoming-type": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 103
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "service-outgoing-list": [
          {
            "service-outgoing-index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 104
                }
              ]
            }
          ]
        },
        "forwarding-sub-layer": [
          "fsl-5",
          "fsl-6"
        ]
      }
    }
  }
]
```

```

    ]
  }
}
}
}
},
"forwarding-sub-layer": {
  "forwarding-sub-layer-list": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-3",
      "forwarding-operation-type": "pop-and-lookup",
      "incoming-type": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10000
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "service-sub-layer": {
          "service-sub-layer": [
            "ssl-1"
          ]
        }
      }
    }
  ],
  {
    "name": "fsl-2",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-1"
        ]
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "aggregation-forwarding-sub-layer": "afl-1",
        "forwarding-label": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10003
              }
            ]
          }
        }
      }
    }
  }
}
}

```

```
    }
  }
},
{
  "name": "fsl-3",
  "traffic-profile": "pf-3",
  "forwarding-operation-type": "impose-and-forward",
  "incoming-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "ssl-1"
      ]
    }
  },
  "outgoing-type": {
    "forwarding-sub-layer": {
      "aggregation-forwarding-sub-layer": "afl-2",
      "forwarding-label": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10004
            }
          ]
        }
      }
    }
  },
},
{
  "name": "fsl-4",
  "traffic-profile": "pf-3",
  "forwarding-operation-type": "pop-and-lookup",
  "incoming-type": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10006
          }
        ]
      }
    }
  },
  "outgoing-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "ssl-2"
      ]
    }
  },
},
{
  "name": "fsl-5",
```

```
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-2"
        ]
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "aggregation-forwarding-sub-layer": "afl-1",
        "forwarding-label": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10009
              }
            ]
          }
        }
      }
    }
  },
  {
    "name": "fsl-6",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-2"
        ]
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "aggregation-forwarding-sub-layer": "afl-2",
        "forwarding-label": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10010
              }
            ]
          }
        }
      }
    }
  }
],
{
  "name": "afl-1",
  "traffic-profile": "pf-2",
  "forwarding-operation-type": "impose-and-forward",
  "incoming-type": {
    "forwarding-aggregation": {
```

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

Figure 8: Example DetNet JSON Relay Service Aggregation

A.5. Example C1 JSON Relay Dissaggregation Configuration

Reference Case C-1. This illustrates where Relay node 2 disaggregates the forwarding sub-layers of DetNet flows 1 and 2 into a service sub-layer.

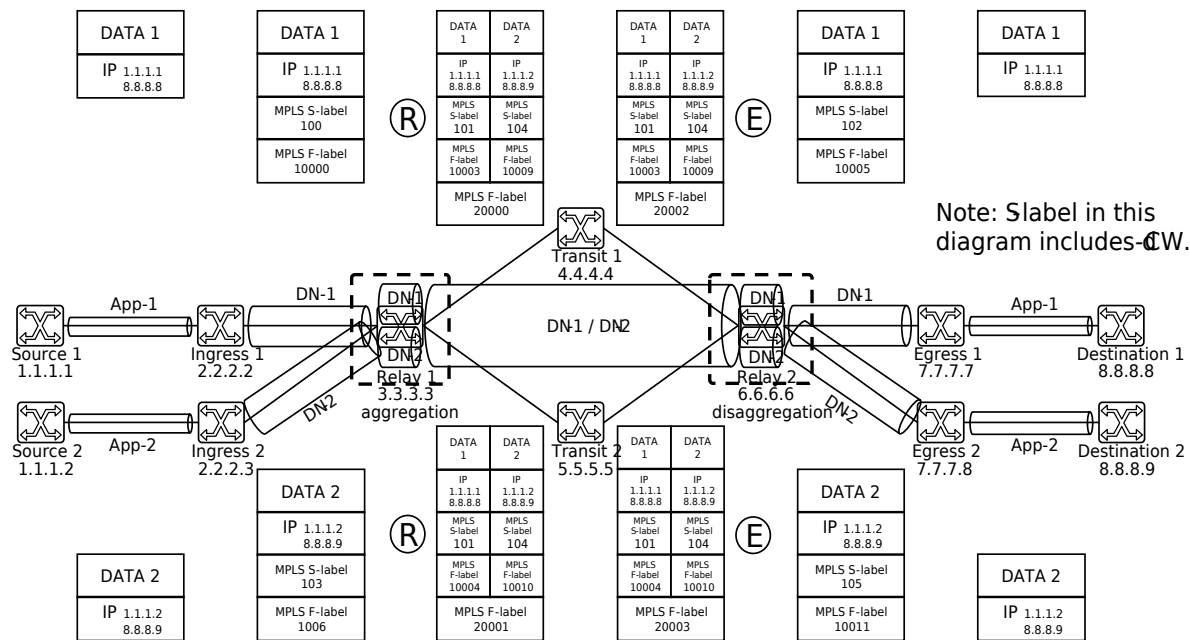


Figure 9: Case C1 Example JSON Service Aggregation


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },
    ]
  }
}
```



```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ],
  },
  {
    "profile-name": "pf-2",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "afl-1",
      "afl-2"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2",
      "fsl-3",
      "fsl-4",
      "fsl-5",
      "fsl-6"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "elimination",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 101
              }
            ]
          }
        }
      }
    }
  ],
  "outgoing-type": {
```

```
        "forwarding-sub-layer": {
          "service-outgoing-list": [
            {
              "service-outgoing-index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 102
                  }
                ]
              },
              "forwarding-sub-layer": [
                "fsl-3"
              ]
            }
          ]
        }
      },
    {
      "name": "ssl-2",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "elimination",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 104
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "forwarding-sub-layer": {
          "service-outgoing-list": [
            {
              "service-outgoing-index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 105
                  }
                ]
              },
              "forwarding-sub-layer": [
                "fsl-6"
              ]
            }
          ]
        }
      }
    }
  ]
}
```

```
    ]
  }
}
]
},
"forwarding-sub-layer": {
  "forwarding-sub-layer-list": [
    {
      "name": "afl-1",
      "traffic-profile": "pf-2",
      "forwarding-operation-type": "pop-and-lookup",
      "incoming-type": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 20002
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "forwarding-disaggregation": {
          "forwarding-sub-layer": [
            "fsl-1",
            "fsl-4"
          ]
        }
      }
    }
  ],
  {
    "name": "afl-2",
    "traffic-profile": "pf-2",
    "forwarding-operation-type": "pop-and-lookup",
    "incoming-type": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20003
            }
          ]
        }
      },
      "outgoing-type": {
        "forwarding-disaggregation": {
          "forwarding-sub-layer": [
            "fsl-2",
            "fsl-5"
          ]
        }
      }
    }
  ]
}
```

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

```
        "service-sub-layer": [
          "ssl-1"
        ]
      },
    },
    "outgoing-type": {
      "interface": {
        "outgoing-interface": "eth2",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10005
            }
          ]
        }
      }
    }
  },
  {
    "name": "fsl-4",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "pop-and-lookup",
    "incoming-type": {
      "forwarding-id": {
        "interface": "eth0",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10009
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-2"
        ]
      }
    }
  },
  {
    "name": "fsl-5",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "pop-and-lookup",
    "incoming-type": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10010
            }
          ]
        }
      }
    }
  }
]
```

```

    }
  },
  "outgoing-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "ssl-2"
      ]
    }
  },
  {
    "name": "fsl-6",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-2"
        ]
      }
    },
    "outgoing-type": {
      "interface": {
        "outgoing-interface": "eth3",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10011
            }
          ]
        }
      }
    }
  }
]
}

```

Figure 10: Example DetNet JSON Relay Service Dissaggregation

A.6. Example C2 JSON Relay Aggregation Service Sub-Layer

Reference Case C-2. This illustrates Relay node 1 aggregates the service sub-layers of DetNet flows 1 and 2 into a forwarding sub-layer

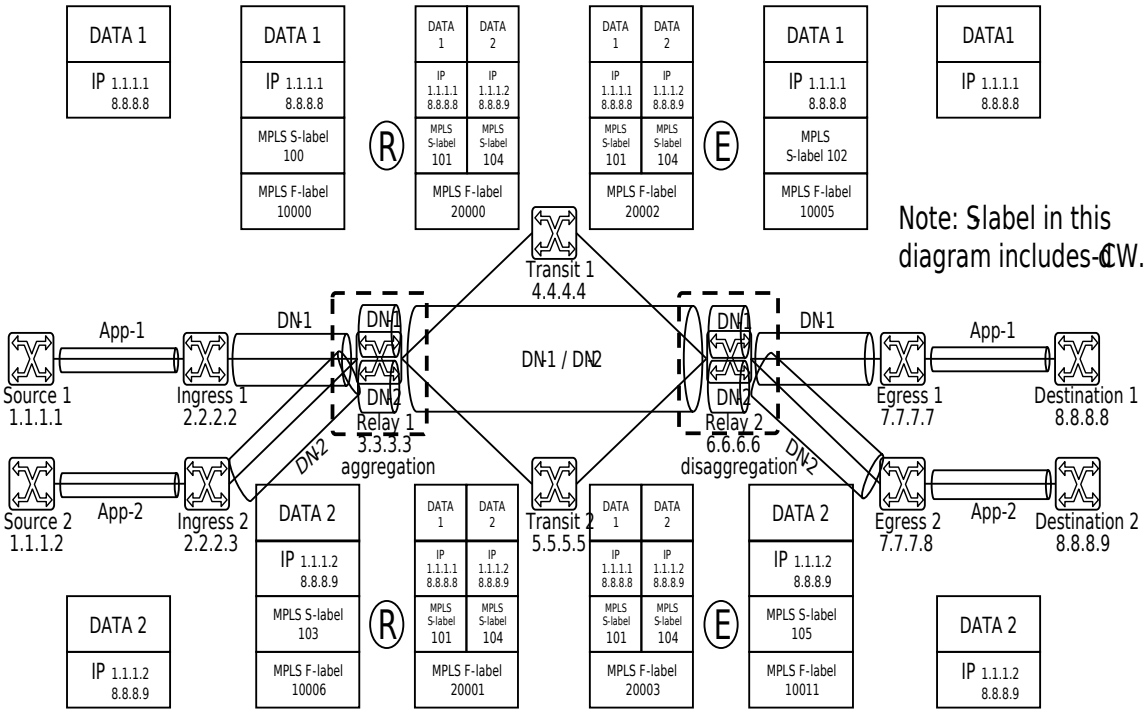


Figure 11: Case C2 Example JSON Service Aggregation


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },
    ]
  }
}
```

```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "pf-2",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "afl-1",
      "afl-2"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "replication",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 100
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "forwarding-sub-layer": {
          "service-outgoing-list": [
            {
              "service-outgoing-index": 0,
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 101
            }
          ]
        },
        "forwarding-sub-layer": [
          "afl-1",
          "afl-2"
        ]
      }
    ]
  },
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "service-protection-type": "replication",
      "sequence-number-length": "long-sn"
    },
    "service-operation-type": "service-relay",
    "incoming-type": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 103
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "service-outgoing-list": [
          {
            "service-outgoing-index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 104
                }
              ]
            }
          },
          "forwarding-sub-layer": [
            "afl-1",
            "afl-2"
          ]
        ]
      }
    ]
  }
}
```

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

```

    "traffic-profile": "pf-3",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-1",
          "ssl-2"
        ]
      }
    },
    "outgoing-type": {
      "interface": {
        "outgoing-interface": "eth2",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20000
            }
          ]
        }
      }
    }
  },
  {
    "name": "afl-2",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-1",
          "ssl-2"
        ]
      }
    },
    "outgoing-type": {
      "interface": {
        "outgoing-interface": "eth3",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20001
            }
          ]
        }
      }
    }
  }
}

```

Figure 12: Example DetNet JSON Relay Aggregation Service Sub-Layer

A.7. Example C3 JSON Relay Disaggregation Service Sub-Layer

Reference Case C-3. This illustrates Relay node 2 disaggregates the forwarding sub-layer with DetNet flows 1 and 2 into a service sub-layers


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },

```



```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "pf-2",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "afl-1",
      "afl-2"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "elimination",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 101
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "forwarding-sub-layer": {
          "service-outgoing-list": [
            {
              "service-outgoing-index": 0,
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 102
            }
          ]
        },
        "forwarding-sub-layer": [
          "fsl-1"
        ]
      ]
    }
  },
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "service-protection-type": "elimination",
      "sequence-number-length": "long-sn"
    },
    "service-operation-type": "service-relay",
    "incoming-type": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 104
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "service-outgoing-list": [
          {
            "service-outgoing-index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 105
                }
              ]
            }
          },
          "forwarding-sub-layer": [
            "fsl-2"
          ]
        ]
      }
    }
  }
}
```

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

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

Figure 13: Example DetNet JSON Relay Disaggregation Service Sub-Layer

A.8. Example C3 JSON Relay Service Sub-Layer Aggregation

Reference Case C-3. This illustrates Relay node 1 aggregates the service sub-layers of DetNet flows 1 and 2 into a service sub-layer of Aggregated DetNet flow 1.


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },

```

```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "pf-2",
    "traffic-requirements": {
      "min-bandwidth": "2000000000",
      "max-latency": 1000000000,
      "max-latency-variation": 1000000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "member-services": [
      "asl-1"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2"
    ]
  },
  {
    "profile-name": "pf-4",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-3",
      "fsl-4"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "none",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
```



```
        "entry": [
          {
            "id": 0,
            "label": 100
          }
        ]
      }
    },
    "outgoing-type": {
      "service-sub-layer": {
        "aggregation-service-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": {
        "service-protection-type": "none",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 103
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "service-sub-layer": {
          "aggregation-service-sub-layer": "asl-1",
          "service-label": {
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 104
                }
              ]
            }
          }
        }
      }
    }
  ],
  {
    "name": "ssl-2",
    "service-rank": 10,
    "traffic-profile": "pf-1",
    "service-protection": {
      "service-protection-type": "none",
      "sequence-number-length": "long-sn"
    },
    "service-operation-type": "service-relay",
    "incoming-type": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 103
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "service-sub-layer": {
        "aggregation-service-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": {
    "service-protection-type": "replication",
    "sequence-number-length": "long-sn"
  },
  "service-operation-type": "service-initiation",
  "incoming-type": {
    "service-aggregation": {
      "service-sub-layer": [
        "ssl-1",
        "ssl-2"
      ]
    }
  },
  "outgoing-type": {
    "forwarding-sub-layer": {
      "service-outgoing-list": [
        {
          "service-outgoing-index": 0,
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 1000
              }
            ]
          },
          "forwarding-sub-layer": [
            "fsl-3",
            "fsl-4"
          ]
        }
      ]
    }
  }
},
{
  "name": "fsl-1",
  "traffic-profile": "pf-3",
  "forwarding-operation-type": "pop-and-lookup",
  "incoming-type": {
    "forwarding-id": {
      "interface": "eth0",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,

```

```
        "label": 10000
      }
    ]
  }
},
"outgoing-type": {
  "service-sub-layer": {
    "service-sub-layer": [
      "ssl-1"
    ]
  }
},
{
  "name": "fsl-2",
  "traffic-profile": "pf-3",
  "forwarding-operation-type": "pop-and-lookup",
  "incoming-type": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10006
          }
        ]
      }
    }
  },
  "outgoing-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "ssl-2"
      ]
    }
  }
},
{
  "name": "fsl-3",
  "traffic-profile": "pf-4",
  "forwarding-operation-type": "impose-and-forward",
  "incoming-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "asl-1"
      ]
    }
  },
  "outgoing-type": {
    "interface": {
      "outgoing-interface": "eth2",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 20000
          }
        ]
      }
    }
  }
}
```

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

Figure 14: Example DetNet JSON Relay Service Sub-Layer Aggregation

A.9. Example C3 JSON Relay Service Sub-Layer Disaggregation

Reference Case C-3. This illustrates Relay node 1 disaggregates Aggregated DetNet flow 1 into the DetNet flows 1 and 2 service sub-layers.

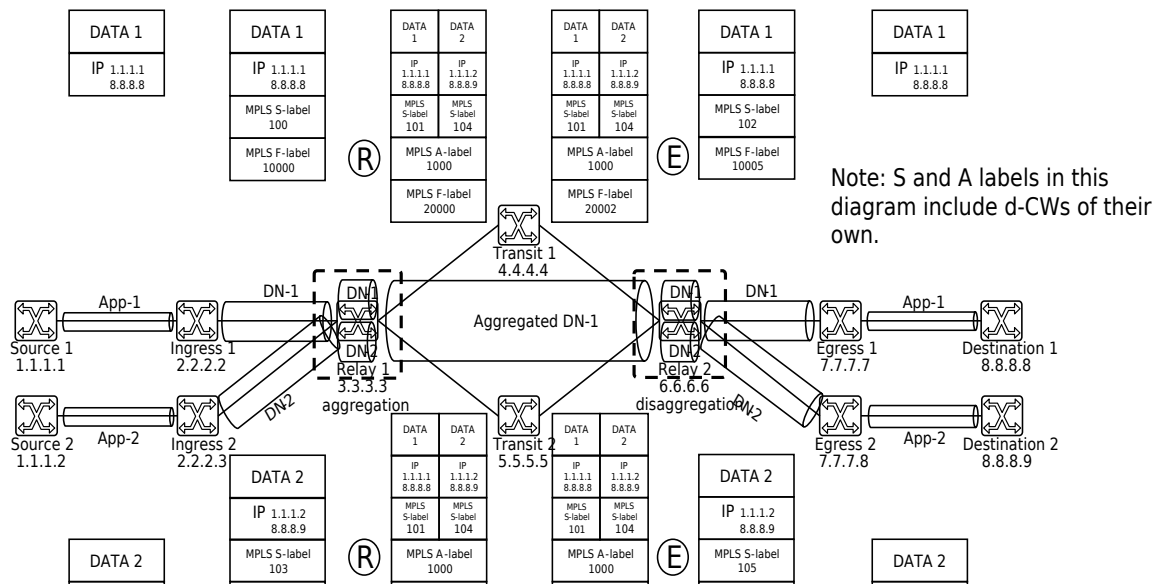


Figure 15: Case C3 Example JSON Service Aggregation


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },
    ],
  },
}
```

```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "pf-2",
    "traffic-requirements": {
      "min-bandwidth": "2000000000",
      "max-latency": 1000000000,
      "max-latency-variation": 1000000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "member-services": [
      "asl-1"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-3",
      "fsl-4"
    ]
  },
  {
    "profile-name": "pf-4",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "none",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
```



```
        "entry": [
          {
            "id": 0,
            "label": 101
          }
        ]
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "service-outgoing-list": [
          {
            "service-outgoing-index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 102
                }
              ]
            }
          },
          "forwarding-sub-layer": [
            "fsl-3"
          ]
        ]
      }
    },
    {
      "name": "ssl-2",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "none",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 104
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "forwarding-sub-layer": {
          "service-outgoing-list": [
            {
              "service-outgoing-index": 0,
              "mpls-label-stack": {
                "entry": [
```

```
        {
          "id": 0,
          "label": 105
        }
      ]
    },
    "forwarding-sub-layer": [
      "fsl-4"
    ]
  }
}
},
{
  "name": "asl-1",
  "service-rank": 10,
  "traffic-profile": "pf-2",
  "service-protection": {
    "service-protection-type": "elimination",
    "sequence-number-length": "long-sn"
  },
  "service-operation-type": "service-termination",
  "incoming-type": {
    "service-id": {
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 1000
          }
        ]
      }
    }
  },
  "outgoing-type": {
    "service-disaggregation": {
      "service-sub-layer": [
        "ssl-1",
        "ssl-2"
      ]
    }
  }
}
],
"forwarding-sub-layer": {
  "forwarding-sub-layer-list": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-4",
      "forwarding-operation-type": "pop-and-lookup",
      "incoming-type": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {

```

```
        "id": 0,
        "label": 20002
      }
    ]
  }
},
"outgoing-type": {
  "service-sub-layer": {
    "service-sub-layer": [
      "asl-1"
    ]
  }
},
{
  "name": "fsl-2",
  "traffic-profile": "pf-4",
  "forwarding-operation-type": "pop-and-lookup",
  "incoming-type": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 20003
          }
        ]
      }
    }
  },
  "outgoing-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "asl-1"
      ]
    }
  }
},
{
  "name": "fsl-3",
  "traffic-profile": "pf-3",
  "forwarding-operation-type": "impose-and-forward",
  "incoming-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "ssl-1"
      ]
    }
  },
  "outgoing-type": {
    "interface": {
      "outgoing-interface": "eth2",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
```

```

    "label": 10005
  }
]
}
},
{
  "name": "fsl-4",
  "traffic-profile": "pf-3",
  "forwarding-operation-type": "impose-and-forward",
  "incoming-type": {
    "service-sub-layer": {
      "service-sub-layer": [
        "ssl-2"
      ]
    }
  },
  "outgoing-type": {
    "interface": {
      "outgoing-interface": "eth3",
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 10011
          }
        ]
      }
    }
  }
}
}
}
}
}
}
```

Figure 16: Example DetNet JSON Relay Service Sub-Layer Aggregation

A.10. Example C4 JSON Relay Forwarding Sub-Layer Aggregation

Reference Case C-4. This illustrates Relay node 1 aggregates the forwarding sub-layers of DetNet flow 1 and 2 into a service sub-layer of Aggregated DetNet flow 1.


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },
    ],
  },
}
```

```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "pf-2",
    "traffic-requirements": {
      "min-bandwidth": "2000000000",
      "max-latency": 1000000000,
      "max-latency-variation": 1000000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "member-services": [
      "asl-1"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2",
      "fsl-3",
      "fsl-4"
    ]
  },
  {
    "profile-name": "pf-4",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-5",
      "fsl-6"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "none",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
```

```
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 100
              }
            ]
          }
        },
      },
      "outgoing-type": {
        "forwarding-sub-layer": {
          "service-outgoing-list": [
            {
              "service-outgoing-index": 0,
              "mpls-label-stack": {
                "entry": [
                  {
                    "id": 0,
                    "label": 101
                  }
                ]
              }
            }
          ],
        },
        "forwarding-sub-layer": [
          "fsl-3"
        ]
      }
    ]
  }
},
{
  "name": "ssl-2",
  "service-rank": 10,
  "traffic-profile": "pf-1",
  "service-protection": {
    "service-protection-type": "none",
    "sequence-number-length": "long-sn"
  },
  "service-operation-type": "service-relay",
  "incoming-type": {
    "service-id": {
      "mpls-label-stack": {
        "entry": [
          {
            "id": 0,
            "label": 103
          }
        ]
      }
    }
  },
  "outgoing-type": {
    "forwarding-sub-layer": {
      "service-outgoing-list": [
        {
          "service-outgoing-index": 0,
```



```

        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 104
            }
          ]
        },
        "forwarding-sub-layer": [
          "fsl-4"
        ]
      ]
    }
  },
  {
    "name": "asl-1",
    "service-rank": 10,
    "traffic-profile": "pf-2",
    "service-protection": {
      "service-protection-type": "replication",
      "sequence-number-length": "long-sn"
    },
    "service-operation-type": "service-initiation",
    "incoming-type": {
      "forwarding-aggregation": {
        "forwarding-sub-layer": [
          "fsl-3",
          "fsl-4"
        ]
      }
    },
    "outgoing-type": {
      "forwarding-sub-layer": {
        "service-outgoing-list": [
          {
            "service-outgoing-index": 0,
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 1000
                }
              ]
            },
            "forwarding-sub-layer": [
              "fsl-5",
              "fsl-6"
            ]
          }
        ]
      }
    }
  }
],
"forwarding-sub-layer": {

```

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

```

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

```

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

```

Figure 17: Example DetNet JSON Relay Service Sub-Layer Aggregation

A.11. Example C4 JSON Relay Service Sub-Layer Disaggregation

Reference Case C-4. This illustrates Relay node 1 disaggregates service sub-layer of Aggregated DetNet flow 1 to forwarding sub-layers of DetNet flow 1 and 2.

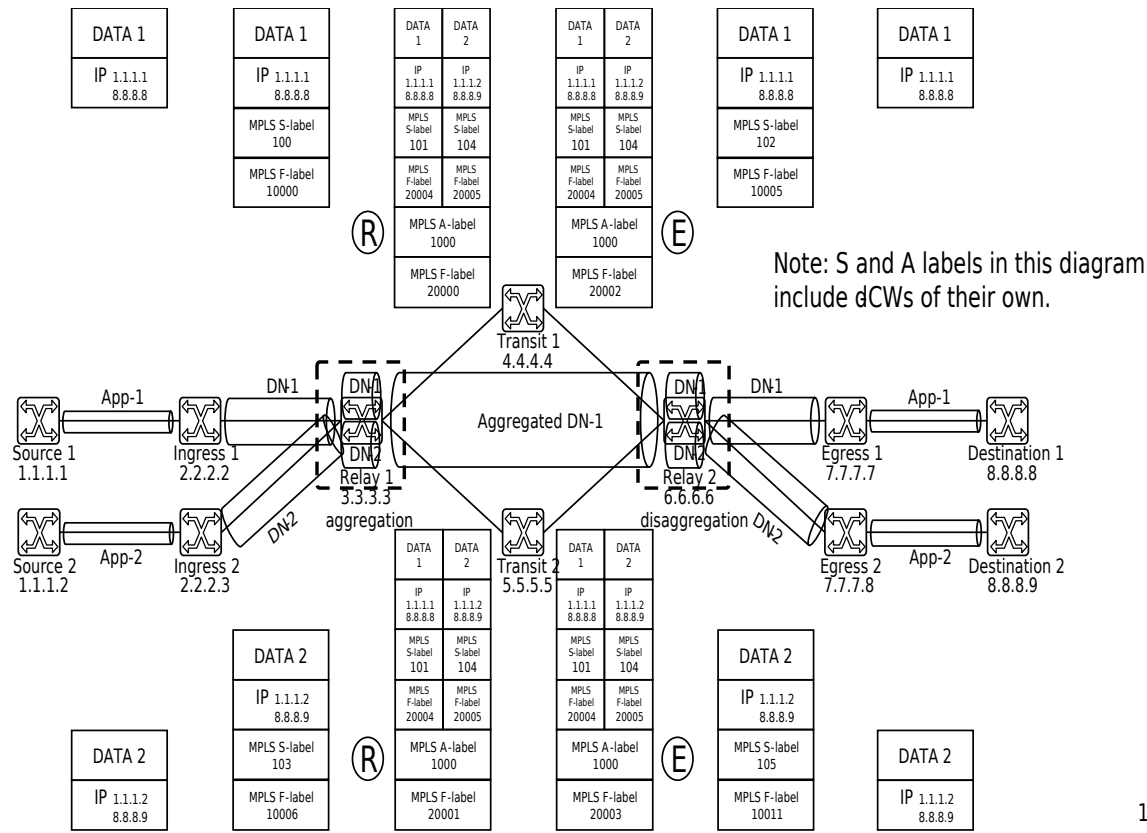


Figure 18: Case C4 Example JSON Service Aggregation


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "traffic-requirements": {
          "min-bandwidth": "1000000000",
          "max-latency": 1000000000,
          "max-latency-variation": 1000000000,
          "max-loss": 2,
          "max-consecutive-loss-tolerance": 5,
          "max-misordering": 0
        }
      },

```

```
    "member-services": [
      "ssl-1",
      "ssl-2"
    ]
  },
  {
    "profile-name": "pf-2",
    "traffic-requirements": {
      "min-bandwidth": "2000000000",
      "max-latency": 1000000000,
      "max-latency-variation": 1000000000,
      "max-loss": 2,
      "max-consecutive-loss-tolerance": 5,
      "max-misordering": 0
    },
    "member-services": [
      "asl-1"
    ]
  },
  {
    "profile-name": "pf-3",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 1,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-3",
      "fsl-4",
      "fsl-5",
      "fsl-6"
    ]
  },
  {
    "profile-name": "pf-4",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "fsl-1",
      "fsl-2"
    ]
  }
],
"service-sub-layer": {
  "service-sub-layer-list": [
    {
      "name": "ssl-1",
      "service-rank": 10,
      "traffic-profile": "pf-1",
      "service-protection": {
        "service-protection-type": "none",
        "sequence-number-length": "long-sn"
      },
      "service-operation-type": "service-relay",
      "incoming-type": {
```



```
        "service-id": {
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 101
              }
            ]
          }
        },
        "outgoing-type": {
          "forwarding-sub-layer": {
            "service-outgoing-list": [
              {
                "service-outgoing-index": 0,
                "mpls-label-stack": {
                  "entry": [
                    {
                      "id": 0,
                      "label": 102
                    }
                  ]
                }
              }
            ],
            "forwarding-sub-layer": [
              "fsl-5"
            ]
          }
        }
      },
      {
        "name": "ssl-2",
        "service-rank": 10,
        "traffic-profile": "pf-1",
        "service-protection": {
          "service-protection-type": "none",
          "sequence-number-length": "long-sn"
        },
        "service-operation-type": "service-relay",
        "incoming-type": {
          "service-id": {
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 104
                }
              ]
            }
          }
        },
        "outgoing-type": {
          "forwarding-sub-layer": {
            "service-outgoing-list": [
              {
                "service-outgoing-index": 0,
```

```
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 105
            }
          ]
        },
        "forwarding-sub-layer": [
          "fsl-6"
        ]
      ]
    }
  },
  {
    "name": "asl-1",
    "service-rank": 10,
    "traffic-profile": "pf-2",
    "service-protection": {
      "service-protection-type": "elimination",
      "sequence-number-length": "long-sn"
    },
    "service-operation-type": "service-termination",
    "incoming-type": {
      "service-id": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 1000
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "forwarding-disaggregation": {
        "forwarding-sub-layer": [
          "fsl-3",
          "fsl-4"
        ]
      }
    }
  }
],
"forwarding-sub-layer": {
  "forwarding-sub-layer-list": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-4",
      "forwarding-operation-type": "pop-and-lookup",
      "incoming-type": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
```

```
        "entry": [
          {
            "id": 0,
            "label": 20002
          }
        ]
      }
    },
    "outgoing-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "asl-1"
        ]
      }
    }
  },
  {
    "name": "fsl-2",
    "traffic-profile": "pf-4",
    "forwarding-operation-type": "pop-and-lookup",
    "incoming-type": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20003
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "asl-1"
        ]
      }
    }
  },
  {
    "name": "fsl-3",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "pop-and-lookup",
    "incoming-type": {
      "forwarding-id": {
        "interface": "eth0",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20004
            }
          ]
        }
      }
    }
  }
}
```

```
    },
    "outgoing-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-1"
        ]
      }
    }
  },
  {
    "name": "fsl-4",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "pop-and-lookup",
    "incoming-type": {
      "forwarding-id": {
        "interface": "eth1",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20005
            }
          ]
        }
      }
    },
    "outgoing-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-2"
        ]
      }
    }
  },
  {
    "name": "fsl-5",
    "traffic-profile": "pf-3",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "service-sub-layer": {
        "service-sub-layer": [
          "ssl-1"
        ]
      }
    },
    "outgoing-type": {
      "interface": {
        "outgoing-interface": "eth2",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10005
            }
          ]
        }
      }
    }
  }
}
```

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

Figure 19: Example DetNet JSON Relay Service Sub-Layer Aggregation

A.12. Example D1 JSON Transit Forwarding Sub-Layer Aggregation

Reference Case D-1. This illustrates Transit node 1 aggregates the forwarding sub-layers of DetNet flow 1 and 2 into a forwarding sub-layer.


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "flow-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayers": [
          "fsl-1",
          "fsl-2"
        ]
      }
    ]
  }
}
```

```
    ]
  },
  {
    "profile-name": "pf-2",
    "flow-spec": {
      "interval": 125,
      "max-pkts-per-interval": 2,
      "max-payload-size": 1518
    },
    "member-fwd-sublayers": [
      "afl-1"
    ]
  }
],
"forwarding-sub-layer": {
  "forwarding-sub-layer-list": [
    {
      "name": "fsl-1",
      "traffic-profile": "pf-1",
      "forwarding-operation-type": "pop-impose-and-forward",
      "incoming-type": {
        "forwarding-id": {
          "interface": "eth0",
          "mpls-label-stack": {
            "entry": [
              {
                "id": 0,
                "label": 10000
              }
            ]
          }
        }
      },
      "outgoing-type": {
        "forwarding-sub-layer": {
          "aggregation-forwarding-sub-layer": "afl-1",
          "forwarding-label": {
            "mpls-label-stack": {
              "entry": [
                {
                  "id": 0,
                  "label": 10002
                }
              ]
            }
          }
        }
      }
    }
  ]
},
{
  "name": "fsl-2",
  "traffic-profile": "pf-1",
  "forwarding-operation-type": "pop-impose-and-forward",
  "incoming-type": {
    "forwarding-id": {
      "interface": "eth1",
      "mpls-label-stack": {
        "entry": [
```



```
{
  {
    "id": 0,
    "label": 10004
  }
]
}
},
{
  "outgoing-type": {
    "forwarding-sub-layer": {
      "aggregation-forwarding-sub-layer": "afl-1",
      "forwarding-label": {
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 10006
            }
          ]
        }
      }
    }
  },
  {
    "name": "afl-1",
    "traffic-profile": "pf-2",
    "forwarding-operation-type": "impose-and-forward",
    "incoming-type": {
      "forwarding-aggregation": {
        "forwarding-sub-layer": [
          "fsl-1",
          "fsl-2"
        ]
      }
    },
    "outgoing-type": {
      "interface": {
        "outgoing-interface": "eth3",
        "mpls-label-stack": {
          "entry": [
            {
              "id": 0,
              "label": 20000
            }
          ]
        }
      }
    }
  }
}
}
```

Figure 20: Example DetNet JSON Relay Service Sub-Layer Aggregation

A.13. Example D1 JSON Transit Forwarding Sub-Layer Disaggregation

Reference Case D-1. This illustrates Transit node 1 disaggregates a forwarding sub-layer into DetNet flow 1 and 2 forwarding sub-layers.

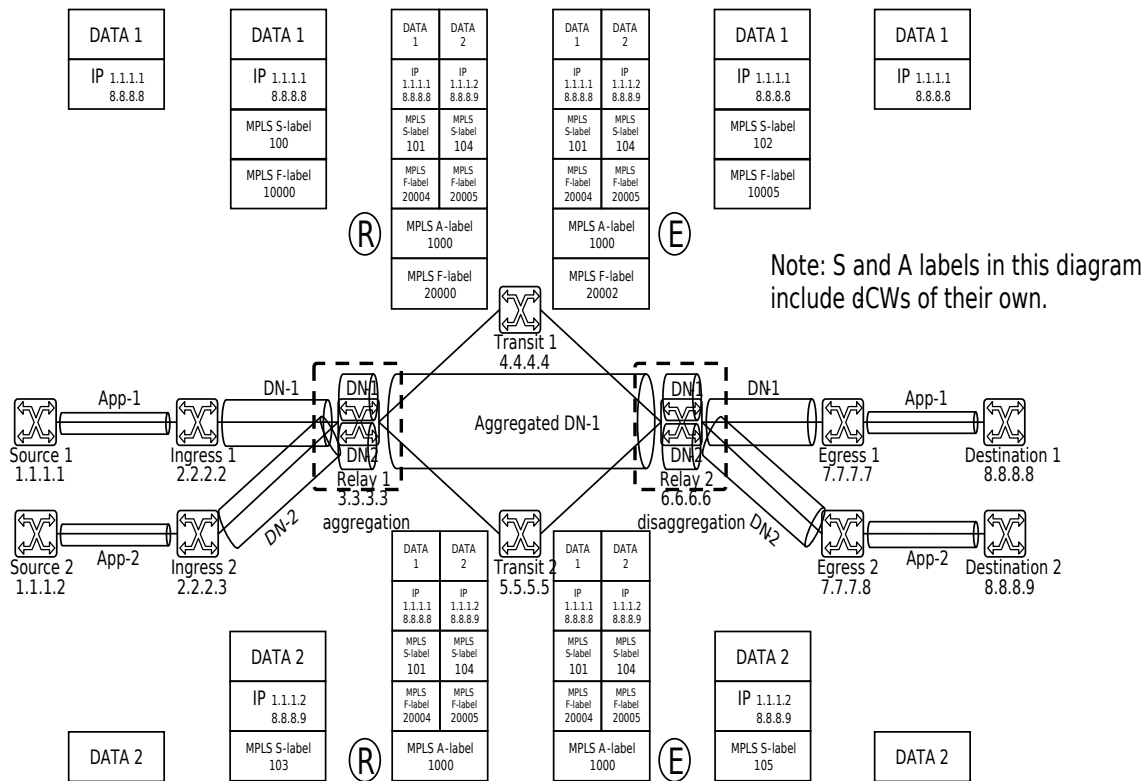


Figure 21: Case D1 Example JSON Service Aggregation


```
{
  "ietf-interfaces:interfaces": {
    "interface": [
      {
        "name": "eth0",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth1",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth2",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth3",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      },
      {
        "name": "eth4",
        "type": "iana-if-type:ethernetCsmacd",
        "oper-status": "up",
        "statistics": {
          "discontinuity-time": "2020-12-18T23:59:00Z"
        }
      }
    ]
  },
  "ietf-detnet:detnet": {
    "traffic-profile": [
      {
        "profile-name": "pf-1",
        "flow-spec": {
          "interval": 125,
          "max-pkts-per-interval": 1,
          "max-payload-size": 1518
        },
        "member-fwd-sublayers": [
          "fsl-1",
          "fsl-2"
        ]
      }
    ]
  }
}
```

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

```

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

```

Figure 22: Example DetNet JSON Relay Service Sub-Layer Aggregation

Authors' Addresses

Xuesong Geng

Huawei Technologies

Email: gengxuesong@huawei.com**Mach(Guoyi) Chen**

Huawei Technologies

Email: mach.chen@huawei.com**Yeoncheol Ryoo**

ETRI

Email: dbduscjf@etri.re.kr**Don Fedyk**

LabN Consulting, L.L.C.

Email: dfedyk@labn.net**Reshad Rahman**

Individual

Email: reshad@yahoo.com**Zhenqiang Li**

China Mobile

Email: lizhenqiang@chinamobile.com