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H. Zheng
Huawei Technologies
A. Guo
Individual
I. Busi
Huawei Technologies
A. Snitser
Sedona
F. Lazzeri
Ericsson
Y. Xu
CAICT
Y. Zhao
China Mobile
X. Liu
Volta Networks
G. Fioccola
Huawei Technologies
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A YANG Data Model for Transport Network Client Signals
draft-ietf-ccamp-client-signal-yang-01

Abstract

A transport network is a server-layer network to provide connectivity services to its client. The topology and tunnel information in the transport layer has already been defined by generic Traffic-engineered models and technology-specific models (e.g., OTN, WSON). However, how the client signals are accessing to the network has not been described. These information is necessary to both client and provider.

This draft describes how the client signals are carried over transport network and defines YANG data models which are required during configuration procedure. More specifically, several client signal (of transport network) models including ETH, STM-n, FC and so on, are defined in this draft.

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Table of Contents

1. Introduction	3
1.1. Overview	3
1.2. Prefixes in Model Names	3
2. Terminology and Notations	4
3. Transport Network Client Signal Overview	4
3.1. Overview of Service Request and Network Configuration Scenarios	4
3.2. Applicability of Proposed Model	7
4. YANG Model for Transport Network Client Signal	8
4.1. YANG Tree for Ethernet Service	8
4.2. YANG Tree for other Transport Network Client Signal Model	13
5. YANG Code for Transport Network Client Signal	14
5.1. The ETH Service YANG Code	14
5.2. YANG Code for ETH type	33
5.3. Other Client Signal YANG Code	43
5.4. Other Client Signal Types YANG Code	48
6. Considerations and Open Issue	49
7. IANA Considerations	49
8. Manageability Considerations	51
9. Security Considerations	51
10. Acknowledgements	51

11. Contributors	51
12. References	52
12.1. Normative References	52
12.2. Informative References	53
Authors' Addresses	54

1. Introduction

1.1. Overview

A transport network is a server-layer network designed to provide connectivity services for a client-layer network to carry the client traffic transparently across the server-layer network resources. Currently the topology and tunnel models which have been defined for transport networks, such as [I-D.ietf-ccamp-otn-topo-yang] and [I-D.ietf-ccamp-otn-tunnel-model], provide server-layer topology abstraction and tunnel configuration between PEs. However, there is a missing piece for configuring how the PEs should map the client-layer traffic, received from the CE, over the server-layer-tunnels: this gap is expected to be solved in this document.

This document defines a data model of all transport network client signals, using YANG language defined in [RFC7950]. The model can be used by applications exposing to a transport network controller via a RESTconf interface. Furthermore, it can be used by an application for the following purposes (but not limited to):

- o To request/update an end-to-end service by driving a new tunnel to be set up to support this service;
- o To request/update an end-to-end service by using an existing tunnel;
- o To receive notification with regard to the information change of the given service;

The YANG modules defined in this document conforms to the Network Management Datastore Architecture (NMDA) defined in [RFC8342].

1.2. Prefixes in Model Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules, including [RFC6991], [RFC8294] and [I-D.ietf-ccamp-otn-tunnel-model], which are shown as follow.

Prefix	YANG module	Reference
yang	ietf-yang-types	[RFC6991]
te-types	ietf-te-types	[ietf-teas-yang-te-types]
rt-types	ietf-routing-types	[RFC8294]
otn-types	ietf-otn-types	[ietf-ccamp-otn-tunnel-model]
eth-types	ietf-eth-tran-types	This Document
clnsv	ietf-trans-client-service	This Document
ethsv	ietf-eth-tran-service	This Document
clnsv-types	ietf-trans-client-svc-types	This Document

2. Terminology and Notations

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in the YANG data tree presented later in this document is defined in [RFC8340]. They are provided below for reference.

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write) and "ro" state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.
- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- o Ellipsis ("...") stands for contents of subtrees that are not shown.

3. Transport Network Client Signal Overview

3.1. Overview of Service Request and Network Configuration Scenarios

A global view of a multi-domain service can be described as the Figure 1 . The customer is usually responsible to configure the CE nodes and to request to the provider the service intent, from the CE nodes perspective, while the provider is responsible to configure the whole network (including the PE nodes) to support the customer service intent. Generally speaking, the network configurations required to support a customer service can be split into two different groups: CE-PE and PE-PE. The CE-PE configuration deals with the client layer one-hop access link, while PE-PE configuration

deals with the server layer tunnel. In Figure 1 we mark the intermediate nodes as 'P', which has same switching capability of PE but just not the 'end-point'. In this example, the link P-P and PE-P are a server-layer intra-domain or inter-domain link.

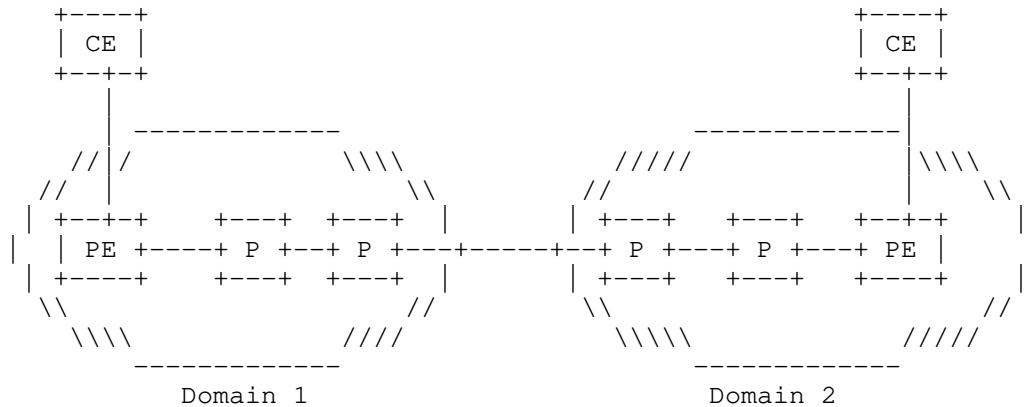


Figure 1: Global view of Client Service with the Network Provider

According to the responsibilities of each controller in [RFC8453], the controllers have different views of the service request and network configuration. The duty of CNC is to give the MDSC a description of the customer service intent: candidate YANG models include L1CSM [I-D.ietf-ccamp-llcsm-yang], L2SM [RFC8466] and L3SM [RFC8299], which are classified as customer service models, according to [RFC8309]. These models provide necessary attributes to describe the customer service intent from the customer/CE perspective, and do not provide any specific network configuration. These models also implies that the customer service description can be considered in a separate manner rather than integratig with network configurations, which also enable the controllers to abstract/virtualize the network resource to make them visible to the customer and also easier to manage. In other words, the network knowledge is not necessary at CNC and CMI, which is seen in an abstracted form as shown in Figure 2.

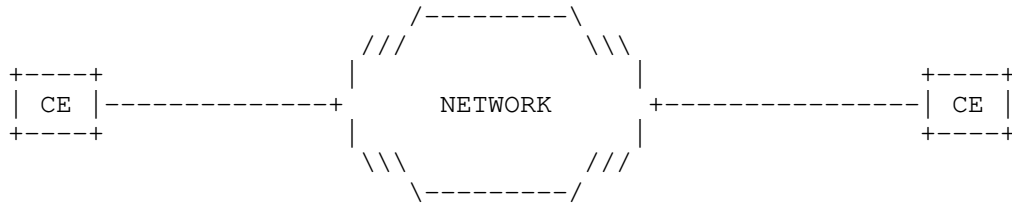


Figure 2: CNC Viewpoint on the Client Service

The functionalities of MDSC have been described in [RFC8453], which include the customer mapping/translation and multi-domain coordination. By receiving the request from CNC, MDSC need to understand what network configuration can support the customer service intent and turn to the corresponding PNCs for configuration. The service request is therefore decomposed by MDSC into a few network configurations and forwarded to one or multiple PNCs respectively in single-domain and multi-domain scenario. In general, the MDSC has the view of both PE and CE nodes and of some abstract information regarding the P nodes, as shown in Figure 3. It is worth noting that this MDSC view is different with Figure 1 at the intra-domain link. Usually these details are hidden, for scalability purposes, and therefore the MDSC has only an abstract view of each domain internal topology.

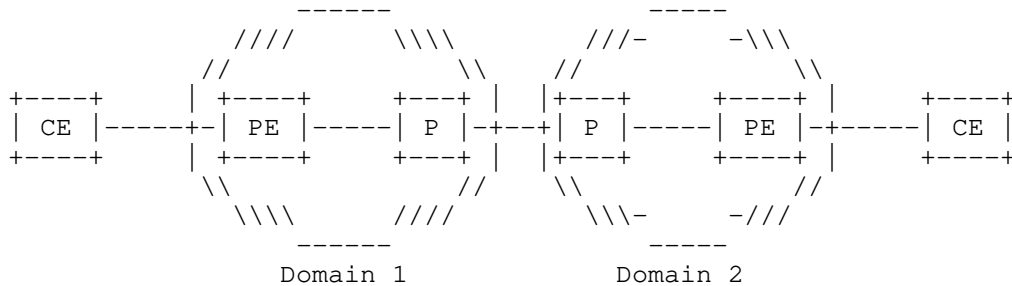


Figure 3: MDSC view of both Client Service and Network Abstraction

PNC is the controller that configure the physical devices, based on the network configuration received from the MDSC. Each PNC has the detailed view of its own domain, the example of view from PNC in domain 1 is shown in Figure 4. The PNC has all the detailed topology information on PE and P nodes and on the intra-domain links. The PNC configures the tunnel/tunnel segment within its domain based on the network configuration provided by the MDSC. The PNC also configures

the network part of the CE-PE access links as well as the mapping of the client-layer traffic and the server-layer tunnels, based on the network configuration provided by the MDSC. The interaction between PNC and MDSC for the client-layer network configuration is accomplished by the models defined in this draft.

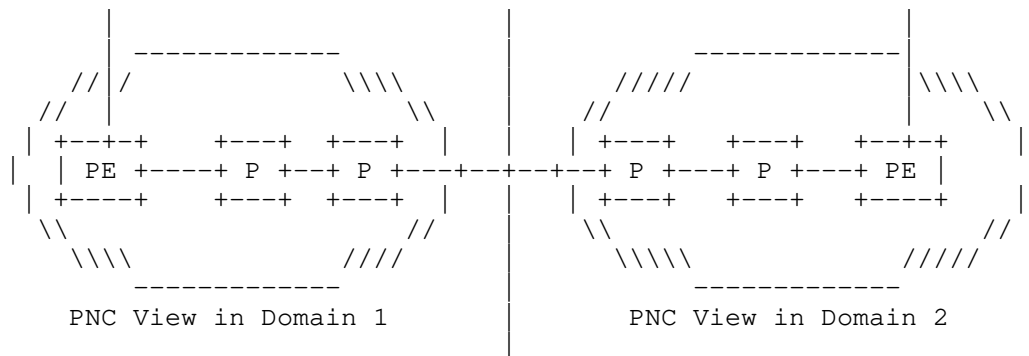


Figure 4: PNC view on Network Configuration

3.2. Applicability of Proposed Model

Existing TE and technology-specific models, such as topology models and tunnel models, support the network configuration among PEs and Ps. The customer service models, such as L1CSM, L2SM and L3SM, focus on describing the attributes among CEs. However, there is a missing piece on how to configure the CE-PE session. The models defined in this document provide the configuration on CE-PE when the provider server-layer network is TE-based technology.

In the example of OTN as the server-layer transport network, a full list of G-PID was summarized in [RFC7139], which can be divided into a few categories. The G-PID signals can be categorized into transparent and non-transparent. Examples of transparent signals may include Ethernetphysical interfaces, FC, STM-n and so on. In this approach the OTN devices is not aware of the client signal type, and this information is only necessary among the controllers. Once the OTN tunnel is set up, there is no switching requested on the client layer, and therefore only signal mapping is needed, without a client tunnel set up. The models that supporting the configuration of transparent signals are defined in Section 4.2. The other category would be non-transparent, such as Carrier Ethernet and MPLS-TP, with a switching request on the client layer. Once the OTN tunnel is set up, a corresponding tunnel in the client layer has to be set up to

carry services. The models that supporting the configuration of transparent signals are defined in Section 4.1.

It is also worth noting that some client signal can be carried over multiple types of networks. For example, the Ethernet services can be carried over either OTN or Ethernet TE tunnels (over optical or microwave networks). The model specified in this document allows the support from networks with different technologies.

4. YANG Model for Transport Network Client Signal

4.1. YANG Tree for Ethernet Service

```

module: ietf-eth-tran-service
  +--rw etht-svc
    +--rw globals
      +--rw named-bandwidth-profiles*
        [bandwidth-profile-name]
        +--rw bandwidth-profile-name      string
        +--rw bandwidth-profile-type?
          | etht-types:bandwidth-profile-type
          +--rw CIR?                      uint64
          +--rw CBS?                      uint64
          +--rw EIR?                      uint64
          +--rw EBS?                      uint64
          +--rw color-aware?              boolean
          +--rw coupling-flag?            boolean
      +--rw etht-svc-instances* [etht-svc-name]
        +--rw etht-svc-name                string
        +--rw etht-svc-title?              string
        +--rw etht-svc-descr?              string
        +--rw etht-svc-customer?           string
        +--rw etht-svc-type?
          | etht-types:service-type
          +--rw etht-svc-lifecycle?
            | etht-types:lifecycle-status
            +--rw te-topology-identifier
              +--rw provider-id?    te-global-id
              +--rw client-id?      te-global-id
              +--rw topology-id?    te-topology-id
        +--rw resilience
          +--rw protection
            +--rw enable?                                boolean
            +--rw protection-type?
              | identityref
              +--rw protection-reversion-disable?        boolean
          +--rw hold-off-time?                            uint32

```



```

| | +--rw wait-to-revert?                uint16
| | +--rw aps-signal-id?                uint8
+--rw restoration
| | +--rw enable?                      boolean
| | +--rw restoration-type?
| | | identityref
| | +--rw restoration-scheme?
| | | identityref
| | +--rw restoration-reversion-disable? boolean
| | +--rw hold-off-time?              uint32
| | +--rw wait-to-restore?            uint16
| | +--rw wait-to-revert?            uint16
+--rw etht-svc-end-points* [etht-svc-end-point-name]
| | +--rw etht-svc-end-point-name
| | | string
| | +--rw etht-svc-end-point-id?
| | | string
| | +--rw etht-svc-end-point-descr?
| | | string
| | +--rw topology-role?
| | | identityref
| | +--rw resilience
+--rw etht-svc-access-points* [access-point-id]
| | +--rw access-point-id             string
| | +--rw access-node-id?            te-types:te-node-id
| | +--rw access-ltp-id?             te-types:te-tp-id
| | +--rw access-role?               identityref
| | +--rw pm-config
| | | +--rw pm-enable?                boolean
| | | +--rw sending-rate-high?       uint64
| | | +--rw sending-rate-low?        uint64
| | | +--rw receiving-rate-high?     uint64
| | | +--rw receiving-rate-low?      uint64
| | +--ro state
| | | +--ro operational-state?        identityref
| | | +--ro provisioning-state?       identityref
| | +--ro performance?              identityref
+--rw service-classification-type?
| | identityref
+--rw (service-classification)?
| | +--:(port-classification)
| | +--:(vlan-classification)
| | | +--rw outer-tag!
| | | | +--rw tag-type?
| | | | | etht-types:eth-tag-classify
| | | +--rw (individual-bundling-vlan)?
| | | | +--:(individual-vlan)
| | | | | +--rw vlan-value?

```

```

|           etht-types:vlanid
|           +---:(vlan-bundling)
|               +---rw vlan-range?
|                   etht-types:vid-range-type
+---rw second-tag!
|   +---rw tag-type?
|       |           etht-types:eth-tag-classify
+---rw (individual-bundling-vlan)?
|   +---:(individual-vlan)
|       |   +---rw vlan-value?
|           |           etht-types:vlanid
+---:(vlan-bundling)
|   +---rw vlan-range?
|       etht-types:vid-range-type
+---rw split-horizon-group?
|   string
+---rw (direction)?
|   +---:(symmetrical)
|       +---rw ingress-egress-bandwidth-profile
|           +---rw (style)?
|               +---:(named)
|                   +---rw bandwidth-profile-name?
|                       string
|               +---:(value)
|                   +---rw bandwidth-profile-type?
|                       |           etht-types:bandwidth-profile-type
+---rw CIR?
|   |           uint64
+---rw CBS?
|   |           uint64
+---rw EIR?
|   |           uint64
+---rw EBS?
|   |           uint64
+---rw color-aware?
|   |           boolean
+---rw coupling-flag?
|       boolean
+---:(asymmetrical)
|   +---rw ingress-bandwidth-profile
|       +---rw (style)?
|           +---:(named)
|               +---rw bandwidth-profile-name?
|                   string
|           +---:(value)
|               +---rw bandwidth-profile-type?
|                   |           etht-types:bandwidth-profile-type
+---rw CIR?

```

```

|         uint64
+--rw CBS?
|         uint64
+--rw EIR?
|         uint64
+--rw EBS?
|         uint64
+--rw color-aware?
|         boolean
+--rw coupling-flag?
|         boolean
+--rw egress-bandwidth-profile
+--rw (style)?
+--:(named)
|   +--rw bandwidth-profile-name?
|   |   string
+--:(value)
+--rw bandwidth-profile-type?
|   etht-types:bandwidth-profile-type
+--rw CIR?
|   uint64
+--rw CBS?
|   uint64
+--rw EIR?
|   uint64
+--rw EBS?
|   uint64
+--rw color-aware?
|   boolean
+--rw coupling-flag?
|   boolean
+--rw vlan-operations
+--rw (direction)?
+--:(symmetrical)
+--rw symmetrical-operation
+--rw pop-tags?   uint8
+--rw push-tags
+--rw outer-tag!
|   +--rw tag-type?
|   |   etht-types:eth-tag-type
+--rw vlan-value?
|   |   etht-types:vlanid
+--rw default-pcp?   uint8
+--rw second-tag!
+--rw tag-type?
|   etht-types:eth-tag-type
+--rw vlan-value?
|   etht-types:vlanid

```

```

|           +--rw default-pcp?   uint8
+---:(asymmetrical)
|   +--rw asymmetrical-operation
|   |   +--rw ingress
|   |   |   +--rw pop-tags?      uint8
|   |   |   +--rw push-tags
|   |   |   |   +--rw outer-tag!
|   |   |   |   |   +--rw tag-type?
|   |   |   |   |   |   etht-types:eth-tag-type
|   |   |   |   |   +--rw vlan-value?
|   |   |   |   |   |   etht-types:vlanid
|   |   |   |   |   +--rw default-pcp?   uint8
|   |   |   +--rw second-tag!
|   |   |   |   +--rw tag-type?
|   |   |   |   |   etht-types:eth-tag-type
|   |   |   |   +--rw vlan-value?
|   |   |   |   |   etht-types:vlanid
|   |   |   |   +--rw default-pcp?   uint8
|   |   +--rw egress
|   |   |   +--rw pop-tags?      uint8
|   |   |   +--rw push-tags
|   |   |   |   +--rw outer-tag!
|   |   |   |   |   +--rw tag-type?
|   |   |   |   |   |   etht-types:eth-tag-type
|   |   |   |   |   +--rw vlan-value?
|   |   |   |   |   |   etht-types:vlanid
|   |   |   |   |   +--rw default-pcp?   uint8
|   |   |   +--rw second-tag!
|   |   |   |   +--rw tag-type?
|   |   |   |   |   etht-types:eth-tag-type
|   |   |   |   +--rw vlan-value?
|   |   |   |   |   etht-types:vlanid
|   |   |   |   +--rw default-pcp?   uint8
+--rw underlay
|   +--rw (technology)?
|   |   +---:(native-ethernet)
|   |   |   +--rw eth-tunnels* [name]
|   |   |   |   +--rw name
|   |   |   |   |   -> /te:te/tunnels/tunnel/name
|   |   |   |   +--rw encoding?      identityref
|   |   |   |   +--rw switching-type? identityref
|   |   |   +---:(frame-base)
|   |   |   |   +--rw otn-tunnels* [name]
|   |   |   |   |   +--rw name
|   |   |   |   |   |   -> /te:te/tunnels/tunnel/name
|   |   |   |   |   +--rw encoding?      identityref
|   |   |   |   |   +--rw switching-type? identityref
|   |   |   +---:(mpls-tp)

```

```

    +--rw pw
      +--rw pw-id?
      |   string
      +--rw pw-name?
      |   string
      +--rw transmit-label?
      |   rt-types:mpls-label
      +--rw receive-label?
      |   rt-types:mpls-label
      +--rw encapsulation-type?
      |   identityref
      +--ro oper-status?
      |   identityref
      +--rw ingress-bandwidth-profile
      |   +--rw (style)?
      |   |   +--:(named)
      |   |   |   +--rw bandwidth-profile-name?   leafref
      |   |   |   +--:(value)
      |   |   |   +--rw bandwidth-profile-type?
      |   |   |   |   etht-types:bandwidth-profile-type
      |   |   |   +--rw CIR?
      |   |   |   |   uint64
      |   |   |   +--rw CBS?
      |   |   |   |   uint64
      |   |   |   +--rw EIR?
      |   |   |   |   uint64
      |   |   |   +--rw EBS?
      |   |   |   |   uint64
      |   +--rw pw-paths* [path-id]
      |   |   +--rw path-id      uint8
      |   |   +--rw tp-tunnels* [name]
      |   |   |   +--rw name      string
      +--rw src-split-horizon-group?   string
      +--rw dst-split-horizon-group?   string
      +--rw admin-status?               identityref
      +--ro state
      |   +--ro operational-state?      identityref
      |   +--ro provisioning-state?     identityref
      |   +--ro creation-time?          yang:date-and-time
      |   +--ro last-updated-time?      yang:date-and-time

```

4.2. YANG Tree for other Transport Network Client Signal Model

```

module: ietf-trans-client-service
  +--rw client-svc
    +--rw client-svc-instances* [client-svc-name]
      +--rw client-svc-name          string
      +--rw client-svc-title?        string
      +--rw client-svc-descr?        string
      +--rw client-svc-customer?     string
      +--rw resilience
      +--rw te-topology-identifier
        | +--rw provider-id?    te-global-id
        | +--rw client-id?      te-global-id
        | +--rw topology-id?    te-topology-id
      +--rw admin-status?            identityref
      +--rw src-access-ports
        | +--rw access-node-id?    te-types:te-node-id
        | +--rw access-ltp-id?     te-types:te-tp-id
        | +--rw client-signal?     identityref
      +--rw dst-access-ports
        | +--rw access-node-id?    te-types:te-node-id
        | +--rw access-ltp-id?     te-types:te-tp-id
        | +--rw client-signal?     identityref
      +--rw direction?              identityref
      +--rw svc-tunnels* [tunnel-name]
        | +--rw tunnel-name        string
      +--ro operational-state?      identityref
      +--ro provisioning-state?     identityref
      +--ro creation-time?          yang:date-and-time
      +--ro last-updated-time?     yang:date-and-time

```

5. YANG Code for Transport Network Client Signal

5.1. The ETH Service YANG Code

This module imports typedefs and modules from [RFC6991], [RFC8294], [I-D.ietf-teas-yang-te-types].

```

<CODE BEGINS> file "ietf-eth-tran-service@2019-11-03.yang"
module ietf-eth-tran-service {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-eth-tran-service";

  prefix "ethtsvc";

  import ietf-yang-types {
    prefix "yang";

```

```
        reference "RFC 6991 - Common YANG Data Types";
    }

    import ietf-te-types {
        prefix "te-types";
        reference "RFC YYYY - Traffic Engineering Common YANG Types";
    }

    import ietf-eth-tran-types {
        prefix "eth-t-types";
        reference "RFC XXXX - A YANG Data Model for Transport
        Network Client Signals";
    }

    import ietf-routing-types {
        prefix "rt-types";
        reference "RFC 8294 - Common YANG Data Types for the
        Routing Area";
    }

    import ietf-te {
        prefix "te";
        reference "RFC YYYY - A YANG Data Model for Traffic
        Engineering Tunnels and Interfaces";
    }

    organization
        "Internet Engineering Task Force (IETF) CCAMP WG";
    contact
        "
        WG List: <mailto:ccamp@ietf.org>

        ID-draft editor:
        Haomian Zheng (zhenghaomian@huawei.com);
        Italo Busi (italo.busi@huawei.com);
        Aihua Guo (aihuaguo.ietf@gmail.com);
        Anton Snitser (antons@sedonasys.com);
        Francesco Lazzeri (francesco.lazzeri@ericsson.com);
        Yunbin Xu (xuyunbin@caict.ac.cn);
        Yang Zhao (zhaoyangyjy@chinamobile.com);
        Xufeng Liu (xufeng.liu.ietf@gmail.com);
        Giuseppe Fioccola (giuseppe.fioccola@huawei.com);
        ";

    description
        "This module defines a YANG data model for describing
        the Ethernet services. The model fully conforms to the
```

Network Management Datastore Architecture (NMDA).

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

```
revision 2019-11-03 {
  description
    "version -01 as an WG document";
  reference
    "draft-ietf-ccamp-client-signal-yang";
}

/*
 * Groupings
 */

grouping vlan-classification {
  description
    "A grouping which represents classification
    on an 802.1Q VLAN tag.";

  leaf tag-type {
    type eth-types:eth-tag-classify;
    description
      "The tag type used for VLAN classification.";
  }
  choice individual-bundling-vlan {
    description
      "VLAN based classification can be individual
      or bundling.";

    case individual-vlan {
      leaf vlan-value {
        type eth-types:vlanid;
        description
          "VLAN ID value.";
      }
    }
  }
}
```



```
    case vlan-bundling {
      leaf vlan-range {
        type etht-types:vid-range-type;
        description
          "List of VLAN ID values.";
      }
    }
  }
}

grouping vlan-write {
  description
    "A grouping which represents push/pop operations
    of an 802.1Q VLAN tag.";

  leaf tag-type {
    type etht-types:eth-tag-type;
    description
      "The VLAN tag type to push/swap.";
  }
  leaf vlan-value {
    type etht-types:vlanid;
    description
      "The VLAN ID value to push/swap.";
  }
}
/*
 * To be added: this attribute is used when:
 * a) the ETH service has only one CoS (as in current version)
 * b) as a default when a mapping between a given CoS value
 *    and the PCP value is not defined (in future versions)
 */
leaf default-pcp {
  type uint8 {
    range "0..7";
  }
  description
    "The default Priority Code Point (PCP) value to push/swap";
}

grouping vlan-operations {
  description
    "A grouping which represents VLAN operations.";

  leaf pop-tags {
    type uint8 {
      range "1..2";
    }
  }
}
```

```
description
  "The number of VLAN tags to pop (or swap if used in
   conjunction with push-tags)";
}
container push-tags {
  description
    "The VLAN tags to push (or swap if used in
     conjunction with pop-tags)";

  container outer-tag {
    presence
      "Indicates existence of the outermost VLAN tag to
       push/swap";

    description
      "The outermost VLAN tag to push/swap.";

    uses vlan-write;
  }
  container second-tag {
    must
      '../outer-tag/tag-type = "eth-types:s-vlan-tag-type" and ' +
      'tag-type = "eth-types:c-vlan-tag-type"'
    {
      error-message
        "
          When pushing/swapping two tags, the outermost tag must
          be specified and of S-VLAN type and the second
          outermost tag must be of C-VLAN tag type.
        ";
      description
        "
          For IEEE 802.1Q interoperability, when pushing/swapping
          two tags, it is required that the outermost tag exists
          and is an S-VLAN, and the second outermost tag is a
          C-VLAN.
        ";
    }
  }

  presence
    "Indicates existence of a second outermost VLAN tag to
     push/swap";

  description
    "The second outermost VLAN tag to push/swap.";

  uses vlan-write;
```

```
    }
  }
}

grouping named-or-value-bandwidth-profile {
  description
    "A grouping to configure a bandwidth profile either by
    referencing a named bandwidth profile or by
    configuring the values of the bandwidth profile attributes.";
  choice style {
    description
      "Whether the bandwidth profile is named or defined by value";

    case named {
      description
        "Named bandwidth profile.";
      leaf bandwidth-profile-name {
        type "string";
        description
          "Name of the bandwidth profile.";
      }
    }
    case value {
      description
        "Bandwidth profile configured by value.";
      uses etht-types:etht-bandwidth-profiles;
    }
  }
}

grouping bandwidth-profiles {
  description
    "A grouping which represent bandwidth profile configuration.";

  choice direction {
    description
      "Whether the bandwidth profiles are symmetrical or
      asymmetrical";
    case symmetrical {
      description
        "The same bandwidth profile is used to describe both
        the ingress and the egress bandwidth profile.";
      container ingress-egress-bandwidth-profile {
        description
          "The bandwidth profile used in both directions.";
        uses named-or-value-bandwidth-profile;
      }
    }
  }
}
```

```
    case asymmetrical {
      description
        "Ingress and egress bandwidth profiles can be specified.";
      container ingress-bandwidth-profile {
        description
          "The bandwidth profile used in the ingress direction.";
        uses named-or-value-bandwidth-profile;
      }
      container egress-bandwidth-profile {
        description
          "The bandwidth profile used in the egress direction.";
        uses named-or-value-bandwidth-profile;
      }
    }
  }
}

grouping etht-svc-access-parameters {
  description
    "ETH services access parameters";

  leaf access-node-id {
    type te-types:te-node-id;
    description
      "The identifier of the access node in
       the ETH topology.";
  }
  leaf access-ltp-id {
    type te-types:te-tp-id;
    description
      "The TE link termination point identifier, used
       together with access-node-id to identify the
       access LTP.";
  }
  leaf access-role {
    type identityref {
      base etht-types:access-role;
    }
    description
      "Indicate the role of access, e.g., working or protection. ";
  }

  container pm-config {
    uses pm-config-grouping;
    description
      "This grouping is used to set the threshold value for
       performance monitoring. ";
  }
}
```

```
    container state {
        config false;
        description
            "The state is used to monitor the status of service. ";
        leaf operational-state {
            type identityref {
                base te-types:tunnel-state-type;
            }
            description
                "Indicating the operational state of client signal. ";
        }
        leaf provisioning-state {
            type identityref {
                base te-types:lsp-state-type;
            }
            description
                "Indicating the provisional state of client signal,
                especially when there is a change, i.e., revise, create. ";
        }
    }

    leaf performance {
        type identityref {
            base etht-types:performance;
        }
        config false;
        description
            "Performance Monitoring for the service. ";
    }
}

grouping etht-svc-tunnel-parameters {
    description
        "ETH services tunnel parameters.";
    choice technology {
        description
            "Service multiplexing is optional and flexible.";

        case native-ethernet {
            /*
             * placeholder to support proprietary multiplexing
             * (for further discussion)
             */
            list eth-tunnels {
                key name;
                description
```

```
        "ETH Tunnel list in native Ethernet scenario.";
        uses tunnels-grouping;
    }
}

case frame-base {
    list otn-tunnels {
        key name;
        description
            "OTN Tunnel list in Frame-based scenario.";
        uses tunnels-grouping;
    }
}

case mpls-tp {
    container pw {
        description
            "Pseudowire information for Ethernet over MPLS-TP.";
        uses pw-segment-grouping;
    }
}
}

/*
 * Open issue: can we constraints it to be used only with mp services?
 */
leaf src-split-horizon-group {
    type string;
    description
        "Identify a split horizon group at the Tunnel source TTP";
}
leaf dst-split-horizon-group {
    type string;
    description
        "Identify a split horizon group at the Tunnel destination TTP";
}
}

grouping etht-svc-pm-threshold-config {
    description
        "Configuraiton parameters for Ethernet service PM thresholds.";

    leaf sending-rate-high {
        type uint64;
        description
            "High threshold of packet sending rate in kbps.";
    }
    leaf sending-rate-low {
```

```
        type uint64;
        description
            "Low threshold of packet sending rate in kbps.";
    }
    leaf receiving-rate-high {
        type uint64;
        description
            "High threshold of packet receiving rate in kbps.";
    }
    leaf receiving-rate-low {
        type uint64;
        description
            "Low threshold of packet receiving rate in kbps.";
    }
}

grouping etht-svc-pm-stats {
    description
        "Ethernet service PM statistics.";

    leaf sending-rate-too-high {
        type uint32;
        description
            "Counter that indicates the number of times the sending
            rate is above the high threshold";
    }
    leaf sending-rate-too-low {
        type uint32;
        description
            "Counter that indicates the number of times the sending
            rate is below the low threshold";
    }
    leaf receiving-rate-too-high {
        type uint32;
        description
            "Counter that indicates the number of times the receiving
            rate is above the high threshold";
    }
    leaf receiving-rate-too-low {
        type uint32;
        description
            "Counter that indicates the number of times the receiving
            rate is below the low threshold";
    }
}

grouping etht-svc-instance-config {
    description
```

```
    "Configuraiton parameters for Ethernet services.";

    leaf etht-svc-name {
        type string;
        description
            "Name of the ETH service.";
    }

    leaf etht-svc-title {
        type string;
        description
            "The Identifier of the ETH service.";
    }

    leaf etht-svc-descr {
        type string;
        description
            "Description of the ETH service.";
    }

    leaf etht-svc-customer {
        type string;
        description
            "Customer of the ETH service.";
    }

    leaf etht-svc-type {
        type etht-types:service-type;
        description
            "Type of ETH service (p2p, mp2mp or rmp).";
        /* Add default as p2p */
    }

    leaf etht-svc-lifecycle {
        type etht-types:lifecycle-status;
        description
            "Lifecycle state of ETH service.";
        /* Add default as installed */
    }
    uses te-types:te-topology-identifier;

    uses resilience-grouping;

    list etht-svc-end-points {
        key etht-svc-end-point-name;
        description
            "The logical end point for the ETH service. ";
        uses etht-svc-end-point-grouping;
    }
```



```
    }

    container underlay {
      description
        "The underlay tunnel information that
         carrying the ETH service. ";
      uses etht-svc-tunnel-parameters;
    }

    leaf admin-status {
      type identityref {
        base te-types:tunnel-admin-state-type;
      }
      default te-types:tunnel-admin-state-up;
      description "ETH service administrative state.";
    }
  }

  grouping etht-svc-instance-state {
    description
      "State parameters for Ethernet services.";

    leaf operational-state {
      type identityref {
        base te-types:tunnel-state-type;
      }
      default te-types:tunnel-state-up;
      description "ETH service operational state.";
    }
    leaf provisioning-state {
      type identityref {
        base te-types:lsp-state-type;
      }
      description "ETH service provisioning state.";
    }
    leaf creation-time {
      type yang:date-and-time;
      description
        "Time of ETH service creation.";
    }
    leaf last-updated-time {
      type yang:date-and-time;
      description
        "Time of ETH service last update.";
    }
  }
}
```

```
/*
 * Data nodes
 */

container etht-svc {
  description
    "ETH services.";

  container globals {
    description
      "Globals Ethernet configuration data container";
    list named-bandwidth-profiles {
      key bandwidth-profile-name;
      description
        "List of named bandwidth profiles used by
        Ethernet services.";

      leaf bandwidth-profile-name {
        type string;
        description
          "Name of the bandwidth profile.";
      }
      uses etht-types:etht-bandwidth-profiles;
    }
  }

  list etht-svc-instances {
    key etht-svc-name;
    description
      "The list of p2p ETH service instances";

    uses etht-svc-instance-config;

    container state {
      config false;
      description
        "Ethernet Service states.";

      uses etht-svc-instance-state;
    }
  }
}

grouping resilience-grouping {
  description
    "Grouping for resilience configuration. ";
  container resilience {
    description
```

```
    "To configure the data plane protection parameters,
    currently a placeholder only, future candidate attributes
    include, Revert, WTR, Hold-off Timer, ...";
    uses te:protection-restoration-properties;
  }
}

grouping etht-svc-end-point-grouping {
  description
    "Grouping for the end point configuration.";
  leaf etht-svc-end-point-name {
    type string;
    description
      "The name of the logical end point of ETH service. ";
  }

  leaf etht-svc-end-point-id {
    type string;
    description
      "The identifier of the logical end point of ETH service.";
  }

  leaf etht-svc-end-point-descr {
    type string;
    description
      "The description of the logical end point of ETH service. ";
  }

  leaf topology-role {
    type identityref {
      base etht-types:topology-role;
    }
    description
      "Indicating the underlay topology role,
      e.g., hub,spoke, any-to-any ";
  }

  container resilience {
    description
      "Placeholder for resilience configuration, for future study. ";
  }

  list etht-svc-access-points {
    key access-point-id;
    min-elements "1";
  }
}
/*
Open Issue:
Is it possible to limit the max-elements only for p2p services?
```

```
        max-elements "2";
    */
    description
        "List of the ETH transport services access point instances.";

    leaf access-point-id {
        type string;
        description
            "ID of the service access point instance";
    }
    uses etht-svc-access-parameters;
}

leaf service-classification-type {
    type identityref {
        base etht-types:service-classification-type;
    }
    description
        "Service classification type.";
}

choice service-classification {
    description
        "Access classification can be port-based or
        VLAN based.";

    case port-classification {
        /* no additional information */
    }

    case vlan-classification {
        container outer-tag {
            presence "The outermost VLAN tag exists";
            description
                "Classifies traffic using the outermost VLAN tag.";

            uses vlan-classification;
        }
        container second-tag {
            must
                ' ../outer-tag/tag-type = "etht-types:classify-s-vlan" and ' +
                ' tag-type = "etht-types:classify-c-vlan"'
            {
                error-message
                    "
                    When matching two tags, the outermost tag must be
                    specified and of S-VLAN type and the second
                    outermost tag must be of C-VLAN tag type.
                "
            }
        }
    }
}
```

```
        ";
        description
        "
            For IEEE 802.1Q interoperability, when matching two
            tags, it is required that the outermost tag exists
            and is an S-VLAN, and the second outermost tag is a
            C-VLAN.
        ";
    }
    presence "The second outermost VLAN tag exists";

    description
        "Classifies traffic using the second outermost VLAN tag.";

    uses vlan-classification;
}
}
}

/*
 * Open issue: can we constraints it to be used only with mp services?
 */
leaf split-horizon-group {
    type string;
    description "Identify a split horizon group";
}

uses bandwidth-profiles;

container vlan-operations {
    description
        "Configuration of VLAN operations.";
    choice direction {
        description
            "Whether the VLAN operations are symmetrical or
            asymmetrical";
        case symmetrical {
            container symmetrical-operation {
                uses vlan-operations;
                description
                    "Symmetrical operations.
                    Expressed in the ingress direction, but
                    the reverse operation is applied to egress traffic";
            }
        }
        case asymmetrical {
            container asymmetrical-operation {
                description "Asymmetrical operations";
            }
        }
    }
}
```

```
        container ingress {
            uses vlan-operations;
            description "Ingress operations";
        }
        container egress {
            uses vlan-operations;
            description "Egress operations";
        }
    }
}

grouping pm-config-grouping {
    description
        "Grouping used for Performance Monitoring Configuration. ";
    leaf pm-enable {
        type boolean;
        description
            "Whether to enable the performance monitoring.";
    }

    leaf sending-rate-high {
        type uint64;
        description
            "The upperbound of sending rate.";
    }

    leaf sending-rate-low {
        type uint64;
        description
            "The lowerbound of sending rate.";
    }

    leaf receiving-rate-high {
        type uint64;
        description
            "The upperbound of receiving rate.";
    }

    leaf receiving-rate-low {
        type uint64;
        description
            "The lowerbound of receiving rate.";
    }
}
```

```
grouping pw-segment-grouping {
  description
    "Grouping used for PW configuration. ";
  leaf pw-id {
    type string;
    description
      "The Identifier information of pseudowire. ";
  }

  leaf pw-name {
    type string;
    description
      "The name information of pseudowire.";
  }

  leaf transmit-label {
    type rt-types:mpls-label;
    description
      "Transmit label information in PW. ";
  }

  leaf receive-label {
    type rt-types:mpls-label;
    description
      "Receive label information in PW. ";
  }

  leaf encapsulation-type {
    type identityref {
      base eth-types:encapsulation-type;
    }
    description
      "The encapsulation type, raw or tag. ";
  }

  leaf oper-status {
    type identityref {
      base te-types:tunnel-state-type;
    }
    config false;
    description
      "The operational state of the PW segment. ";
  }

  container ingress-bandwidth-profile {
    description
      "Bandwidth Profile for ingress. ";
    uses pw-segment-named-or-value-bandwidth-profile;
  }
}
```

```
    }

    list pw-paths {
        key path-id;
        description
        "A list of pw paths. ";

        leaf path-id {
            type uint8;
            description
            "The identifier of pw paths. ";
        }

        list tp-tunnels {
            key name;
            description
            "Names of TP Tunnel underlay";
            leaf name {
                type string;
                description
                "Names of TP Tunnel underlay";
            }
        }
    }

    }

    grouping pw-segment-named-or-value-bandwidth-profile {
        description
        "A grouping to configure a bandwidth profile either by
        referencing a named bandwidth profile or by
        configuring the values of the bandwidth profile attributes.";
        choice style {
            description
            "Whether the bandwidth profile is named or defined by value";
            case named {
                description
                "Named bandwidth profile.";
                leaf bandwidth-profile-name {
                    type leafref {
                        path "/ethtsvc:etht-svc/ethtsvc:globals/"
                            + "ethtsvc:named-bandwidth-profiles/"
                            + "ethtsvc:bandwidth-profile-name";
                    }
                }
                description
                "Name of the bandwidth profile.";
            }
        }
    }
}
```



```

    }
    case value {
      description
        "Bandwidth profile configured by value.";
      uses eth-types:pw-segment-bandwidth-profile-grouping;
    }
  }
}

grouping tunnels-grouping {
  description
    "A group of tunnels. ";
  leaf name {
    type leafref {
      path "/te:te/te:tunnels/te:tunnel/te:name";
      require-instance false;
    }
    description "Dependency tunnel name";
  }
  leaf encoding {
    type identityref {
      base te-types:lsp-encoding-types;
    }
    description "LSP encoding type";
    reference "RFC3945";
  }
  leaf switching-type {
    type identityref {
      base te-types:switching-capabilities;
    }
    description "LSP switching type";
    reference "RFC3945";
  }
}
}
<CODE ENDS>

```

5.2. YANG Code for ETH type

This module references a few documents including [RFC2697], [RFC2698], [RFC4115], [IEEE802.1ad], [IEEE802.1q] and [MEF10].

```

<CODE BEGINS> file "ietf-eth-tran-types@2019-11-03.yang"
module ietf-eth-tran-types {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-eth-tran-types";

```

```
prefix "eth-t-types";

organization
  "Internet Engineering Task Force (IETF) CCAMP WG";
contact
  "
    WG List: <mailto:ccamp@ietf.org>

    ID-draft editor:
      Haomian Zheng (zhenghaomian@huawei.com);
      Italo Busi (italo.busi@huawei.com);
      Aihua Guo (aihuaguo.ietf@gmail.com);
      Anton Snitser (antons@sedonasys.com);
      Francesco Lazzeri (francesco.lazzeri@ericsson.com);
      Yunbin Xu (xuyunbin@caict.ac.cn);
      Yang Zhao (zhaoyangy@chinamobile.com);
      Xufeng Liu (xufeng.liu.ietf@gmail.com);
      Giuseppe Fioccola (giuseppe.fioccola@huawei.com);
  ";

description
  "This module defines the ETH types.
   The model fully conforms to the Network Management
   Datastore Architecture (NMDA).

   Copyright (c) 2019 IETF Trust and the persons
   identified as authors of the code. All rights reserved.

   Redistribution and use in source and binary forms, with or
   without modification, is permitted pursuant to, and subject
   to the license terms contained in, the Simplified BSD License
   set forth in Section 4.c of the IETF Trust's Legal Provisions
   Relating to IETF Documents
   (https://trustee.ietf.org/license-info).
   This version of this YANG module is part of RFC XXXX; see
   the RFC itself for full legal notices.";

revision 2019-11-03 {
  description
    "version -01 as a WG draft";
  reference
    "draft-ietf-ccamp-client-signal-yang";
}

/*
 * Identities
 */
```

```
identity eth-vlan-tag-type {
  description
    "ETH VLAN tag type.";
}

identity c-vlan-tag-type {
  base eth-vlan-tag-type;
  description
    "802.1Q Customer VLAN";
}

identity s-vlan-tag-type {
  base eth-vlan-tag-type;
  description
    "802.1Q Service VLAN (QinQ)";
}

identity service-classification-type {
  description
    "Service classification.";
}

identity port-classification {
  base service-classification-type;
  description
    "Port classification.";
}

identity vlan-classification {
  base service-classification-type;
  description
    "VLAN classification.";
}

identity eth-vlan-tag-classify {
  description
    "VLAN tag classification.";
}

identity classify-c-vlan {
  base eth-vlan-tag-classify;
  description
    "Classify 802.1Q Customer VLAN tag.
    Only C-tag type is accepted";
}

identity classify-s-vlan {
  base eth-vlan-tag-classify;
```

```
    description
      "Classify 802.1Q Service VLAN (QinQ) tag.
       Only S-tag type is accepted";
  }

  identity classify-s-or-c-vlan {
    base eth-vlan-tag-classify;
    description
      "Classify S-VLAN or C-VLAN tag-classify.
       Either tag is accepted";
  }

  identity bandwidth-profile-type {
    description
      "Bandwidth Profile Types";
  }

  identity mef-10-bwp {
    base bandwidth-profile-type;
    description
      "MEF 10 Bandwidth Profile";
  }

  identity rfc-2697-bwp {
    base bandwidth-profile-type;
    description
      "RFC 2697 Bandwidth Profile";
  }

  identity rfc-2698-bwp {
    base bandwidth-profile-type;
    description
      "RFC 2698 Bandwidth Profile";
  }

  identity rfc-4115-bwp {
    base bandwidth-profile-type;
    description
      "RFC 4115 Bandwidth Profile";
  }

  identity service-type {
    description
      "Type of Ethernet service.";
  }

  identity p2p-svc {
    base service-type;
```

```
    description
      "Ethernet point-to-point service (EPL, EVPL).";
  }

  identity rmp-svc {
    base service-type;
    description
      "Ethernet rooted-multitpoint service (E-TREE, EP-TREE).";
  }

  identity mp2mp-svc {
    base service-type;
    description
      "Ethernet multipoint-to-multitpoint service (E-LAN, EP-LAN).";
  }

  identity lifecycle-status {
    description
      "Lifecycle Status.";
  }

  identity installed {
    base lifecycle-status;
    description
      "Installed.";
  }

  identity planned {
    base lifecycle-status;
    description
      "Planned.";
  }

  identity pending-removal {
    base lifecycle-status;
    description
      "Pending Removal.";
  }

/*
 * Type Definitions
 */

typedef eth-tag-type {
  type identityref {
    base eth-vlan-tag-type;
  }
  description
```

```
    "Identifies a specific ETH VLAN tag type.";
}

typedef eth-tag-classify {
  type identityref {
    base eth-vlan-tag-classify;
  }
  description
    "Identifies a specific VLAN tag classification.";
}

typedef vlanid {
  type uint16 {
    range "1..4094";
  }
  description
    "The 12-bit VLAN-ID used in the VLAN Tag header.";
}

typedef vid-range-type {
  type string {
    pattern "([1-9][0-9]{0,3}(-[1-9][0-9]{0,3})?" +
            "(,[1-9][0-9]{0,3}(-[1-9][0-9]{0,3})?)*)";
  }
  description
    "A list of VLAN Ids, or non overlapping VLAN ranges, in
    ascending order, between 1 and 4094.
    This type is used to match an ordered list of VLAN Ids, or
    contiguous ranges of VLAN Ids. Valid VLAN Ids must be in the
    range 1 to 4094, and included in the list in non overlapping
    ascending order.

    For example: 1,10-100,50,500-1000";
}

typedef bandwidth-profile-type {
  type identityref {
    base bandwidth-profile-type;
  }
  description
    "Identifies a specific Bandwidth Profile type.";
}

typedef service-type {
  type identityref {
    base service-type;
  }
  description
```

```
    "Identifies the type of Ethernet service.";
}

typedef lifecycle-status {
    type identityref {
        base lifecycle-status;
    }
    description
        "Identifies the Lifecycle Status .";
}

/*
 * Grouping Definitions
 */

grouping etht-bandwidth-profiles {
    description
        "Bandwidth profile configuration parameters.";

    leaf bandwidth-profile-type {
        type etht-types:bandwidth-profile-type;
        description
            "The type of bandwidth profile.";
    }
    leaf CIR {
        type uint64;
        description
            "Committed Information Rate in Kbps";
    }
    leaf CBS {
        type uint64;
        description
            "Committed Burst Size in KBytes";
    }
    leaf EIR {
        type uint64;
        /* Need to indicate that EIR is not supported by RFC 2697

        must
            '..../bw-profile-type = "mef-10-bwp" or ' +
            '..../bw-profile-type = "rfc-2698-bwp" or ' +
            '..../bw-profile-type = "rfc-4115-bwp"'

        must
            '..../bw-profile-type != "rfc-2697-bwp"'
        */
        description
            "Excess Information Rate in Kbps
```

```
        In case of RFC 2698, PIR = CIR + EIR";
    }
    leaf EBS {
        type uint64;
        description
            "Excess Burst Size in KBytes.
             In case of RFC 2698, PBS = CBS + EBS";
    }
    leaf color-aware {
        type boolean;
        description
            "Indicates whether the color-mode is
             color-aware or color-blind.";
    }
    leaf coupling-flag {
        type boolean;
        /* Need to indicate that Coupling Flag is defined only for MEF 10

        must
            '../bw-profile-type = "mef-10-bwp"'
        */
        description
            "Coupling Flag.";
    }
}

identity topology-role {
    description
        "The role of underlay topology, e.g.,
         hub, spoke, any-to-any. ";
}

identity resilience {
    description
        "Placeholder for resilience information in data plane,
         for future study. ";
}

identity access-role {
    description
        "Indicating whether the access is a working or protection access.";
}

identity performance {
    description
        "Placeholder for performance information, for future study.";
}
```



```
identity encapsulation-type {
  description
    "Indicating how the service is encapsulated (to PW), e.g, raw or tag. ";
}

grouping pw-segement-bandwidth-profile-grouping {
  description
    "bandwidth profile grouping for PW segment. ";
  leaf bandwidth-profile-type {
    type eth-types:bandwidth-profile-type;
    description
      "The type of bandwidth profile.";
  }
  leaf CIR {
    type uint64;
    description
      "Committed Information Rate in Kbps";
  }
  leaf CBS {
    type uint64;
    description
      "Committed Burst Size in in KBytes";
  }
  leaf EIR {
    type uint64;
    /* Need to indicate that EIR is not supported by RFC 2697

    must
      '../bw-profile-type = "mef-10-bwp" or ' +
      '../bw-profile-type = "rfc-2698-bwp" or ' +
      '../bw-profile-type = "rfc-4115-bwp"'

    must
      '../bw-profile-type != "rfc-2697-bwp"'
    */
    description
      "Excess Information Rate in Kbps
      In case of RFC 2698, PIR = CIR + EIR";
  }
  leaf EBS {
    type uint64;
    description
      "Excess Burst Size in KBytes.
      In case of RFC 2698, PBS = CBS + EBS";
  }
}

grouping eth-bandwidth {
  description
```

```
        "Available bandwidth for ethernet.";
    leaf eth-bandwidth {
        type uint64{
            range "0..100000000000";
        }
        units "Kbps";
        description
            "Available bandwidth value expressed in kilobits per second";
    }
}

grouping eth-label-restriction {
    description
        "Label Restriction for ethernet.";
    leaf tag-type {
        type eth-types:eth-tag-type;
        description "VLAN tag type.";
    }
    leaf priority {
        type uint8;
        description "priority.";
    }
}

grouping eth-label {
    description
        "Label for ethernet.";
    leaf vlanid {
        type eth-types:vlanid;
        description
            "VLAN tag id.";
    }
}

grouping eth-label-step {
    description "Label step for Ethernet VLAN";
    leaf eth-step {
        type uint16 {
            range "1..4095";
        }
    }
    default 1;
    description
        "Label step which represent possible increments for
        an Ethernet VLAN tag.";
    reference
        "IEEE 802.1ad: Provider Bridges.";
}
}
```

```
}
```

```
<CODE ENDS>
```

5.3. Other Client Signal YANG Code

This module imports typedefs and modules from [RFC6991], [I-D.ietf-ccamp-otn-tunnel-model], [I-D.ietf-teas-yang-te-types].

```
<CODE BEGINS> file "ietf-trans-client-service@2019-11-03.yang"
module ietf-trans-client-service {
  /* TODO: FIXME */
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-trans-client-service";
  prefix "clntsvc";

  import ietf-te-types {
    prefix "te-types";
    reference "RFC YYYY - Traffic Engineering Common YANG Types";
  }

  import ietf-layer1-types {
    prefix "layer1-types";
    reference "RFC ZZZZ - A YANG Data Model for Layer 1 Types";
  }

  import ietf-yang-types {
    prefix "yang";
    reference "RFC 6991 - Common YANG Data Types";
  }

  import ietf-trans-client-svc-types {
    prefix "clntsvc-types";
    reference "RFC XXXX - A YANG Data Model for
              Transport Network Client Signals";
  }

  organization
    "Internet Engineering Task Force (IETF) CCAMP WG";
  contact
    "
      ID-draft editor:
        Haomian Zheng (zhenghaomian@huawei.com);
        Aihua Guo (aihuaguo.ietf@gmail.com);
        Italo Busi (italo.busi@huawei.com);
```

```
Anton Snitser (antons@sedonasys.com);
Francesco Lazzeri (francesco.lazzeri@ericsson.com);
Yunbin Xu (xuyunbin@caict.ac.cn);
Yang Zhao (zhaoyangyjy@chinamobile.com);
Xufeng Liu (Xufeng_Liu@jabil.com);
Giuseppe Fioccola (giuseppe.fioccola@huawei.com);
";

description
  "This module defines a YANG data model for describing
  transport network client services. The model fully conforms
  to the Network Management Datastore Architecture (NMDA).

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  (https://trustee.ietf.org/license-info).
  This version of this YANG module is part of RFC XXXX; see
  the RFC itself for full legal notices."

revision 2019-11-03 {
  description
    "version -01 as a WG document";
  reference
    "draft-ietf-ccamp-client-signal-yang";
}

/*
 * Groupings
 */
grouping client-svc-access-parameters {
  description
    "Transport network client signals access parameters";

  leaf access-node-id {
    type te-types:te-node-id;
    description
      "The identifier of the access node in the underlying
      transport network topology.";
  }

  leaf access-ltp-id {
    type te-types:te-tp-id;
```

```
        description
            "The TE link termination point identifier, used together with
            access-node-id to identify the access LTP.";
    }

    leaf client-signal {
        type identityref {
            base layer1-types:client-signal;
        }
        description
            "Identify the client signal type associated with this port";
    }

}

grouping client-svc-tunnel-parameters {
    description
        "Transport network client signals tunnel parameters";

    leaf tunnel-name {
        type string;
        description
            "TE tunnel instance name.";
    }
}

grouping client-svc-instance-config {
    description
        "Configuration parameters for client services.";
    leaf client-svc-name {
        type string;
        description
            "Identifier of the p2p transport network client signals.";
    }

    leaf client-svc-title {
        type string;
        description
            "Name of the p2p transport network client signals.";
    }

    leaf client-svc-descr {
        type string;
        description
            "Description of the transport network client signals.";
    }
}
```

```
leaf client-svc-customer {
  type string;
  description
    "Customer of the transport network client signals.";
}

container resilience {
  description "Place holder for resilience functionalities";
}

uses te-types:te-topology-identifier;

leaf admin-status {
  type identityref {
    base te-types:tunnel-admin-state-type;
  }
  default te-types:tunnel-admin-state-up;
  description "Client signals administrative state.";
}

container src-access-ports {
  description
    "Source access port of a client signal.";
  uses client-svc-access-parameters;
}

container dst-access-ports {
  description
    "Destination access port of a client signal.";
  uses client-svc-access-parameters;
}

  leaf direction {
    type identityref {
      base clntsvc-types:direction;
    }
    description "Uni-dir or Bi-dir for the client signal.";
  }

list svc-tunnels {
  key tunnel-name;
  description
    "List of the TE Tunnels supporting the client signal.";
  uses client-svc-tunnel-parameters;
}

grouping client-svc-instance-state {
```

```
description
  "State parameters for client services.";
leaf operational-state {
  type identityref {
    base te-types:tunnel-state-type;
  }
  config false;
  description "Client signal operational state.";
}
leaf provisioning-state {
  type identityref {
    base te-types:lsp-state-type;
  }
  config false;
  description "Client signal provisioning state.";
}
leaf creation-time {
  type yang:date-and-time;
  config false;
  description "The time of the client signal be created.";
}
leaf last-updated-time {
  type yang:date-and-time;
  config false;
  description "The time of the client signal's latest update.";
}
}

/*
 * Data nodes
 */

container client-svc {
  description
    "Transport client services.";

  list client-svc-instances {
    key client-svc-name;
    description
      "The list of p2p transport client service instances";

    uses client-svc-instance-config;
    uses client-svc-instance-state;
  }
}
}
```

<CODE ENDS>

5.4. Other Client Signal Types YANG Code

This module defines the types for other client signal types.

```
<CODE BEGINS> file "ietf-trans-client-service@2019-11-03.yang"

module ietf-trans-client-svc-types {
  namespace "urn:ietf:params:xml:ns:yang:ietf-trans-client-svc-types";
  prefix "clntsvc-types";

  organization
    "Internet Engineering Task Force (IETF) CCAMP WG";
  contact
    "
      ID-draft editor:
      Haomian Zheng (zhenghaomian@huawei.com);
      Aihua Guo (aihuaguo.ietf@gmail.com);
      Italo Busi (italo.busi@huawei.com);
      Anton Snitser (antons@sedonasys.com);
      Francesco Lazzeri (francesco.lazzeri@ericsson.com);
      Yunbin Xu (xuyunbin@caict.ac.cn);
      Yang Zhao (zhaoyangyjy@chinamobile.com);
      Xufeng Liu (Xufeng_Liu@jabil.com);
      Giuseppe Fioccola (giuseppe.fioccola@huawei.com);
    ";

  description
    "This module defines a YANG data model for describing
    transport network client types. The model fully conforms
    to the Network Management Datastore Architecture (NMDA).

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    the RFC itself for full legal notices."

  revision 2019-11-03 {
```



```
    description
      "version -01 as a WG document";
    reference
      "draft-ietf-ccamp-client-signal-yang";
  }

  identity direction {
    description
      "Direction information of Client Signal.";
  }

  identity bidirectional {
    base direction;
    description
      "Client Signal is bi-directional.";
  }

  identity unidirectional {
    base direction;
    description
      "Client Signal is uni-directional.";
  }
}
<CODE ENDS>
```

6. Considerations and Open Issue

Editor Notes: This section is used to note temporary discussion/conclusion that to be fixed in the future version, and will be removed before publication. We currently categorize all the client signal types into transparent and non-transparent, with separate models. There was consensus that no common model is needed for these two categories. Further Alignment with RFC8407 would be required before publication. The RFC Editor will replace XXXX, YYYY and ZZZZ with the number assigned to the RFC once this draft becomes an RFC.

7. IANA Considerations

It is proposed that IANA should assign new URIs from the "IETF XML Registry" [RFC3688] as follows:

URI: urn:ietf:params:xml:ns:yang:ietf-eth-tran-service
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-trans-client-service
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-eth-tran-types
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-trans-client-svc-types
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

This document registers following YANG modules in the YANG Module Names registry [RFC6020].

name: ietf-eth-tran-service
namespace: urn:ietf:params:xml:ns:yang:ietf-eth-tran-service
prefix: ethtsvc
reference: RFC XXXX: A YANG Data Model for Transport
Network Client Signals

name: ietf-eth-tran-types
namespace: urn:ietf:params:xml:ns:yang:ietf-eth-tran-types
prefix: etht-types
reference: RFC XXXX: A YANG Data Model for Transport
Network Client Signals

name: ietf-trans-client-service
namespace: urn:ietf:params:xml:ns:yang:ietf-trans-client-service
prefix: clntsvc
reference: RFC XXXX: A YANG Data Model for Transport
Network Client Signals

name: ietf-trans-client-svc-types
namespace: urn:ietf:params:xml:ns:yang:ietf-trans-client-svc-types
prefix: clntsvc-types
reference: RFC XXXX: A YANG Data Model for Transport
Network Client Signals

8. Manageability Considerations

TBD.

9. Security Considerations

The data following the model defined in this document is exchanged via, for example, the interface between an orchestrator and a network domain controller.

The YANG module defined in this document can be accessed via the RESTCONF protocol defined in [RFC8040], or maybe via the NETCONF protocol [RFC6241].

There are a number of data nodes defined in the YANG module which are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., POST) to these data nodes without proper protection can have a negative effect on network operations.

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11. Contributors

Yanlei Zheng
China Unicom
Email: zhengyl@dimpt.com

Zhe Liu
Huawei Technologies,
Email: liuzhe123@huawei.com

Sergio Belotti
Nokia,
Email: sergio.belotti@nokia.com

Yingxi Yao
Shanghai Bell,
yingxi.yao@nokia-sbell.com

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Authors' Addresses

Haomian Zheng
Huawei Technologies
H1-1-A043S Huawei Industrial Base, Songshanhu
Dongguan, Guangdong
P.R.China

Email: zhenghaomian@huawei.com

Aihua Guo
Individual

Email: aihuaguo.ietf@gmail.com

Italo Busi
Huawei Technologies

Email: Italo.Busi@huawei.com

Anton Snitser
Sedona

Email: antons@sedonasys.com

Francesco Lazzeri
Ericsson

Email: francesco.lazzeri@ericsson.com

Yunbin Xu
CAICT

Email: xuyunbin@caict.ac.cn

Yang Zhao
China Mobile

Email: zhaoyangyjy@chinamobile.com

Xufeng Liu
Volta Networks

Email: xufeng.liu.ietf@gmail.com

Giuseppe Fioccola
Huawei Technologies

Email: giuseppe.fioccola@huawei.com

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D. Hiremagalur, Ed.
G. Grammel, Ed.
Juniper
G. Galimberti, Ed.
Cisco
R. Kunze, Ed.
Deutsche Telekom
D. Beller
Nokia
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Extension to the Link Management Protocol (LMP/DWDM -rfc4209) for Dense
Wavelength Division Multiplexing (DWDM) Optical Line Systems to manage
the application code of optical interface parameters in DWDM application
draft-ietf-ccamp-dwdm-if-lmp-01

Abstract

This memo defines extensions to LMP(rfc4209) for managing Optical parameters associated with Wavelength Division Multiplexing (WDM) systems in accordance with the Interface Application Identifier approach defined in ITU-T Recommendation G.694.1.[ITU-T.G694.1] and its extensions.

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Table of Contents

1. Introduction	2
2. DWDM line system	3
3. Use Cases	4
3.1. Optical interface parameter collection	4
3.2. DWDM client - ROADM interconnection discovery	5
3.3. Service Setup	5
3.4. Link Monitoring Use Cases	6
4. Extensions to LMP-WDM Protocol	7
5. General Parameters - OCh_General	7
6. ApplicationIdentifier - OCh_ApplicationIdentifier	9
7. OCh_Ss - OCh transmit parameters	11
8. OCh_Rs - receive parameters	12
9. Security Considerations	12
10. IANA Considerations	12
11. Contributors	13
12. References	13
12.1. Normative References	14
12.2. Informative References	15
Authors' Addresses	15

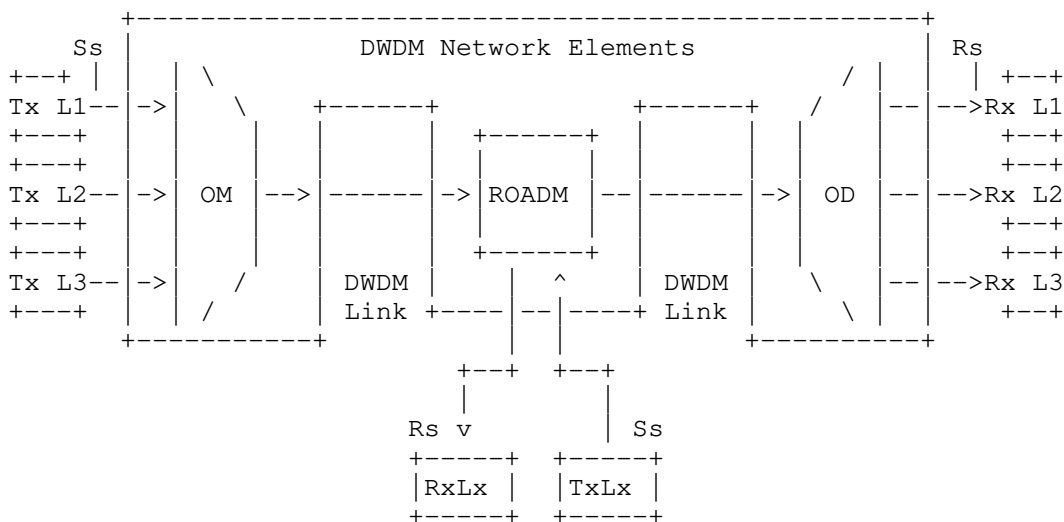
1. Introduction

LMP [RFC4902] provides link property correlation capabilities that can be used between a transceiver device and an Optical Line System (OLS) device. Link property correlation is a procedure by which, intrinsic parameters and capabilities are exchanged between two ends of a link. Link property correlation as defined in RFC3591 allows either end of the link to supervise the received signal and operate within a commonly understood parameter window. Here the term 'link' refers in particular to the attachment link between OXC and OLS (see Figure 1). The relevant interface parameters are in line with

"draft-dharini-ccamp-dwdm-if-yang". Use cases are 1- Optical interface parameter collection, 2- DWDM client - ROADM interconnection discovery, 3- Service Setup, 4- Service Setup

2. DWDM line system

Figure 1 shows a set of reference points (Rs and Ss), for a single-channel connection between transmitter (Tx) and receiver (Rx) devices. Here the DWDM network elements in between those devices include an Optical Multiplexer (OM) and an Optical Demultiplexer (OD). In addition it may include one or more Optical Amplifiers (OA) and one or more Optical Add-Drop Multiplexers (ROADM).



Ss = Sender reference point at the DWDM network element tributary output

Rs = Receiver reference point at the DWDM network element tributary input

Lx = Lambda x

OM = Optical Mux

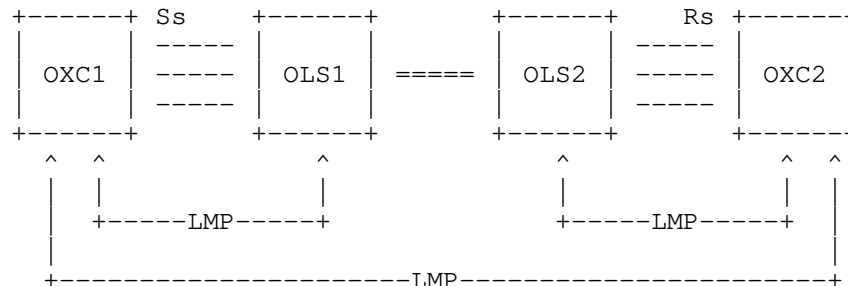
OD = Optical Demux

ROADM = Reconfigurable Optical Add Drop Mux

from Fig. 5.1/G.698.2

Figure 1: Linear Single Channel approach

Figure 2 Extended LMP Model (from [RFC4209])



OXC : is an entity that contains transponders
 OLS : generic optical system, it can be -
 Optical Mux, Optical Demux, Optical Add
 Drop Mux, Amplifier etc.
 OLS to OLS : represents the Optical Multiplex section
 <xref target="ITU-T.G709"/>
 Rs/Ss : reference points in between the OXC and the OLS

Figure 2: Extended LMP Model

3. Use Cases

A comparison with the traditional operation scenarios provides an insight of similarities and distinctions in operation and management of DWDM interfaces. The following use cases provide an overview about operation and maintenance processes.

3.1. Optical interface parameter collection

It is necessary to identify the Optical interface characteristics and setting in order to properly calculate the end to end path and match the Head End interface against the Tail End interface compatibility. The optical parameters may have multiple possible values that the Controller (SDN or GMPLS) can use and select for the best network optimisation. In case of GMPLS the LMP is suitable to support the parameters exchange between the ROADM and the Transponder (or DWDM interface located into the client box).

3.2. DWDM client - ROADM interconnection discovery

Being the the DWDM port and ROADM port belonging to different domains and Network Elements, the interconnection between them is not embedded in the Optical Nodes and can not be shared to the EMS and the Controller. The Controller needs then to retrieve the connectivity using data coming from the two domains correlating them to discover the relationship. The methods to discover the interconnection can be LMP, LLDP, installation provisioning or any other mechanism checking using the light transmitted by the DWDM transmitter and detector by the ROADM port photodiode. This use case is fundamental to build the interconnections between the DWDM and Client layer (e.g. Routers) and calculate the multilayer network topology.

3.3. Service Setup

It is necessary to differentiate between different operational issues for setting up a light path (a DWDM connection is specific in having defined maximum impairments) within an operational network.

The first step is to determine if transceivers located at different end-points are interoperable, i.e. support a common set of operational parameters. In this step it is required to determine transceiver capabilities in a way to be able to correlate them for interoperability purposes. Such parameters include modulation scheme, modulation parameters, FEC to name a few. If both transceivers are controlled by the same NMS or CP, such data is readily available. However in cases where the transceivers are controlled by different CP, a protocol needs to be used to inform the controlling instance (NMS or CP) about transceiver parameters. It is suggested to extend LMP for that purpose.

The second step is to determine the feasibility of a lightpath between two transceivers without applying an optical signal. Understanding the limitations of the transceiver pair, a path through the optical network has to be found, whereby each path has an individual set of impairments deteriorating a wavelength traveling along that path. Since a single transceiver can support multiple parameter sets, the selection of a path may limit the permissible parameter sets determined in previous steps.

The third step is then to setup the connection itself and to determine the Wavelength. This is done using the NMS of the optical transport network or by means of a control plane interaction such as signaling and includes the path information as well as the parameter set information necessary to enable communication.

In a fourth step, optical monitoring is activated in the WDM network in order to monitor the status of the connection. The monitor functions of the optical interfaces at the terminals are also activated in order to monitor the end to end connection.

Furthermore it should be possible to automate this step. After connecting the client device to the neighbor control plane-enabled transport node, a control adjacency may be automatically established, e.g. using LMP.

3.4. Link Monitoring Use Cases

The use cases described below are assuming that power monitoring functions are available in the ingress and egress network element of the DWDM network, respectively. By performing link property correlation it would be beneficial to include the current transmit power value at reference point Ss and the current received power value at reference point Rs. For example if the Client transmitter power has a value of 0dBm and the ROADM interface measured power is -6dBm the fiber patch cord connecting the two nodes may be pinched or the connectors are dirty. As discussed before, the actual path or selection of a specific wavelength within the allowed set is outside the scope of LMP. The computing entities (e.g. the first optical node originating the circuit) can rely on GMPLS IGP (OSPF) to retrieve all the information related to the network, calculate the path to reach the endpoint and signal the path implementation through the network via RSVP-TE.

[ITU-T.G.698.2] defines a single channel optical interface for DWDM systems that allows interconnecting network-external optical transponders across a DWDM network. The optical transponders are external to the DWDM network. This so-called 'Black Link' approach illustrated in Fig. 5-1 of [ITU-T.G.698.2]. The single channel fiber link between the Ss/Rs reference points and the ingress/egress port of the network element on the domain boundary of the DWDM network (DWDM border NE) is called access link. Based on the definition in [ITU-T.G.698.2] it is part of the DWDM network. The access link is typically realized as a passive fiber link that has a specific optical attenuation (insertion loss). As the access link is an integral part of the DWDM network, it is desirable to monitor its attenuation. Therefore, it is useful to detect an increase of the access link attenuation, for example, when the access link fiber has been disconnected and reconnected (maintenance) and a bad patch panel connection (connector) resulted in a significantly higher access link attenuation (loss of signal in the extreme case of an open connector or a fiber cut). In the following section, two use cases are presented and discussed:

- 1) pure access link monitoring
- 2) access link monitoring with a power control loop

These use cases require a power monitor as described in G.697 (see section 6.1.2), that is capable to measure the optical power of the incoming or outgoing single channel signal. The use case where a power control loop is in place could even be used to compensate an increased attenuation if the optical transmitter can still be operated within its output power range defined by its application code.

4. Extensions to LMP-WDM Protocol

This document defines extensions to [RFC4209] to allow a set of characteristic parameters, to be exchanged between a router or optical switch (e.g. OTN cross connect) and the optical line system to which it is attached. In particular, this document defines additional Data Link sub-objects to be carried in the LinkSummary message defined in [RFC4204] and [RFC6205]. The OXC and OLS systems may be managed by different Network management systems and hence may not know the capability and status of their peer. These messages and their usage are defined in subsequent sections of this document.

The following new messages are defined for the WDM extension for ITU-T G.698.2 [ITU-T.G698.2]/ITU-T G.698.1 [ITU-T.G698.1]/ITU-T G.959.1 [ITU-T.G959.1]

- OCh_General (sub-object Type = TBA)
- OCh_ApplicationIdentifier (sub-object Type = TBA)
- OCh_Ss (sub-object Type = TBA)
- OCh_Rs (sub-object Type = TBA)

5. General Parameters - OCh_General

These are a set of general parameters as described in [G698.2] and [G.694.1]. Please refer to the "draft-dharini-ccamp-dwdm-if-yang" for more details about these parameters and the [RFC6205] for the wavelength definition.

The general parameters are

1. Central Frequency - (Tera Hz) 4 bytes (see RFC6205 sec.3.2)
2. Number of Application Identifiers (A.I.) Supported
3. Single-channel Application Identifier in use
4. Application Identifier Type in use
5. Application Identifier in use

Figure 3: The format of the this sub-object (Type = TBA, Length = TBA) is as follows:

0										1										2										3									
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1								
Type										Length										(Reserved)																			
Central Frequency																																							
Number of Application Identifiers Supported																				(Reserved)																			
Single-channel Application Identifier Number in use										A.I. Type in use										A.I. length																			
Single-channel Application Identifier in use																																							
Single-channel Application Identifier in use																																							
Single-channel Application Identifier in use																																							

A.I. Type in use: STANDARD, PROPRIETARY

A.I. Type in use: STANDARD

Refer to G.698.2 recommendation : B-DScW-ytz(v)

0										1										2										3									
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1								
Single-channel Application Code																																							
Single-channel Application Code																																							
Single-channel Application Code																																							

A.I. Type in use: PROPRIETARY

Note: if the A.I. type = PROPRIETARY, the first 6 Octets of the Application Identifier in use are six characters of the PrintableString must contain the Hexadecimal representation of an OUI (Organizationally Unique Identifier) assigned to the vendor whose implementation generated the Application Identifier; the remaining octets of the PrintableString are

unspecified.

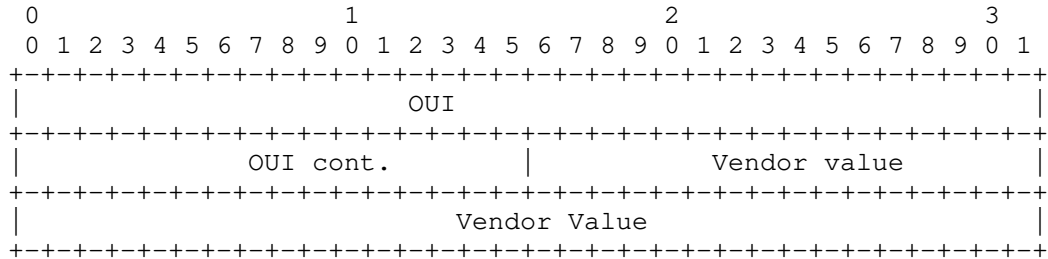


Figure 3: OCh_General

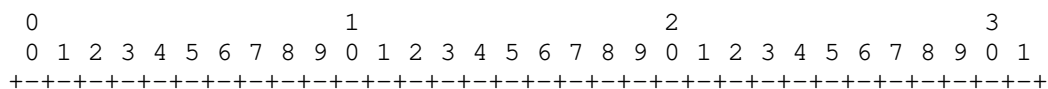
6. ApplicationIdentifier - OCh_ApplicationIdentifier

This message is to exchange the application identifiers supported as described in [G698.2]. There can be more than one Application Identifier supported by the transmitter/receiver in the OXC. The number of application identifiers supported is exchanged in the "OCh_General" message. (from [G698.1]/[G698.2]/[G959.1] and G.874.1)

The parameters are

1. Number of Application Identifiers (A.I.) Supported
 2. Single-channel application identifier Number uniquely identifies this entry - 8 bits
 3. Application Identifier Type (A.I.) (STANDARD/PROPRIETARY)
 4. Single-channel application identifier -- 96 bits (from [G698.1]/[G698.2]/[G959.1])
- this parameter can have multiple instances as the transceiver can support multiple application identifiers.

Figure 4: The format of the this sub-object (Type = TBA, Length = TBA) is as follows:



Type	Length	(Reserved)
Number of Application Identifiers Supported		(Reserved)
Single-channel Application Identifier Number	A.I. Type	A.I. length
Single-channel Application Identifier		
Single-channel Application Identifier		
Single-channel Application Identifier		
// //		
Single-channel Application Identifier Number	A.I. Type	A.I. length
Single-channel Application Identifier		
Single-channel Application Identifier		
Single-channel Application Identifier		

A.I. Type in use: STANDARD, PROPRIETARY

A.I. Type in use: STANDARD

Refer to G.698.2 recommendation : B-DScW-ytz(v)

0	1	2	3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1			
Single-channel Application Code			
Single-channel Application Code			
Single-channel Application Code			

A.I. Type in use: PROPRIETARY

Note: if the A.I. type = PROPRIETARY, the first 6 Octets of the Application Identifier in use are six characters of the PrintableString must contain the Hexadecimal representation of an OUI (Organizationally Unique Identifier) assigned to the vendor whose implementation generated the Application Identifier; the remaining octets of the PrintableString are unspecified.

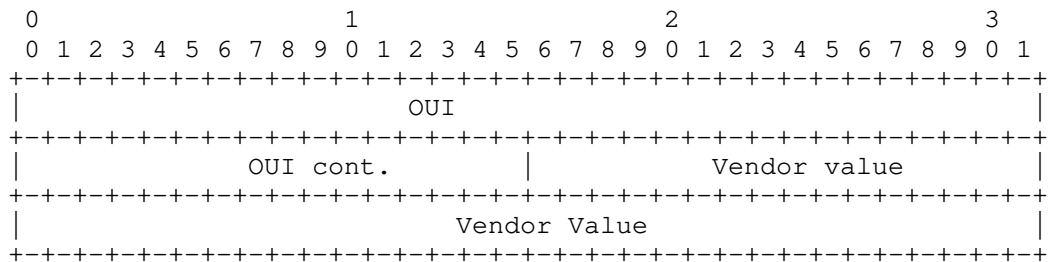


Figure 4: OCh_ApplicationIdentifier

7. OCh_Ss - OCh transmit parameters

These are the G.698.2 parameters at the Source(Ss reference points). Please refer to "draft-dharini-ccamp-dwdm-if-yang" for more details about these parameters.

1. Output power

Figure 5: The format of the OCh sub-object (Type = TBA, Length = TBA) is as follows:

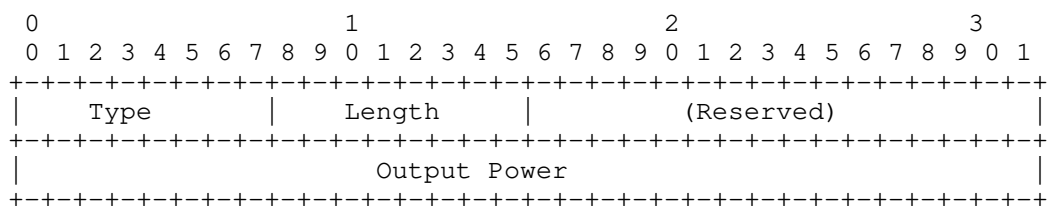


Figure 5: OCh_Ss transmit parameters

8. OCh_Rs - receive parameters

These are the G.698.2 parameters at the Sink (Rs reference points).

1. Current Input Power - (0.1dbm) 4bytes

Figure 6: The format of the OCh receive sub-object (Type = TBA, Length = TBA) is as follows:

The format of the OCh receive/OLS Sink sub-object (Type = TBA, Length = TBA) is as follows:

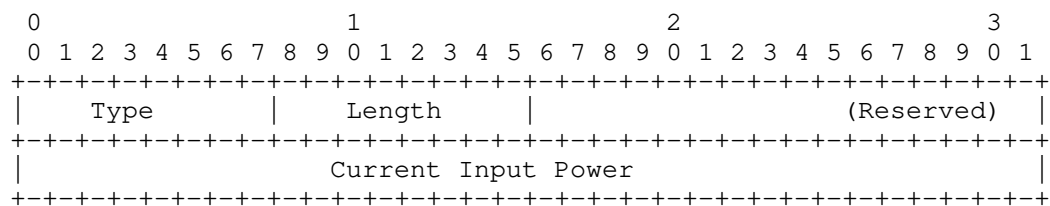


Figure 6: OCh_Rs receive parameters

9. Security Considerations

LMP message security uses IPsec, as described in [RFC4204]. This document only defines new LMP objects that are carried in existing LMP messages, similar to the LMP objects in [RFC:4209]. This document does not introduce new security considerations.

10. IANA Considerations

LMP <xref target="RFC4204"/> defines the following name spaces and the ways in which IANA can make assignments to these namespaces:

- LMP Message Type
 - LMP Object Class
 - LMP Object Class type (C-Type) unique within the Object Class
 - LMP Sub-object Class type (Type) unique within the Object Class
- This memo introduces the following new assignments:

LMP Sub-Object Class names:

under DATA_LINK Class name (as defined in <xref target="RFC4204"/>)

- OCh_General (sub-object Type = TBA)
- OCh_ApplicationIdentifier (sub-object Type = TBA)
- OCh_Ss (sub-object Type = TBA)
- OCh_Rs (sub-object Type = TBA)

11. Contributors

Arnold Mattheus
Deutsche Telekom
Darmstadt
Germany
email a.mattheus@telekom.de

John E. Drake
Juniper
1194 N Mathilda Avenue
HW-US, Pennsylvania
USA
jdrake@juniper.net

Zafar Ali
Cisco
3000 Innovation Drive
KANATA
ONTARIO K2K 3E8
zali@cisco.com

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Authors' Addresses

Dharini Hiremagalur (editor)
Juniper
1194 N Mathilda Avenue
Sunnyvale - 94089 California
USA

Phone: +1408
Email: dharinih@juniper.net

Gert Grammel (editor)
Juniper
Oskar-Schlemmer Str. 15
80807 Muenchen
Germany

Phone: +49 1725186386
Email: ggrammel@juniper.net

Gabriele Galimberti (editor)
Cisco
Via S. Maria Molgora, 48 c
20871 - Vimercate
Italy

Phone: +390392091462
Email: ggalimbe@cisco.com

Ruediger Kunze (editor)
Deutsche Telekom
Winterfeldtstr. 21-27
10781 Berlin
Germany

Phone: +491702275321
Email: RKunze@telekom.de

Dieter Beller
Nokia
Lorenzstrasse, 10
70435 Stuttgart
Germany

Phone: +4971182143125
Email: Dieter.Beller@nokia.com

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G. Galimberti, Ed.
Cisco
R. Kunze
Deutsche Telekom
D. Hiremagalur, Ed.
G. Grammel, Ed.
Juniper
November 4, 2019

A YANG model to manage the optical interface parameters for an external
transponder in a WDM network
draft-ietf-ccamp-dwdm-if-param-yang-02

Abstract

This memo defines a Yang model related to the Optical Transceiver parameters characterising coherent 100G and above interfaces. 100G and above Transceivers support coherent modulation, multiple modulation formats, multiple FEC codes including some not yet specified (or by in phase of specification by) ITU-T G.698.2 [ITU.G698.2] or any other ITU-T recommendation. More context about the state of the Coherent transceivers is described in draft-many-coherent-DWDM-if-control. Use cases are described in RFC7698.

The Yang model defined in this memo can be used for Optical Parameters monitoring and/or configuration of the endpoints of a multi-vendor IaDI optical link. The use of this model does not guarantee interworking of transceivers over a DWDM. Optical path feasibility and interoperability has to be determined by means outside the scope of this document. The purpose of this model is to program interface parameters to consistently configure the mode of operation of transceivers.

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Table of Contents

1. Introduction	3
2. The Internet-Standard Management Framework	3
3. Conventions	4
4. Overview	4
4.1. Optical Parameters Description	5
4.1.1. Parameters at Ss	5
4.1.2. Interface at point Rs	5
4.2. Use Cases	5
4.3. Optical Interface for external transponder in a WDM network	5
5. Structure of the Yang Module	7
6. Yang Module	8
7. Security Considerations	19
8. IANA Considerations	19
9. Acknowledgements	19
10. Contributors	19
11. References	21
11.1. Normative References	21
11.2. Informative References	23
Appendix A. Change Log	23
Appendix B. Open Issues	23
Authors' Addresses	23

1. Introduction

This memo defines a Yang model that translates and obsolete the SNMP mib module defined in draft-galikunze-ccamp-dwdm-if-snmp-mib for managing single channel optical interface parameters of DWDM applications, using the approach specified in G.698.2. This model supports parameters to characterize coherent transceivers found in current implementations to specify the mode of operation. As application identifiers like those specified in ITU-T G.874.1 [ITU.G874.1] are not available we use mode templates instead. A mode template describes transceiver characteristics in detail and can be identified by a mode-id.

This draft refers and supports the RFC7698 and draft-many-coherent-DWDM-if-control.

The YANG model describing and extending the optical parameters allows different vendors and operators to retrieve, provision and exchange information across the multi-vendor IaDI interfaces in an abstract manner.

The they concept introduced by this YANG model is the notion of a mode. A mode is a combination of parameters or parameter ranges that is supported by a transceiver. As an example, operating a device in QPSK mode may use a different FEC and requires less OSNR to reach the FEC limit than the same transceiver operating in QAM16 mode. Given the number of parameters and their possible combinations it is important for vendors to be able to qualify a set of combinations which is the basis to define a mode. The YANG model furthermore provides means to selecting one mode as current-mode from that pre-defined list of modes supported by the transceiver module. Once selected, current-opt-if-och-mode-params provide the means to configure specific parameters at run time and retrieve actual parameters from the module. For example, the frequency is a parameter that can be set within min/max boundaries set by the current mode. Laser Temperature however is a ro parameter available at run-time that can be checked against the mode boundaries and may trigger an event.

2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

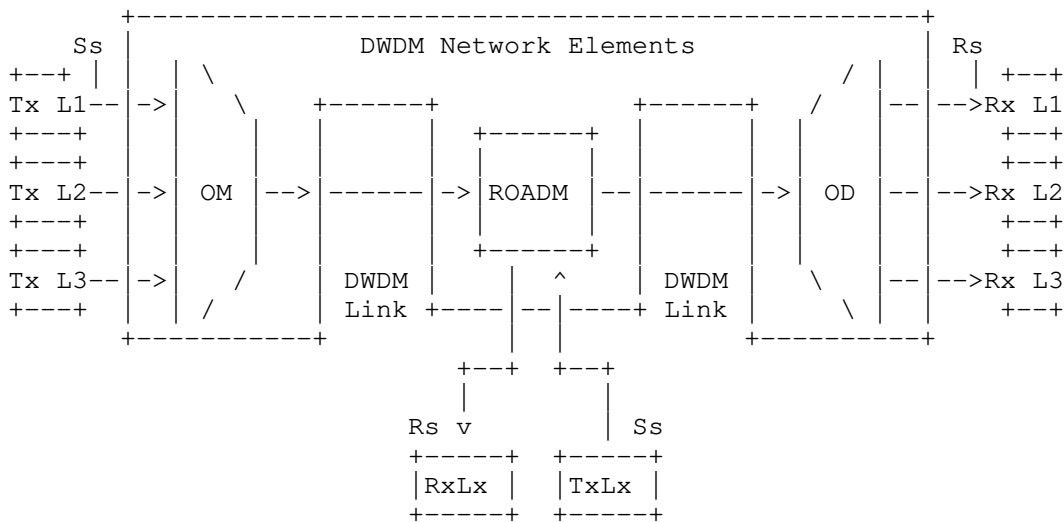
This memo specifies a Yang model for optical interfaces.

3. Conventions

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]. In the description of OIDs the convention: Set (S) Get (G) and Trap (T) conventions will describe the action allowed by the parameter.

4. Overview

Figure 1 shows a set of reference points, for single-channel connection between transmitters (Tx) and receivers (Rx). Here the DWDM network elements include an OM and an OD (which are used as a pair with the opposing element), one or more optical amplifiers and may also include one or more OADMs.



Ss = reference point at the DWDM network element tributary output
Rs = reference point at the DWDM network element tributary input
Lx = Lambda x
OM = Optical Mux
OD = Optical Demux
ROADM = Reconfigurable Optical Add Drop Mux

from Fig. 5.1/G.698.2

Figure 1: External transponder in WDM networks

4.1. Optical Parameters Description

The link between the external transponders through a WDM network media channels are managed at the edges, i.e. at the transmitters (Tx) and receivers (Rx) attached to the S and R reference points respectively.

Definitions of the optical parameters are provided below to increase the readability of the document.

4.1.1. Parameters at Ss

output-power:

The mean launched power at Ss is the average power (in dBm) of a pseudo-random data sequence coupled into the DWDM link.

central frequency:

This parameter indicates the Central frequency value that Ss and Rs will be set to work (in THz)

4.1.2. Interface at point Rs

input-power:

The average received power (in dBm) at point Rs.

Curr-OSNR:

Current Optical Signal to Noise Ratio (OSNR) estimated at Rx Transceiver port.

Curr-q-factor:

"Q" factor estimated at Rx Transceiver port.

4.2. Use Cases

The use cases are described in draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk

4.3. Optical Interface for external transponder in a WDM network

The ietf-ext-xponder-wdm-if is an augment to the ietf-interface. It allows the user to set the operating mode of transceivers as well as other operational parameters. The module provides also threshold settings and notifications to supervise measured parameters and notify the client.

```
module: ietf-ext-xponder-wdm-if
  augment /if:interfaces/if:interface:
    +--rw optIfOChRsSs
    +--rw if-current-mode
```

```

+--ro mode-id?                               string
+--ro application-identifier?                 string
+--ro min-central-frequency?                  uint32
+--ro max-central-frequency?                  uint32
+--ro min-input-power?                        dbm-t
+--ro max-input-power?                        dbm-t
+--ro min-output-power?                       dbm-t
+--ro max-output-power?                       dbm-t
+--ro min-osnr-margin?                        int32
+--ro min-q-margin?                          int32
+--ro fec-info?                              string
+--ro fec-bitrate?                           string
+--ro fec-gain?                              string
+--ro fec-ber-mantissa-threshold?             uint32
+--ro fec-ber-exponent-threshold?             int32
+--ro number-of-lanes?                        uint32
+--ro min-laser-temperature?                  int32
+--ro max-laser-temperature?                  int32
+--ro max-total-rx-optical-power?             dbm-t
+--ro max-chromatic-dispersion?               int32
+--ro max-diff-group-delay?                   int32
+--ro modulation-format?                      string
+--ro bits-per-symbol?                        uint32
+--ro num-symbols-in-alphabet?                uint32
+--ro symbols-index?                          uint32
+--ro if-supported-mode
+--ro number-of-modes-supported?               uint32
+--ro mode-list* [mode-id]
+--ro mode-id?                               string
+--ro application-identifer?                  string
+--ro min-central-frequency?                  uint32
+--ro max-central-frequency?                  uint32
+--ro min-channel-input-power?                dbm-t
+--ro max-channel-input-power?                dbm-t
+--ro min-channel-output-power?               dbm-t
+--ro max-channel-output-power?               dbm-t
+--ro min-osnr-margin?                        int32
+--ro min-q-margin?                          int32
+--ro fec-info?                              string
+--ro fec-bitrate?                           string
+--ro fec-gain?                              string
+--ro pre-fec-ber-mantissa-threshold?         uint32
+--ro pre-fec-ber-exponent-threshold?         int32
+--ro number-of-lanes?                        uint32
+--ro min-laser-temperature?                  int32
+--ro max-laser-temperature?                  int32
+--ro max-total-rx-optical-power?             dbm-t
+--ro max-chromatic-dispersion?               int32

```

```

    |      +---ro max-diff-group-delay?      int32
    |      +---ro modulation-format?        string
    |      +---ro baud-rate?                string
    |      +---ro bits-per-symbol?          uint32
    |      +---ro num-symbols-in-alphabet?   uint32
    |      +---ro symbols-index?            uint32
+---rw current-opt-if-och-mode-params
    |      +---rw mode-id?                  string
    |      +---rw central-frequency?        uint32
    |      +---rw channel-output-power?     int32
    |      +---ro channel-input-power?      int32
    |      +---ro total-input-power?        int32
    |      +---rw min-fec-ber-mantissa-threshold? uint32
    |      +---rw min-fec-ber-exponent-threshold? int32
    |      +---rw max-fec-ber-mantissa-threshold? uint32
    |      +---rw max-fec-ber-exponent-threshold? int32
    |      +---rw number-of-tcas-supported?  uint32
    |      +---rw mode-list* [tca-type]
    |      |      +---rw tca-type          opt-if-och-tca-types
    |      |      +---rw min-threshold?    int32
    |      |      +---rw max-threshold?    int32
    |      +---ro cur-osnr?                int32
    |      +---ro cur-q-factor?            int32
    |      +---ro uncorrected-words?       uint64
    |      +---ro pre-fec-ber-mantissa?    uint32
    |      +---ro pre-fec-ber-exponent?    int32

```

notifications:

```

+---n opt-if-och-central-frequency-change
    |      +---ro if-name?    -> /if:interfaces/interface/name
    |      +---ro new-opt-if-och-central-frequency
    |      |      +---ro central-frequency?          uint32
+---n opt-if-och-mode-change
    |      +---ro if-name?    -> /if:interfaces/interface/name
    |      +---ro mode-id?          string
+---n opt-if-och-min-tca
    |      +---ro if-name?    -> /if:interfaces/interface/name
    |      +---ro tca-type?    opt-if-och-tca-types

```

5. Structure of the Yang Module

ietf-ext-xponder-wdm-if is a top level model for the support of this feature.

6. Yang Module

The ietf-ext-xponder-wdm-if is defined as an extension to ietf interfaces.

```
<CODE BEGINS> file "ietf-ext-xponder-wdm-if.yang"

module draft-ietf-ccamp-dwdm-if-param-yang-02 {
  namespace "urn:ietf:params:xml:ns:yang:ietf-ext-xponder-wdm-if";
  prefix ietf-ext-xponder-wdm-if;

  import ietf-interfaces {
    prefix if;
  }

  organization
    "IETF CCAMP
    Working Group";

  contact
    "WG Web:   <http://tools.ietf.org/wg/ccamp/>
    WG List:  <mailto:ccamp@ietf.org>

    Editor:   Dharini Hiremagalur
              <mailto:dharinih@juniper.net>";

  description
    "This module contains a collection of YANG definitions for
    configuring Optical interfaces.

    Copyright (c) 2016 IETF Trust and the persons identified
    as authors of the code. All rights reserved.

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

  revision "2019-11-04" {
    description
      "Revision 1.4";
    reference
      "";
  }
```

```
revision "2019-07-08" {
  description
    "Revision 1.3";
  reference
    "";
}
revision "2018-10-22" {
  description
    "Revision 1.2";
  reference
    "";
}
revision "2018-03-06" {
  description
    "Revision 1.1";
  reference
    "";
}
revision "2017-03-06" {
  description
    "Revision 1.0";
  reference
    "";
}
revision "2016-03-17" {
  description
    "Initial revision.";
  reference
    "";
}

typedef dbm-t {
  type decimal64 {
    fraction-digits 2;
    range "-50..-30 | -10..5 | 10000000";
  }
  description "
    Amplifier Power in dBm";
}
typedef opt-if-och-tca-types {
  type enumeration {
    enum max-laser-linewdt {
      description "The maximum laser linewidth";
    }
    enum min-tx-power-tca {
```



```
    description "The min tx power TCA";
  }
  enum max-tx-power-tca {
    description "The min tx power TCA";
  }
  enum min-rx-power-tca{
    description "The min tx power TCA";
  }
  enum max-rx-power-tca{
    description "The min tx power TCA";
  }
  enum max-pol-power-diff-tca{
    description "The power difference between polarization TCA";
  }
  enum max-pol-skew-diff-tca{
    description "The skew between the two polarization TCA";
  }
  enum min-frequency-offset-tca{
    description "Min Frequency offset TCA";
  }
  enum max-frequency-offset-tca{
    description "Max Frequency offset TCA";
  }
  enum min-osnr-tca{
    description "Min OSNR TCA";
  }
  enum max-osnr-tca{
    description "Max OSNR TCA";
  }
  enum min-laser-temperature-tca{
    description "The min tx power TCA";
  }
  enum max-laser-temperature-tca{
    description "Temperature TCA";
  }
  enum min-fec-ber-tca{
    description "Min Pre Fec BER TCA";
  }
  enum max-fec-ber-tca{
    description "Max Pre Fec BER TCA";
  }
  enum min-q-tca{
    description "Min Q TCA";
  }
  enum max-q-tca {
    description "Max Q TCA";
  }
}
```

```

    description "The different types of TCA's";
}

grouping opt-if-och-power {
    description "Interface optical Power";

    leaf channel-output-power {
        type int32;
        units ".01dbm";
        description "The output power for this interface in .01 dBm.
                     The setting of the output power is optional";
    }

    leaf channel-input-power {
        type int32;
        units ".01dbm";
        config false;
        description "The current channel input power of this interface";
    }

    leaf total-input-power {
        type int32;
        units ".01dbm";
        config false;
        description "The total input power of this interface";
    }
}

grouping opt-if-och-tca-thresholds {
    description "Thresholds for TCA's";
    leaf tca-type {
        type opt-if-och-tca-types;
        description "type of the TCA eg TX Power";
    }
    leaf min-threshold {
        type int32;
        description "A TCA is generated if the variable is less than
                     this value";
    }
    leaf max-threshold {
        type int32;
        description "A TCA is generated if the variable is more than
                     this value";
    }
}

grouping opt-if-och-fec {
    description "FEC info";
}

```

```
    leaf fec-info {
      type string { length "1..255"; }
      config false;
      description "FEC Type - eg GFEC";
    }
    leaf fec-bitrate {
      type string { length "1..255"; }
      config false;
      description "FEC Overhead rate ";
    }
    leaf fec-gain {
      type string { length "1..255"; }
      config false;
      description "FEC Overhead rate ";
    }
    leaf pre-fec-ber-mantissa-threshold {
      type uint32;
      description "Mantissa of the FEC BER threshold";
    }
    leaf pre-fec-ber-exponent-threshold {
      type int32;
      description "Exponent of the FEC BER threshold";
    }
  }
}

grouping opt-if-och-central-frequency {
  description "Interface Central Frequency";
  leaf central-frequency {
    type uint32;
    description "This parameter indicates the frequency of this
                  interface ";
  }
}

grouping opt-if-och-modulation-params {
  description "Optical modulation parameters for the lane";

  leaf modulation-format {
    type string { length "1..255"; }
    config false;
    description "Modulation format for this mode";
  }
  leaf baud-rate {
    type uint32;
    description "Baud-rate or symbol rate";
  }
  leaf bits-per-symbol {
    type uint32;
  }
}
```

```

        description "This parameter the bits per symbol for this mode";
    }
    leaf num-symbols-in-alphabet {
        type uint32;
        description "This parameter the bits per symbol for this mode";
    }
    leaf symbols-index {
        type uint32;
        description "This parameter is the symbol index this mode";
    }
}

```

```

grouping opt-if-och-lane-param {
    description "Optical parameters for the lane";

    leaf number-of-lanes {
        type uint32;
        config false;
        description "Number of optical lanes of this interface";
    }
    leaf min-laser-temperature {
        type int32;
        units ".01C";
        config false;
        description "Minimum Laser Temperature of this mode for this
                    lane";
    }
    leaf max-laser-temperature {
        type int32;
        units ".01C";
        config false;
        description "Maximum Laser Temperature of this mode for this
                    lane";
    }
    leaf max-total-rx-optical-power {
        type dbm-t;
        config false;
        description "Maximum rx optical power of this mode for this
                    lane";
    }
    leaf max-chromatic-dispersion {
        type int32;
        config false;
        description "Maximum chromatic dispersion of this mode for this
                    lane";
    }
    leaf max-diff-group-delay {
        type int32;
    }
}

```

```

        config false;
        description "Maximum Differential group delay of this mode for
                    this lane";
    }
    uses opt-if-och-modulation-params;
}

grouping opt-if-och-tca-list {
    description "List of TCA's";
    leaf number-of-tcas-supported {
        type uint32;
        description "Number of TCAs supported by this interface";
    }
    list mode-list {
        key "tca-type";
        description "List of the TCAs";
        uses opt-if-och-tca-thresholds;
    }
}

grouping opt-if-och-fec-tca-thresholds {
    description "Pre FEC BER Thresholds for TCA's";
    leaf min-fec-ber-mantissa-threshold {
        type uint32;
        description "Min Mantissa of the FEC BER threshold";
    }
    leaf min-fec-ber-exponent-threshold {
        type int32;
        description "Min Exponent of the FEC BER threshold";
    }
    leaf max-fec-ber-mantissa-threshold {
        type uint32;
        description "Max Mantissa of the FEC BER threshold";
    }
    leaf max-fec-ber-exponent-threshold {
        type int32;
        description "Max Exponent of the FEC BER threshold";
    }
}

grouping opt-if-och-mode-params {
    description "OCh mode parameters";

    leaf mode-id {
        type string { length "1..255"; }
        description "ID for the OCh mode template";
    }
    leaf min-osnr-margin {

```

```
        type int32;
        units "dB";
        config false;
        description "OSNR margin to FEC threshold";
    }
    leaf q-margin {
        type int32;
        units "dB";
        config false;
        description "Q-Factor margin to FEC threshold";
    }
    uses opt-if-och-central-frequency;
    uses opt-if-och-power;
    uses opt-if-och-fec-tca-thresholds;
    uses opt-if-och-tca-list;
}

grouping opt-if-och-statistics {
    description "OCh statistics";
    leaf cur-osnr {
        type int32;
        units "dB";
        config false;
        description "OSNR margin to FEC threshold";
    }
    leaf cur-q-factor {
        type int32;
        units "dB";
        config false;
        description "Q-Factor of the interface";
    }
    leaf uncorrected-words {
        type uint64;
        config false;
        description "Post-FEC errored words";
    }
    leaf pre-fec-ber-mantissa {
        type uint32;
        config false;
        description "Pre-FEC errored words mantissa";
    }
    leaf pre-fec-ber-exponent {
        type int32;
        config false;
        description "Pre-FEC errored words exponent";
    }
}
```

```
grouping opt-if-och-mode {
  description "OCh mode template";

  leaf mode-id {
    type string { length "1..255"; }
    config false;
    description "ID for the OCh mode template";
  }
  leaf application-identifier {
    type uint32;
    config false;
    description "This parameter indicates the application identifier
      according to G.698.2";
  }
  leaf min-central-frequency {
    type uint32;
    config false;
    description "This parameter indicates the minimum frequency for
      this template";
  }
  leaf max-central-frequency {
    type uint32;
    config false;
    description "This parameter indicates the minimum frequency for
      this template";
  }
  leaf min-channel-input-power {
    type dbm-t;
    config false;
    description "The minimum input power of this interface";
  }
  leaf max-channel-input-power {
    type dbm-t;
    config false;
    description "The maximum input power of this interface";
  }
  leaf min-channel-output-power {
    type dbm-t;
    config false;
    description "The minimum output power of this interface";
  }
  leaf max-channel-output-power {
    type dbm-t;
    config false;
    description "The maximum output power of this interface";
  }
  leaf osnr-margin {
    type int32;
  }
}
```

```
        units "dB";
        config false;
        description "OSNR margin to FEC threshold";
    }
    leaf q-margin {
        type int32;
        units "dB";
        config false;
        description "Q-Factor margin to FEC threshold";
    }
    uses opt-if-och-fec;
    uses opt-if-och-lane-param;
}

grouping opt-if-och-mode-list {
    description "List of Mode list group";

    leaf number-of-modes-supported {
        type uint32;
        description "Number of modes supported by this interface";
    }
    list mode-list {
        key "mode-id";
        description "List of the modes";
        uses opt-if-och-mode;
    }
}

notification opt-if-och-central-frequency-change {
    description "A change of Central Frequency has been detected";

    leaf "if-name" {
        type leafref { path "/if:interfaces/if:interface/if:name"; }
        description "Interface name";
    }
    container new-opt-if-och-central-frequency {
        description "The new Central Frequency of the interface";
        uses opt-if-och-central-frequency;
    }
}

notification opt-if-och-mode-change {
    description "A change of Mode Template has been detected";

    leaf "if-name" {
        type leafref { path "/if:interfaces/if:interface/if:name"; }
        description "Interface name";
    }
}
```



```

    leaf mode-id {
        type string { length "1..255"; }
        description "ID for the OCh mode template";
    }
}

notification opt-if-och-min-tca {
    description "A min output TCA notification";

    leaf "if-name" {
        type leafref { path "/if:interfaces/if:interface/if:name"; }
        description "Interface name";
    }
    leaf tca-type {
        type opt-if-och-tca-types;
        description "Type of TCA for eg min tx power TCA";
    }
}

augment "/if:interfaces/if:interface" {
    description "Parameters for an optical interface";

    container optIfOChRsSs {
        description "RsSs path configuration for an interface";

        container if-current-mode {
            description "Current mode template of the interface";
            uses opt-if-och-mode;
        }
        container if-supported-mode {
            config false;
            description "Supported mode list of this interface";
            uses opt-if-och-mode-list;
        }
        container current-opt-if-och-mode-params {
            description "Current parameters of this interface";
            uses opt-if-och-mode-params;
            uses opt-if-och-statistics;
        }
    }
}
}

<CODE ENDS>

```

7. Security Considerations

The YANG module defined in this memo is designed to be accessed via the NETCONF protocol [RFC6241]. The lowest NETCONF layer is the secure transport layer and the mandatory-to-implement secure transport is SSH [RFC6242]. The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF users to a pre-configured subset of all available NETCONF protocol operation and content.

8. IANA Considerations

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

URI: urn:ietf:params:xml:ns:yang:ietf-interfaces:ietf-ext-xponder-wdm-if

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

This document registers a YANG module in the YANG Module Names registry [RFC6020].

This document registers a YANG module in the YANG Module Names registry [RFC6020].

prefix: ietf-ext-xponder-wdm-if reference: RFC XXXX

9. Acknowledgements

10. Contributors

Dean Bogdanovic
Westford
U.S.A.
email ivandean@gmail.com

Bernd Zeuner
Deutsche Telekom
Darmstadt
Germany
email B.Zeuner@telekom.de

Massimiliano Salsi
Juniper Networks
1133 Innovation Way
Sunnyvale, CA, 94089
U.S.A.
+1 408936847
email msalsi@google.com

Arnold Mattheus
Deutsche Telekom
Darmstadt
Germany
email a.mattheus@telekom.de

Manuel Paul
Deutsche Telekom
Berlin
Germany
email Manuel.Paul@telekom.de

Walid Wakim
Cisco
9501 Technology Blvd
ROSEMONT, ILLINOIS 60018
UNITED STATES
email wwakim@cisco.com

Kam Lam
Nokia
USA
+1 732 331 3476
kam.lam@nokia.com

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Appendix A. Change Log

This optional section should be removed before the internet draft is submitted to the IESG for publication as an RFC.

Note to RFC Editor: please remove this appendix before publication as an RFC.

Appendix B. Open Issues

Note to RFC Editor: please remove this appendix before publication as an RFC.

Authors' Addresses

Gabriele Galimberti (editor)
Cisco
Via Santa Maria Molgora, 48 c
20871 - Vimercate
Italy

Phone: +390392091462
Email: ggalimbe@cisco.com

Ruediger Kunze
Deutsche Telekom
Winterfeldtstr. 21-27
10781 Berlin
Germany

Phone: +491702275321
Email: RKunze@telekom.de

Dharini Hiremagalur (editor)
Juniper
1133 Innovation Way
Sunnyvale - 94089 California
USA

Email: dharinih@juniper.net

Gert Grammel (editor)
Juniper
Oskar-Schlemmer Str. 15
80807 Muenchen
Germany

Phone: +49 1725186386
Email: ggrammel@juniper.net

CCAMP Working Group
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H. Zheng
Huawei Technologies
Y. Lee
SKKU
A. Guo
Individual
V. Lopez
Telefonica
D. King
University of Lancaster
October 18, 2019

A YANG Data Model for Layer 0 Types
draft-ietf-ccamp-layer0-types-02

Abstract

This document defines a collection of common data types and groupings in the YANG data modeling language. These derived common types and groupings are intended to be imported by modules that model Layer 0 Traffic Engineering (TE) configuration and state capabilities such as Wavelength Switched Optical Networks (WSOs) and Spectrum Switched optical Networks (SSOs). The applicability of this document is mainly for TE, but not limited to.

The YANG data model in this document conforms to the Network Management Datastore Architecture defined in RFC8342.

Status of This Memo

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

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Table of Contents

1. Introduction	2
1.1. Terminology and Notations	3
1.2. Prefix in Data Node Names	3
2. Overview	3
2.1. TE Types Module Contents	3
3. YANG Code for Layer0 Types	6
4. Security Considerations	21
5. IANA Considerations	22
6. Acknowledgements	22
7. Contributors	22
8. References	23
8.1. Normative References	23
8.2. Informative References	24
Authors' Addresses	25

1. Introduction

YANG [RFC6020] and [RFC7950] is a data modeling language used to model configuration data, state data, Remote Procedure Calls, and notifications for network management protocols such as NETCONF [RFC6241]. The YANG language supports a small set of built-in data types and provides mechanisms to derive other types from the built-in types.

This document introduces a collection of common data types derived from the built-in YANG data types. The derived types and groupings are designed to be the common types applicable for modeling Traffic Engineering (TE) features as well as non-TE features (e.g., physical network configuration aspect) for Layer 0 optical networks in model(s) defined outside of this document. Examples of Layer 0

optical networks are Wavelength Switched Optical Networks (WSONs) [RFC6163] and Spectrum Switched optical Networks (SSONs) [RFC7698].

[ITU-Tg6982] defines amplified multichannel Dense Wavelength Division Multiplexing (DWDM) applications with single channel optical interfaces. The YANG data model defined in this document refers to the standard application mode defined in [ITU-Tg6982] .

1.1. Terminology and Notations

Refer to [RFC7446] and [RFC7581] for the key terms used in this document, and the terminology for describing YANG data models can be found in [RFC7950].

1.2. Prefix in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules.

Prefix	YANG module	Reference
layer0-types	ietf-layer0-types	[RFCXXXX]

Note: The RFC Editor will replace XXXX with the number assigned to the RFC once this draft becomes an RFC.

YANG module ietf-layer0-types (defined in Section 3) references [RFC6163], [RFC7205], and [RFC7698].

2. Overview

This document defines one YANG module for common Layer 0 TE types: ietf-layer0-types for WSON and SSON specific types.

2.1. TE Types Module Contents

The ietf-layer0-types module contains common Layer 0 TE types that are to be imported by layer 0 specific technology such as WSON and SSON.

The ietf-layer0-types module contains the following YANG reusable types and groupings:

Operational-mode:

A type that represents operational-model type as defined in [ITU-Tg6982].

Vendor-identifier:

A type that represents vendor identifier as defined in [RFC7581].

layer0-node-type:

A base YANG identity for supported node type as defined in [RFC6163].

wavelength-assignment:

A base YANG identity for allocated wavelength assignment type as defined in [RFC6163].

layer0-grid-type:

A base YANG identity for the node type as defined in [RFC6163] and [RFC7698].

term-type:

A base YANG identity for the supported termination type as defined in [ITU-Tg709].

layer0-bandwidth-type:

A base YANG identity for the layer0 bandwidth type as defined in [ITU-Tg709].

dwdm-ch-spc-type:

A base YANG identity for the DWDM channel spacing type as defined in [RFC6205].

cwdm-ch-spc-type:

A base YANG identity for the CWDM channel spacing type as defined in [RFC6205].

FEC-type:

A base YANG identity for the FEC type as defined in [ITU-Tg709].

wson-path-bandwidth:

A YANG grouping that defines the WSON path bandwidth attributes as defined in [RFC6163].

wson-link-bandwidth:

A YANG grouping that defines WSON link bandwidth attributes as defined in [RFC6163].

wson-link-label:

A YANG grouping that defines the label for WSON links as defined in [RFC6205].

wson-path-label:

A YANG grouping that defines the label for WSON paths as defined in [RFC6205].

layer0-label-restriction:

A YANG grouping that defines the layer 0 label restriction applicable for both WSON and SSON and per priority level as defined in [RFC3209].

wson-label-step:

A YANG grouping that defines label steps for WSON as defined in [I-D.ietf-teas-yang-te-topo].

flexi-grid-node-attributes:

A YANG grouping that defines flexi-grid node attributes as defined in [RFC7698].

flexi-grid-path-bandwidth:

A YANG grouping that defines flexi-grid path bandwidth attributes as defined in [RFC7698].

flexi-grid-link-bandwidth:

A YANG grouping that defines flexi-grid link bandwidth attributes as defined in [RFC7698].

flexi-grid-link-label:

A YANG grouping that defines flexi-grid link label attributes as defined in [RFC7698].

flexi-grid-channel:

A YANG grouping that defines flexi-grid channel as defined in [RFC7698].

flexi-grid-path-label:

A YANG grouping that defines flexi-grid path label for both single channel and multiple carriers as defined in [RFC7698].

flexi-grid-label-restriction:

A YANG grouping that defines flexi-grid label restrictions and per priority level as defined in [RFC3209].

flexi-grid-label-step:

A YANG grouping that defines flexi-grid label steps as defined in [I-D.ietf-teas-yang-te-topo].

3. YANG Code for Layer0 Types

```
<CODE BEGINS>file "ietf-layer0-types@2019-10-18.yang"
module ietf-layer0-types {
  namespace "urn:ietf:params:xml:ns:yang:ietf-layer0-types";
  prefix "layer0-types";

  organization
    "IETF CCAMP Working Group";
  contact
    "WG Web: <http://tools.ietf.org/wg/ccamp/>
    WG List: <mailto:ccamp@ietf.org>

    Editor: Haomian Zheng
      <mailto:zhenghaomian@huawei.com>

    Editor: Young Lee
      <mailto:younglee.tx@gmail.com>

      Editor: Aihua Guo
      <mailto:aihuaguo.ietf@gmail.com>

    Editor: Victor Lopez
      <mailto:victor.lopezalvarez@telefonica.com>

    Editor: Daniel King
      <mailto:d.king@lancaster.ac.uk>";
```

description

"This module defines Optical Layer 0 types. This module provides groupings that can be applicable to Layer 0 Fixed Optical Networks (e.g., CWDM (Coarse Wavelength Division Multiplexing) and DWDM (Dense Wavelength Division Multiplexing)) and Flexi-grid Optical Networks.

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revision "2019-10-18" {

description

"Initial Version";

reference

"RFC XXXX: A YANG Data Model for WSON (Wavelength Switched Optical Networks)";

}

typedef operational-mode {

type string;

description

"Vendor-specific mode that guarantees interoperability.

It must be an string with the following format:

B-DScW-ytz(v) where all these attributes are conformant to the ITU-T recommendation";

reference "ITU-T G.698.2 (11/2009) Section 5.3";

}

typedef vendor-identifier {

type string;

description

"vendor identifier that uses vendor-specific mode";

reference "TBD";

}

typedef frequency-thz {

type decimal64 {

fraction-digits 3;

}

units THz;

description

```
    "The DWDM frequency in THz, e.g., 193.12500";
  reference
    "RFC6205: Generalized Labels for
    Lambda-Switch-Capable (LSC) Label Switching Routers";
}

typedef frequency-ghz {
  type decimal64 {
    fraction-digits 1;
  }
  units GHz;
  description
    "The DWDM frequency in GHz, e.g., 193125.00";
  reference
    "RFC6205: Generalized Labels for
    Lambda-Switch-Capable (LSC) Label Switching Routers";
}

typedef dwdm-n
{
  type int16;
  description
    "The given value 'N' is used to determine the nominal
    central frequency.

    The nominal central frequency, 'f' is defined by,
     $f = 193.125 \text{ THz} + N \times 0.00625 \text{ THz}$ ,
    where 193.125 THz is the ITU-T 'anchor frequency' for
    transmission over the C band. ";
}

typedef cwdm-n
{
  type int16;
  description
    "The given value 'N' is used to compute the channel
    wavelength as per the formula:
    Wavelength (nm) = 1471 + N x 20 ";
}

typedef flexi-n
{
  type int16;
  description
    "The given value 'N' is used to determine the nominal
    central frequency.

    The nominal central frequency, 'f' is defined by,
```

```
        f = 193.125 THz + N x 0.00625 THz,  
        where 193.125 THz is the ITU-T 'anchor frequency' for  
        transmission over the C band. ";  
    }  
  
    identity layer0-node-type {  
        description  
            "layer0 node type.";  
        reference  
            "RFC6163:Framework for GMPLS and Path Computation Element  
            (PCE) Control of Wavelength Switched Optical Networks (WSNs)";  
    }  
  
    identity flexi-grid-node {  
        base layer0-node-type;  
        description  
            "Flexi-grid node";  
    }  
  
    identity wson-node-foadm {  
        base layer0-node-type;  
        description  
            "Fixed OADM (Optical Add-Drop Multiplexer) node";  
    }  
  
    identity wson-node-roadm {  
        base layer0-node-type;  
        description  
            "ROADM (Reconfigurable Optical Add-Drop Multiplexer)  
            or OXC (Optical Cross Connect) node";  
    }  
  
    identity wson-node-ila {  
        base layer0-node-type;  
        description  
            "ILA (In-Line Amplifier) node";  
    }  
  
    identity wavelength-assignment {  
        description  
            "Wavelength selection base";  
    }  
  
    identity unspecified-wavelength-assignment {  
        base wavelength-assignment;  
        description  
            "No method specified";  
    }
```



```
identity first-fit-wavelength-assignment {
  base wavelength-assignment;
  description
    "All the available wavelengths are numbered,
    and this WA (Wavelength Assignment) method chooses
    the available wavelength with the lowest index";
}

identity random-wavelength-assignment {
  base wavelength-assignment;
  description
    "This WA method chooses an available
    wavelength randomly";
}

identity least-loaded-wavelength-assignment {
  base wavelength-assignment;
  description
    "This WA method selects the wavelength that
    has the largest residual capacity on the most loaded
    link along the route (in multi-fiber networks)";
}

identity layer0-grid-type {
  description
    "Layer 0 grid type";
}

identity flexi-grid-dwdm {
  base layer0-grid-type;
  description
    "Flexi-grid";
}

identity wson-grid-dwdm {
  base layer0-grid-type;
  description
    "DWDM grid";
}

identity wson-grid-cwdm {
  base layer0-grid-type;
  description
    "CWDM grid";
}

identity term-type {
  description
```

```
    "Termination type";
}

identity term-phys {
  base term-type;
  description
    "Physical layer termination";
}

identity term-otu {
  base term-type;
  description
    "OTU (Optical Transport Unit) termination";
}

identity term-odu {
  base term-type;
  description
    "ODU (Optical Data Unit) termination";
}

identity term-opu {
  base term-type;
  description
    "OPU (Optical Payload Unit) termination";
}

identity term-section {
  base term-type;
  description
    "Section layer termination";
}

identity layer0-bandwidth-type {
  description
    "Bandwidth type carried by a single wavelength channel";
}

identity bw-otul {
  base layer0-bandwidth-type;
  description
    "OTU1 (2.66G)";
}

identity bw-otule {
  base layer0-bandwidth-type;
  description
    "OTU1e (11.04G)";
}
```

```
}

identity bw-otu1f {
  base layer0-bandwidth-type;
  description
    "OTU1f (11.27G)";
}

identity bw-otu2 {
  base layer0-bandwidth-type;
  description
    "OTU2 (10.70G)";
}

identity bw-otu2e {
  base layer0-bandwidth-type;
  description
    "OTU2e (11.09G)";
}

identity bw-otu2f {
  base layer0-bandwidth-type;
  description
    "OTU2f (11.31G)";
}

identity bw-otu3 {
  base layer0-bandwidth-type;
  description
    "OTU3 (43.01G)";
}

identity bw-otu3e1 {
  base layer0-bandwidth-type;
  description
    "OTU3e1 (44.57G)";
}

identity bw-otu3e2 {
  base layer0-bandwidth-type;
  description
    "OTU3e2 (44.58G)";
}

identity bw-otu4 {
  base layer0-bandwidth-type;
  description
    "OTU4 (111.80G)";
}
```

```
}

identity bw-otucn {
  base layer0-bandwidth-type;
  description
    "OTUCn (beyond 100G)";
}

identity dwdm-ch-spc-type {
  description
    "DWDM channel spacing type";
}

identity dwdm-100ghz {
  base dwdm-ch-spc-type;
  description
    "100GHz channel spacing";
}

identity dwdm-50ghz {
  base dwdm-ch-spc-type;
  description
    "50GHz channel spacing";
}

identity dwdm-25ghz {
  base dwdm-ch-spc-type;
  description
    "25GHz channel spacing";
}

identity dwdm-12p5ghz {
  base dwdm-ch-spc-type;
  description
    "12.5GHz channel spacing";
}

identity flexi-ch-spc-type {
  description
    "Flexi-grid channel spacing type";
}

identity flexi-ch-spc-6p25ghz {
  base flexi-ch-spc-type;
  description
    "6.25GHz channel spacing";
}
```

```
identity flexi-slot-width-granularity {
  description
    "Flexi-grid slot width granularity";
}

identity flexi-swg-12p5ghz {
  base flexi-slot-width-granularity;
  description
    "12.5GHz slot width granularity";
}

identity cwdm-ch-spc-type {
  description
    "CWDM channel spacing type";
}

identity cwdm-20nm {
  base cwdm-ch-spc-type;
  description
    "20nm channel spacing";
}

identity fec-type {
  description
    "FEC (Forward Error Correction) type";
}

identity g-fec {
  base fec-type;
  description
    "G-FEC (Generic-FEC) ";
}

identity e-fec {
  base fec-type;
  description
    "E-FEC (Enhanced-FEC) ";
}

identity no-fec {
  base fec-type;
  description
    "No FEC";
}

/* Groupings. */
grouping wson-path-bandwidth {
  description "WSON (Wavelength Switched Optical Network)
    path bandwidth attributes";
  leaf bandwidth-type {
```

```
    type identityref {
      base layer0-bandwidth-type;
    }
    description "WSON bandwidth type";
  }
}

grouping wson-link-bandwidth {
  description "WSON link bandwidth attributes";
  leaf-list supported-bandwidth-list {
    type identityref {
      base layer0-bandwidth-type;
    }
    description "WSON bandwidth type";
  }
}

grouping wson-link-label {
  description
    "Generic label for WSON links";
  choice grid-type {
    description
      "Label for DWDM or CWDM grid";
    case dwdm {
      leaf dwdm-n {
        type layer0-types:dwdm-n;
        description
          "The central frequency of DWDM. ";
        reference
          "RFC6205: Generalized Labels for
            Lambda-Switch-Capable (LSC) Label Switching Routers";
      }
    }
    case cwdm {
      leaf cwdm-n {
        type layer0-types:cwdm-n;
        description
          "Channel wavelength computing input. ";
        reference
          "RFC6205: Generalized Labels for
            ambda-Switch-Capable (LSC) Label Switching Routers";
      }
    }
  }
}

grouping wson-path-label {
  description
```

```

    "Generic label for WSON paths";
  choice grid-type {
    description
      "Label for DWDM or CWDM grid";
    case dwdm {
      choice single-or-super-channel {
        description "single or super channel";
        case single {
          leaf dwdm-n {
            type layer0-types:dwdm-n;
            description
              "The central frequency of DWDM. ";
          }
        }
        case super {
          leaf-list subcarrier-dwdm-n {
            type int16;
            description
              "List of subcarrier channels for the super channel.

              The given value 'N' for each subcarrier channel
              is used to determine the nominal
              central frequency.

              The nominal central frequency, 'f', is defined by,
               $f = 193.1 \text{ THz} + N \times \text{'channel spacing (THz)'}$ ,
              where 193.1 THz is the ITU-T 'anchor frequency' for
              transmission over the C band,
              N is a positive or negative integer including 0";
            reference
              "ITU-T Recommendation G.694.1: Spectral grids for
              WDM applications: DWDM frequency grid";
          }
        }
      }
    }
  }
}

case cwdm {
  leaf cwdm-n {
    type layer0-types:cwdm-n;
    description
      "Channel wavelength computing input. ";
    reference
      "RFC6205: Generalized Labels for
      Lambda-Switch-Capable (LSC) Label Switching Routers";
  }
}

```

```
    }
  }

  grouping layer0-label-restriction {
    description
      "layer0 label restriction.";

    leaf grid-type {
      type identityref {
        base layer0-grid-type;
      }
      description "Grid type";
    }
    leaf priority {
      type uint8;
      description "Priority";
    }
  }

  grouping wson-label-step {
    description "Label step information for WSON";
    choice layer0-grid-type {
      description
        "Grid type: DWDM, CWDM, etc.";
      case dwdm {
        leaf wson-dwdm {
          type identityref {
            base dwdm-ch-spc-type;
          }
          description
            "Label-step is the channel-spacing (GHz), e.g.,
            100, 50, 25, or 12.5 GHz for DWDM";
          reference
            "RFC6205: Generalized Labels for
            Lambda-Switch-Capable (LSC) Label Switching Routers";
        }
      }
      case cwdm {
        leaf wson-cwdm {
          type identityref {
            base cwdm-ch-spc-type;
          }
          description
            "label-step is the channel-spacing (nm), i.e., 20 nm
            for CWDM, which is the only value defined for CWDM";
          reference
            "RFC6205: Generalized Labels for
            Lambda-Switch-Capable (LSC) Label Switching Routers";
        }
      }
    }
  }
}
```



```
    }
  }
}

grouping flexi-grid-node-attributes {
  description "Flexi-grid node attributes";

  container flexi-grid-node {
    description "Flexi-grid node attributes";
    leaf node-type {
      type identityref {
        base layer0-node-type;
      }
      description "Flexi-grid node type";
    }
  }
}

grouping flexi-grid-path-bandwidth {
  description "Flexi-grid path bandwidth attributes";
  leaf bandwidth-type {
    type identityref {
      base layer0-bandwidth-type;
    }
    description "Flexi-grid bandwidth type";
  }
}

grouping flexi-grid-link-bandwidth {
  description "flexi-grid link bandwidth attributes";
  leaf-list supported-bandwidth-list {
    type identityref {
      base layer0-bandwidth-type;
    }
    description "Flexi-grid bandwidth type";
  }
}

grouping flexi-grid-link-label {
  description "Flexi-grid link label.";
  leaf flexi-n {
    type int16;
    description
      "The central frequency in Flexi-grid.";
    reference
      "RFC7698: Framework and Requirements for GMPLS-Based Control
      of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM)";
  }
}
```

```
        Networks";
    }
}

grouping flexi-grid-channel {
    description "Flexi-grid channel grouping.";

    uses flexi-grid-link-label;

    leaf flexi-m {
        type uint16 {
            range "1..max";
        }
        description
            "M is used to determine the slot width. A slot width is
            constrained to be M x SWG (that is, M x 12.5 GHz),
            where M is a positive integer.";
        reference
            "RFC7698: Framework and Requirements for GMPLS-Based Control
            of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM)
            Networks";
    }
}

grouping flexi-grid-path-label {
    description "Flexi-grid path label.";
    choice single-or-super-channel {
        description "single of super channel";
        case single {
            uses flexi-grid-channel;
        }
        case super {
            list subcarrier-flexi-n {
                key flexi-n;
                uses flexi-grid-channel;
                description
                    "List of subcarrier channels for flexi-grid
                    super channel.";
            }
        }
    }
}

grouping flexi-grid-label-restriction {
    description
        "Flexi-grid-specific label restriction";
    uses layer0-label-restriction;

    container flexi-grid {
```

```
description "flexi-grid definition";
leaf nominal-central-frequency-granularity {
  type identityref {
    base flexi-ch-spc-type;
  }
  default flexi-ch-spc-6p25ghz;
  description
    "It is the spacing between allowed nominal central
    frequencies. Default is 6.25 GHz";
  reference
    "RFC7698: Framework and Requirements for GMPLS-Based Control
    of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM)
    Networks";
}

leaf slot-width-granularity {
  type identityref {
    base flexi-slot-width-granularity;
  }
  default flexi-swg-12p5ghz;
  description
    "Minimum space between slot widths. Default is
    12.5 GHz";
  reference
    "RFC7698: Framework and Requirements for GMPLS-Based Control
    of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM)
    Networks";
}

leaf min-slot-width-factor {
  type uint16 {
    range "1..max";
  }
  default 1;
  description
    "Minimum slot width is calculated by:
    Minimum slot width (GHz) =
    min-slot-width-factor * slot-width-granularity";
  reference
    "RFC8363: GMPLS OSPF-TE Extensions in Support of Flexi-Grid
    Dense Wavelength Division Multiplexing (DWDM) Networks";
}

leaf max-slot-width-factor {
  type uint16 {
    range "1..max";
  }
  description
```

```
        "Maximum slot width is calculated by:
        Maximum slot width (GHz) =
        max-slot-width-factor * slot-width-granularity";
    reference
    "RFC8363: GMPLS OSPF-TE Extensions in Support of Flexi-Grid
    Dense Wavelength Division Multiplexing (DWDM) Networks";
}

}

}

grouping flexi-grid-label-step {
    description "Label step information for flexi-grid";
    leaf flex {
        type identityref {
            base flexi-ch-spc-type;
        }
        default flexi-ch-spc-6p25ghz;
    }
    description
    "Label-step is the nominal central frequency
    granularity (GHz), e.g., 6.25 GHz";
    reference
    "RFC7698: Framework and Requirements for GMPLS-Based Control
    of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM)
    Networks";
}
}
}
<CODE ENDS>
```

4. Security Considerations

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

The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF users to a preconfigured subset of all available NETCONF protocol operations and content. The NETCONF Protocol over Secure Shell (SSH) [RFC6242] describes a method for invoking and running NETCONF within a Secure Shell (SSH) session as an SSH subsystem. The NETCONF access control model [RFC8341]

provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

The YANG module in this document defines optical layer0 type definitions (i.e., typedef, identity and grouping statements) in YANG data modeling language to be imported and used by other layer 0 specific modules. When imported and used, the resultant schema will have data nodes that can be writable, or readable. The access to such data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations.

The security considerations spelled out in the YANG 1.1 specification [RFC7950] apply for this document as well.

5. IANA Considerations

It is proposed that IANA should assign new URIs from the "IETF XML Registry" [RFC3688] as follows:

URI: urn:ietf:params:xml:ns:yang:ietf-layer0-types
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

This document registers following YANG modules in the YANG Module Names registry [RFC7950].

name:	ietf-layer0-types
namespace:	urn:ietf:params:xml:ns:yang:ietf-layer0-types
prefix:	layer0-types
reference:	RFC XXXX(TBD)

6. Acknowledgements

TBD.

7. Contributors

Dhruv Dhody
Huawei
Email: dhruv.ietf@gmail.com

Bin Yeong Yoon
ETRI
Email: byyun@etri.re.kr

Ricard Vilalta
CTTC
Email: ricard.vilalta@cttc.es

Italo Busi
Huawei
Email: Italo.Busi@huawei.com

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Authors' Addresses

Haomian Zheng
Huawei Technologies
H1-1-A043S Huawei Industrial Base, Songshanhu
Dongguan, Guangdong 523808
China

Email: zhenghaomian@huawei.com

Young Lee
SKKU
Sung Kyun Kwan University
Seoul
South Korea

Email: younglee.tx@gmail.com

Aihua Guo
Individual

Email: aihuaguo.ietf@gmail.com

Victor Lopez
Telefonica

Email: victor.lopezalvarez@telefonica.com

Daniel King
University of Lancaster

Email: d.king@lancaster.ac.uk

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H. Zheng
I. Busi
Huawei Technologies
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A YANG Data Model for Layer 1 Types
draft-ietf-ccamp-layer1-types-03

Abstract

This document defines a collection of common data types and groupings in YANG data modeling language for layer 1 networks. These derived common types and groupings are intended to be imported by modules that specifies the OTN networks, including the topology, tunnel, client signal adaptation and service.

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Table of Contents

1. Introduction	2
2. Terminology and Notations	2
3. Prefix in Data Node Names	3
4. Layer 1 Types Overview	3
4.1. Relationship with other Modules	3
4.2. Content in Layer 1 Type Module	3
4.3. Usage of groupings in Layer1-types	5
5. YANG Code for Layer1 Types	6
6. Security Considerations	20
7. IANA Considerations	20
8. Acknowledgements	21
9. Contributors	21
10. References	22
10.1. Normative References	22
10.2. Informative References	23
Authors' Addresses	24

1. Introduction

This document introduces a collection of common data types which would be used in Layer 1 networks. The derived types and groupings are designed to be the common types applicable for modeling Traffic Engineering (TE) features for Layer 1 optical networks.

Typical L1 network, the Optical Transport Networking, was specified in [RFC7062]. Corresponding routing and signaling protocol have been specified in [RFC7138] and [RFC7139]. The types and groupings defined in this document is consistent to these document, and will be imported in other Layer 1 data models, including but not restrictive to, [I-D.ietf-ccamp-otn-topo-yang], [I-D.ietf-ccamp-otn-tunnel-model] and [I-D.ietf-ccamp-llcsm-yang].

The data model in this draft has only types defined including groupings, typedef and identities. There is no need to include configuration and state data according to the new Network Management Datastore Architecture [RFC8342]. The content in this draft is in consistent with [MEF63].

2. Terminology and Notations

Refer to [RFC7062] for the key terms used in this document, and the terminology for describing YANG data models can be found in [RFC7950].

3. Prefix in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules.

Prefix	YANG module	Reference
layer1-types	ietf-layer1-types	This Document

4. Layer 1 Types Overview

4.1. Relationship with other Modules

This document defines one YANG module for common Layer 1 types. The objective is to specifies common Layer 1 TE types that can be imported by layer 1 specific technology, for example OTN, in its technology-specific modules such as topology and tunnels. It is worth noting that the generic traffic-engineering (TE) types module is specified in [I-D.ietf-teas-yang-te-types] as ietf-te-types, and both the module ietf-te-types and ietf-layer1-types are needed to be imported when the OTN is configured.

4.2. Content in Layer 1 Type Module

The module ietf-layer1-types contains the following YANG reusable types and groupings:

tributary-slot-granularity:

This is to define the granularity of the server layer ODU Link (HO ODUk or ODUCn) supporting a client layer ODU LSP (LO ODUj or ODUk, respectively). Three granularities, 1.25G/2.5G/5G, have been specified.

odu-type:

This is to specify the type of ODUk LSP.

client-signal:

This is to specify the client signal types of OTN networks. The initial input was the G-PID specified in [RFC7139]. Identities about

a few categories of client signal types, including ETH, STM-n, OC and Fiber Channel have been specified.

otn-label-range-type:

The label range type of OTN has two different representations, tributary slots (TS) and tributary port number (TPN), according to [RFC7139]. Respective representation is specified under this same base type.

otn-link-bandwidth:

This grouping defines the link bandwidth information and could be used in OTN topology model for bandwidth representation. All the bandwidth related sections in generic topology module, ietf-te-topology, need to be augmented with this grouping for the usage of Layer 1.

otn-path-bandwidth:

This grouping defines the path bandwidth information and could be used in OTN topology model for bandwidth representation. All the bandwidth related sections in generic topology module, ietf-te-topology, need to be augmented with this grouping for the usage of Layer 1. This grouping is also applicable to set up the OTN tunnel.

otn-label-restriction and otn-label-step:

These groupings are used for the augmentation of OTN label in a specific way.

otn-label-start-end and otn-label-hop:

These groupings are used for the augmentation of label for OTN link and path respectively.

optical-interface-func:

The optical interface function is specified in [MEF63]. This grouping describes the functionality which encodes bits for transmission and the corresponding decode upon reception.

service-performance-metric:

The service performance metric is a quantitative characterization of Layer 1 characteristic information delivery quality experienced by the Layer 1 subscriber.

4.3. Usage of groupings in Layer1-types

As described in [RFC7139], the OTN label usually represents the Tributary Port Number (TPN) and the related set of Tributary Slots (TS) assigned to a client layer ODU LSP (LO ODUj or ODUk) on a given server layer ODU (HO-ODU or ODUCn, respectively) Link (e.g., ODU2 LSP over ODU3 Link). Some special OTN label values are also defined for an ODUk LSP being setup over an OTUk Link.

The same OTN label shall be assigned to the same ODUk LSP at the two ends of an OTN Link.

As described in [RFC7139], TPN can be a number from 1 to 4095 and TS are numbered from 1 to 4095, although the actual maximum values depend on the type of server layer ODU. For example, a server layer ODU4 provides 80 time slots (numbered from 1 to 80) and the TPN values can be any number from 1 to 80.

The OTN Label Range represents the values for the TPN and TS that are available for ODUk LSPs to be setup over a given OTN Link.

The OTN Label Range is defined by the label-restriction list, defined in [I-D.ietf-teas-yang-te-types], which, for OTN, should be augmented using the otn-label-restriction grouping.

Each entry in the label-restriction list represents either the range of the available TPN values or the range of the available TS values: the range-type attribute defines the type of range for each entry of the list.

Each entry of the label-restriction list, as defined in [I-D.ietf-teas-yang-te-types], defines a label-start, a label-end, a label-step and a range-bitmap. The label-start and label-end definitions for OTN should be augmented using the otn-link-label grouping. The label-step definition for OTN should be augmented using the otn-label-step grouping. It is expected that the otn-label-step will always be equal to its default value (i.e., 1).

As described in [RFC7139], in some cases, the TPN assignment rules is flexible (e.g., ODU4 Link) while in other cases the TPN assignment rules are fixed (e.g., ODU1 Link). In the latter case, only the TS range is reported: not reporting the TPN range means that the TPN shall be set equal to the TS number assigned to the ODUk LSP.

As described in [RFC7139], in some cases, the TPN assignment rules depends on the TS Granularity (e.g., ODU2 or ODU3 Links). Different entries in the label-restriction list will report different TPN

ranges for each TS granularity supported by the link, as indicated by the `tsg` attribute.

As described in [RFC7139], in some cases, the TPN ranges are different for different types of ODUk LSPs. For example, on an ODU2 Link with 1,25G TS granularity, there is TPN range 1-4 for ODU1 and another TPN range 1-8 in common for ODU0 and ODUflex. Different entries in the label-restriction list will report different TPN ranges for different set of ODUk types, as indicated by the `odu-type-list`.

5. YANG Code for Layer1 Types

```
<CODE BEGINS>file "ietf-layer1-types@2019-11-01.yang"
module ietf-layer1-types {
  namespace "urn:ietf:params:xml:ns:yang:ietf-layer1-types";
  prefix "layer1-types";

  organization
    "IETF CCAMP Working Group";
  contact
    "WG Web: <http://tools.ietf.org/wg/ccamp/>
    WG List: <mailto:ccamp@ietf.org>

    Editor: Haomian Zheng
            <mailto:zhenghaomian@huawei.com>

    Editor: Italo Busi
            <mailto:Italo.Busi@huawei.com>";

  description
    "This module defines Layer 1 types. The model fully conforms
    to the Network Management Datastore Architecture (NMDA).

    Copyright (c) 2018 IETF Trust and the persons
    identified as authors of the code. All rights reserved.

    Redistribution and use in source and binary forms, with or
    without modification, is permitted pursuant to, and subject
    to the license terms contained in, the Simplified BSD License
    set forth in Section 4.c of the IETF Trust's Legal Provisions
    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).
    This version of this YANG module is part of RFC XXXX; see
    the RFC itself for full legal notices.";

  revision "2019-11-01" {
```

```
    description
      "Initial Version";
    reference
      "RFC XXXX: A YANG Data Model for Layer 1 Types";
      // RFC Ed.: replace XXXX with actual RFC number, update date
      // information and remove this note
  }

  identity tributary-slot-granularity {
    description
      "Tributary slot granularity";
    reference
      "G.709/Y.1331, February 2016: Interfaces for the Optical
      Transport Network (OTN)";
  }

  identity tsg-1.25G {
    base tributary-slot-granularity;
    description
      "1.25G tributary slot granularity";
  }

  identity tsg-2.5G {
    base tributary-slot-granularity;
    description
      "2.5G tributary slot granularity";
  }

  identity tsg-5G {
    base tributary-slot-granularity;
    description
      "5G tributary slot granularity";
  }

  identity odu-type {
    description
      "Base identity for protocol framing used by tributary signals.";
  }

  identity ODU0 {
    base odu-type;
    description
      "ODU0 protocol (1.24G), RFC7139/ITU-T G.709, as standard track.";
  }

  identity ODU1 {
    base odu-type;
    description
```



```
    "ODU1 protocol (2.49G), RFC7139/ITU-T G.709, as standard track.";
}

identity ODU1e {
    base odu-type;
    description
        "ODU1e protocol (10.35G), RFC7963/ITU-T G.sup43, as informational.";
}

identity ODU2 {
    base odu-type;
    description
        "ODU2 protocol (10.03G), RFC7139/ITU-T G.709, as standard track.";
}

identity ODU2e {
    base odu-type;
    description
        "ODU2e protocol (10.39G), RFC7139/ITU-T G.709, as standard track.";
}

identity ODU3 {
    base odu-type;
    description
        "ODU3 protocol (40.31G), RFC7139/ITU-T G.709, as standard track.";
}

identity ODU3e1 {
    base odu-type;
    description
        "ODU3e1 protocol (41.77G), RFC7963/ITU-T G.sup43, as informational.";
}

identity ODU3e2 {
    base odu-type;
    description
        "ODU3e2 protocol (41.78G), RFC7963/ITU-T G.sup43, as informational.";
}

identity ODU4 {
    base odu-type;
    description
        "ODU4 protocol (104.79G), RFC7139/ITU-T G.709, as standard track.";
}

identity ODUFlex-cbr {
    base odu-type;
    description
```

```
        "ODU Flex CBR protocol for transporting constant bit rate
        signal";
    }

    identity ODUFlex-gfp {
        base odu-type;
        description
            "ODU Flex GFP protocol for transporting stream of packets
            using Generic Framing Procedure";
    }

    identity client-signal {
        description
            "Base identity from which specific client signals for the
            tunnel are derived";
    }

    identity ETH-1Gb {
        base client-signal;
        description
            "Client signal type of 1GbE";
    }

    identity ETH-10Gb-LAN {
        base client-signal;
        description
            "Client signal type of 10GbE LAN";
    }

    identity ETH-10Gb-WAN {
        base client-signal;
        description
            "Client signal type of 10GbE WAN";
    }

    identity ETH-40Gb {
        base client-signal;
        description
            "Client signal type of 40GbE";
    }

    identity ETH-100Gb {
        base client-signal;
        description
            "Client signal type of 100GbE";
    }

    identity STM-1 {
```

```
    base client-signal;
    description
      "Client signal type of STM-1";
  }

  identity STM-4 {
    base client-signal;
    description
      "Client signal type of STM-4";
  }

  identity STM-16 {
    base client-signal;
    description
      "Client signal type of STM-16";
  }

  identity STM-64 {
    base client-signal;
    description
      "Client signal type of STM-64";
  }

  identity STM-256 {
    base client-signal;
    description
      "Client signal type of STM-256";
  }

  identity OC-3 {
    base client-signal;
    description
      "Client signal type of OC3";
  }

  identity OC-12 {
    base client-signal;
    description
      "Client signal type of OC12";
  }

  identity OC-48 {
    base client-signal;
    description
      "Client signal type of OC48";
  }

  identity OC-192 {
    base client-signal;
```

```
    description
      "Client signal type of OC192";
  }

  identity OC-768 {
    base client-signal;
    description
      "Client signal type of OC768";
  }

  identity FC-100 {
    base client-signal;
    description
      "Client signal type of Fibre Channel FC-100";
  }

  identity FC-200 {
    base client-signal;
    description
      "Client signal type of Fibre Channel FC-200";
  }

  identity FC-400 {
    base client-signal;
    description
      "Client signal type of Fibre Channel FC-400";
  }

  identity FC-800 {
    base client-signal;
    description
      "Client signal type of Fibre Channel FC-800";
  }

  identity FC-1200 {
    base client-signal;
    description
      "Client signal type of Fibre Channel FC-1200";
  }

  identity FC-1600 {
    base client-signal;
    description
      "Client signal type of Fibre Channel FC-1600";
  }

  identity FC-3200 {
    base client-signal;
```

```
    description
      "Client signal type of Fibre Channel FC-3200";
  }

  identity FICON-4G {
    base client-signal;
    description
      "Client signal type of Fibre Connection 4G";
  }

  identity FICON-8G {
    base client-signal;
    description
      "Client signal type of Fibre Connection 8G";
  }

  identity otn-label-range-type {
    description
      "Base identity from which specific OTN label
        range types derived";
  }

  identity label-range-trib-slot {
    base otn-label-range-type;
    description
      "Defines a range of OTN tributary slots";
  }

  identity label-range-trib-port {
    base otn-label-range-type;
    description
      "Defines a range of OTN tributary ports";
  }

  grouping otn-link-bandwidth {
    description "link bandwidth attributes for OTN";
    list odulist {
      key "odu-type";
      description
        "OTN bandwidth definition";
      leaf odu-type {
        type identityref {
          base layer1-types:odu-type;
        }
        description "ODU type";
      }
      leaf number {
        type uint16;
      }
    }
  }
```

```
        description "Number of ODUs";
    }
}

grouping otn-path-bandwidth {
    description
        "path bandwidth attributes for OTN";
    leaf odu-type {
        type identityref {
            base layer1-types:odu-type;
        }
        description "ODU type";
    }
}

grouping otn-label-range-info {
    description "label range information for OTN";
    leaf range-type {
        type identityref {
            base layer1-types:otn-label-range-type;
        }
        description "type for range";
    }
    leaf tsg {
        type identityref {
            base layer1-types:tributary-slot-granularity;
        }
        description
            "Tributary slot granularity.";
        reference
            "G.709/Y.1331, February 2016: Interfaces for the
            Optical Transport Network (OTN)";
    }
    leaf-list odu-type-list {
        type identityref {
            base odu-type;
        }
        description
            "List of ODU types to which the label range applies.
            Empty odu-type-list means all the ODU types are applicable
            per label range. ";
    }
    leaf priority {
        type uint8;
        description "priority.";
    }
}
```

```
grouping otn-label-start-end {
  description
    "The OTN label-start or label-end used to specify an OTN label range."
;
  choice otn-label-type {
    description
      "OTN label range type, either TPN range or TS range";
    case tributary-port {
      leaf tpn {
        type uint16 {
          range "1..4095";
        }
        description
          "Tributary Port Number. Applicable in case of mux services.";
        reference
          "RFC7139: GMPLS Signaling Extensions for Control of Evolving
            G.709 Optical Transport Networks.";
      }
    }
    case tributary-slot {
      leaf ts {
        type uint16 {
          range "1..4095";
        }
        description
          "Tributary Slot Number. Applicable in case of mux services.";
        reference
          "RFC7139: GMPLS Signaling Extensions for Control of Evolving
            G.709 Optical Transport Networks.";
      }
    }
  }
}

grouping otn-label-hop {
  description "label information for OTN, for label-hop";
  leaf tpn {
    type uint16 {
      range "1..4095";
    }
    description
      "Tributary Port Number. Applicable in case of mux services.";
    reference
      "RFC7139: GMPLS Signaling Extensions for Control of Evolving
        G.709 Optical Transport Networks.";
  }
  leaf tsg {
    type identityref {
      base layer1-types:tributary-slot-granularity;
    }
  }
}
```

```
    }
    description "Tributary slot granularity.";
    reference
      "G.709/Y.1331, February 2016: Interfaces for the
       Optical Transport Network (OTN)";
  }
  leaf ts-list {
    type string {
      pattern "([1-9][0-9]{0,3}(-[1-9][0-9]{0,3})?"
        + "(,[1-9][0-9]{0,3}(-[1-9][0-9]{0,3})?)*)";
    }
    description
      "A list of available tributary slots ranging
       between 1 and 4095.
       For example 1-20,25,50-1000";
    reference "RFC 7139: GMPLS Signaling Extensions for Control
      of Evolving G.709 Optical Transport Networks";
  }
}

grouping otn-label-step {
  description "Label step for OTN";
  choice otn-label-type {
    description
      "OTN label range type, either TPN range or TS range";
    case tributary-port {
      leaf tpn {
        type uint16 {
          range "1..4095";
        }
        default 1;
        description
          "Label step which represents possible increments for
           Tributary Port Number.";
        reference
          "RFC7139: GMPLS Signaling Extensions for Control of Evolving
           G.709 Optical Transport Networks.";
      }
    }
    case tributary-slot {
      leaf ts {
        type uint16 {
          range "1..4095";
        }
        default 1;
        description
          "Label step which represents possible increments for
           Tributary Slot Number.";
      }
    }
  }
}
```



```
        reference
          "RFC7139: GMPLS Signaling Extensions for Control of Evolving
            G.709 Optical Transport Networks.";
      }
    }
  }

  identity coding-func {
    description
      "base identity from which coding func is derived.";
  }

  identity ETH-1000X-PCS-36 {
    base "coding-func";
    description
      "PCS clause 36 coding function that corresponds to
        1000BASE-X";
    reference "MEF63 & IEEE802.3";
  }

  identity ETH-10GW-PCS-49-WIS-50 {
    base "coding-func";
    description
      "PCS clause 49 and WIS clause 50 coding func that
        corresponds to 10GBASE-W (WAN PHY)";
    reference "MEF63 & IEEE802.3";
  }

  identity ETH-10GR-PCS-49 {
    base "coding-func";
    description
      "PCS clause 49 coding function that corresponds to
        10GBASE-R (LAN PHY)";
    reference "MEF63 & IEEE802.3";
  }

  identity ETH-40GR-PCS-82 {
    base "coding-func";
    description
      "PCS clause 82 coding function that corresponds to
        40GBASE-R";
    reference "MEF63 & IEEE802.3";
  }

  identity ETH-100GR-PCS-82 {
    base "coding-func";
    description
```

```
        "PCS clause 82 coding function that corresponds to
          100GBASE-R";
        reference "MEF63 & IEEE802.3";
    }

    identity optical-interface-func {
        description
            "base identity from which optical-interface-function is
            derived.";
    }

    identity SX-PMD-clause-38 {
        base "optical-interface-func";
        description
            "SX-PMD-clause-38 Optical Interface function for
            1000BASE-X PCS-36";
        reference "MEF63 & IEEE802.3";
    }

    identity LX-PMD-clause-38 {
        base "optical-interface-func";
        description
            "LX-PMD-clause-38 Optical Interface function for
            1000BASE-X PCS-36";
        reference "MEF63 & IEEE802.3";
    }

    identity LX10-PMD-clause-59 {
        base "optical-interface-func";
        description
            "LX10-PMD-clause-59 Optical Interface function for
            1000BASE-X PCS-36";
        reference "MEF63 & IEEE802.3";
    }

    identity BX10-PMD-clause-59 {
        base "optical-interface-func";
        description
            "BX10-PMD-clause-59 Optical Interface function for
            1000BASE-X PCS-36";
        reference "MEF63 & IEEE802.3";
    }

    identity LW-PMD-clause-52 {
        base "optical-interface-func";
        description
            "LW-PMD-clause-52 Optical Interface function for
            10GBASE-W PCS-49-WIS-50";
    }
```

```
        reference "MEF63 & IEEE802.3";
    }

    identity EW-PMD-clause-52 {
        base "optical-interface-func";
        description
            "EW-PMD-clause-52 Optical Interface function for
            10GBASE-W PCS-49-WIS-50";
        reference "MEF63 & IEEE802.3";
    }

    identity LR-PMD-clause-52 {
        base "optical-interface-func";
        description
            "LR-PMD-clause-52 Optical Interface function for
            10GBASE-R PCS-49";
        reference "MEF63 & IEEE802.3";
    }

    identity ER-PMD-clause-52 {
        base "optical-interface-func";
        description
            "ER-PMD-clause-52 Optical Interface function for
            10GBASE-R PCS-49";
        reference "MEF63 & IEEE802.3";
    }

    identity LR4-PMD-clause-87 {
        base "optical-interface-func";
        description
            "LR4-PMD-clause-87 Optical Interface function for
            40GBASE-R PCS-82";
        reference "MEF63 & IEEE802.3";
    }

    identity ER4-PMD-clause-87 {
        base "optical-interface-func";
        description
            "ER4-PMD-clause-87 Optical Interface function for
            40GBASE-R PCS-82";
        reference "MEF63 & IEEE802.3";
    }

    identity FR-PMD-clause-89 {
        base "optical-interface-func";
        description
            "FR-PMD-clause-89 Optical Interface function for
            40GBASE-R PCS-82";
    }
```

```
        reference "MEF63 & IEEE802.3";
    }

    identity LR4-PMD-clause-88 {
        base "optical-interface-func";
        description
            "LR4-PMD-clause-88 Optical Interface function for
            100GBASE-R PCS-82";
        reference "MEF63 & IEEE802.3";
    }

    identity ER4-PMD-clause-88 {
        base "optical-interface-func";
        description
            "ER4-PMD-clause-88 Optical Interface function for
            100GBASE-R PCS-82";
        reference "MEF63 & IEEE802.3";
    }

    identity service-performance-metric {
        description
            "list of service-specific performance metric";
    }

    identity One-way-Delay {
        base "service-performance-metric";
        description "one-way-delay";
    }

    identity One-way-Errored-Second {
        base "service-performance-metric";
        description "one-way-errored-second";
    }

    identity One-way-Severely-Errored-Second {
        base "service-performance-metric";
        description "one-way-severely-errored-second";
    }

    identity One-way-Unavailable-Second {
        base "service-performance-metric";
        description "one-way-unavailable-second";
    }

    identity One-way-Availability {
        base "service-performance-metric";
        description "one-way-availability";
    }
}
```

```
    identity network-performance-metric {  
        description "list of network-specific performance metric";  
    }  
  
}  
<CODE ENDS>
```

6. Security Considerations

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

The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

The YANG module in this document defines layer 1 type definitions (i.e., typedef, identity and grouping statements) in YANG data modeling language to be imported and used by other layer 1 technology-specific modules. When imported and used, the resultant schema will have data nodes that can be writable, or readable. The access to such data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations.

The security considerations spelled out in the YANG 1.1 specification [RFC7950] apply for this document as well.

7. IANA Considerations

It is proposed that IANA should assign new URIs from the "IETF XML Registry" [RFC3688] as follows:

```
URI: urn:ietf:params:xml:ns:yang:ietf-layer1-types  
Registrant Contact: The IESG  
XML: N/A; the requested URI is an XML namespace.
```

This document registers following YANG modules in the YANG Module Names registry [RFC7950].

```
name:          ietf-layer1-types
namespace:     urn:ietf:params:xml:ns:yang:ietf-otn-types
prefix:        layer1-types
reference:     RFC XXXX
```

8. Acknowledgements

TBD.

9. Contributors

Dieter Beller
Nokia
Email: dieter.beller@nokia.com

Sergio Belotti
Nokia
Email: sergio.belotti@nokia.com

Yanlei Zheng
China Unicom
Email: zhengyl@dimpt.com

Aihua Guo
Huawei Technologies
Email: aihuaguo@huawei.com

Young Lee
Huawei Technologies
Email: leeyoung@huawei.com

Lei Wang
China Mobile
Email: wangleiyj@chinamobile.com

Oscar Gonzalez de Dios
Telefonica
Email: oscar.gonzalezdedios@telefonica.com

Xufeng Liu
Volta Networks
Email: xufeng.liu.ietf@gmail.com

Yunbin Xu
CAICT
Email: xuyunbin@ritr.com

Anurag Sharma
Google
Email: ansha@google.com

Rajan Rao
Infinera
Email: rrao@infinera.com

Victor Lopez
Telefonica
Email: victor.lopezalvarez@telefonica.com

Yunbo Li
China Mobile
Email: liyunbo@chinamobile.com

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Authors' Addresses

Haomian Zheng
Huawei Technologies
H1-1-A043S Huawei Industrial Base, Songshanhu
Dongguan, Guangdong 523808
China

Email: zhenghaomian@huawei.com

Italo Busi
Huawei Technologies
Milan
Italy

Email: Italo.Busi@huawei.com

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Y. Lee
SKKU (Sung Kyun Kwan University)

V. Lopez
Telefonica

G. Galimberti
Cisco

Jean Luc Auge
Orange

D. Beller
Nokia

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A Yang Data Model for Optical Impairment-aware Topology

draft-ietf-ccamp-optical-impairment-topology-yang-02

Abstract

In order to provision an optical connection through optical networks, a combination of path continuity, resource availability, and impairment constraints must be met to determine viable and optimal paths through the network. The determination of appropriate paths is known as Impairment-Aware Routing and Wavelength Assignment (IA-RWA) for WSON, while it is known as Impairment-Aware Routing and Spectrum Assignment (IA-RSA) for SSON.

This document provides a YANG data model for the impairment-aware TE topology in optical networks.

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[Page 1]

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Table of Contents

1. Introduction	3
1.1. Terminology	4
1.2. Tree diagram	4
1.3. Prefixes in Data Node Names.....	4
2. Reference Architecture.....	5
2.1. Control Plane Architecture.....	5
2.2. Transport Data Plane.....	6
2.3. OMS Media Links.....	7
2.3.1. Optical Tributary Signal (OTSi)	7
2.3.2. Optical Tributary Signal Group (OTSiG)	8
2.3.3. Media Channel Group (MCG)	10
2.4. Amplifiers	11
2.5. Transponders	11
2.6. WSS/Filter	12
2.7. Optical Fiber	12
3. YANG Model (Tree Structure).....	17
4. Optical Impairment Topology YANG Model	19

5. Security Considerations.....	38
6. IANA Considerations	38
7. Acknowledgments	39
8. References	40
8.1. Normative References.....	40
8.2. Informative References.....	40
9. Contributors	42
Authors' Addresses	42

1. Introduction

In order to provision an optical connection (an optical path) through a wavelength switched optical networks (WSONs) or spectrum switched optical networks (SSONs), a combination of path continuity, resource availability, and impairment constraints must be met to determine viable and optimal paths through the network. The determination of appropriate paths is known as Impairment-Aware Routing and Wavelength Assignment (IA-RWA) [RFC6566] for WSON, while it is known as IA-Routing and Spectrum Assignment (IA-RSA) for SSON.

This document provides a YANG data model for the impairment-aware Traffic Engineering (TE) topology in WSONs and SSONs. The YANG model described in this document is a WSON/SSON technology-specific Yang model based on the information model developed in [RFC7446] and the two encoding documents [RFC7581] and [RFC7579] that developed protocol independent encodings based on [RFC7446].

The intent of this document is to provide a Yang data model, which can be utilized by a Multi-Domain Service Coordinator (MDSC) to collect states of WSON impairment data from the Transport PNCs to enable impairment-aware optical path computation according to the ACTN Architecture [RFC8453]. The communication between controllers is done via a NETCONF [RFC8341] or a RESTCONF [RFC8040]. Similarly, this model can also be exported by the MDSC to a Customer Network Controller (CNC), which can run an offline planning process to map latter the services in the network.

This document augments the generic TE topology draft [TE-TOPO] where possible.

This document defines one YANG module: ietf-optical-impairment-topology (Section 3) according to the new Network Management Datastore Architecture [RFC8342].

1.1. Terminology

Refer to [RFC6566], [RFC7698], and [G.807] for the key terms used in this document.

The following terms are defined in [RFC7950] and are not redefined here:

- o client
- o server
- o augment
- o data model
- o data node

The following terms are defined in [RFC6241] and are not redefined here:

- o configuration data
- o state data

The terminology for describing YANG data models is found in [RFC7950].

1.2. Tree diagram

A simplified graphical representation of the data model is used in Section 2 of this this document. The meaning of the symbols in these diagrams is defined in [RFC8340].

1.3. Prefixes in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules, as shown in Table 1.

Prefix	YANG module	Reference
optical-imp-topo	ietf-optical-impairment-topology	[RFCXXXX]
layer0-types	ietf-layer0-types	[L0-Types]
nw	ietf-network	[RFC8345]
nt	ietf-network-topology	[RFC8345]

tet	ietf-te-topology	[TE-TOPO]	
-----+	-----+	-----+	-----+

Table 1: Prefixes and corresponding YANG modules

Note: The RFC Editor will replace XXXX with the number assigned to the RFC once this draft becomes an RFC.

2. Reference Architecture

2.1. Control Plane Architecture

Figure 1 shows the control plane architecture.

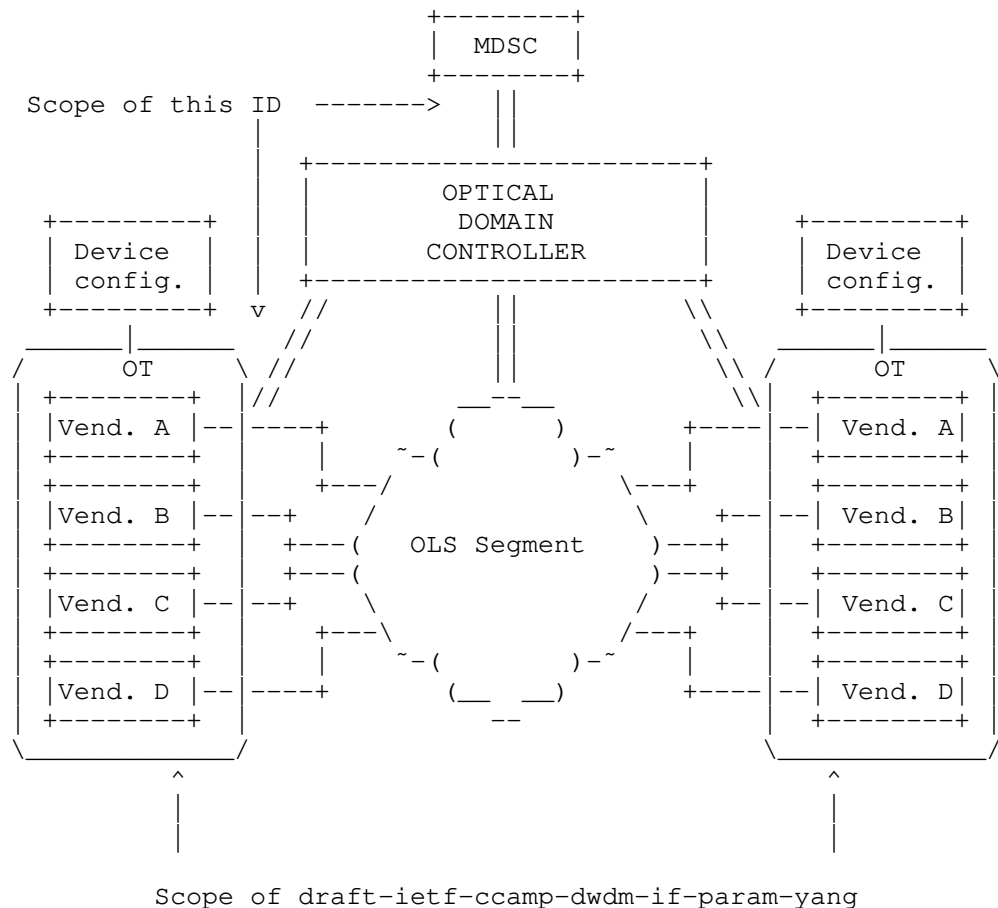


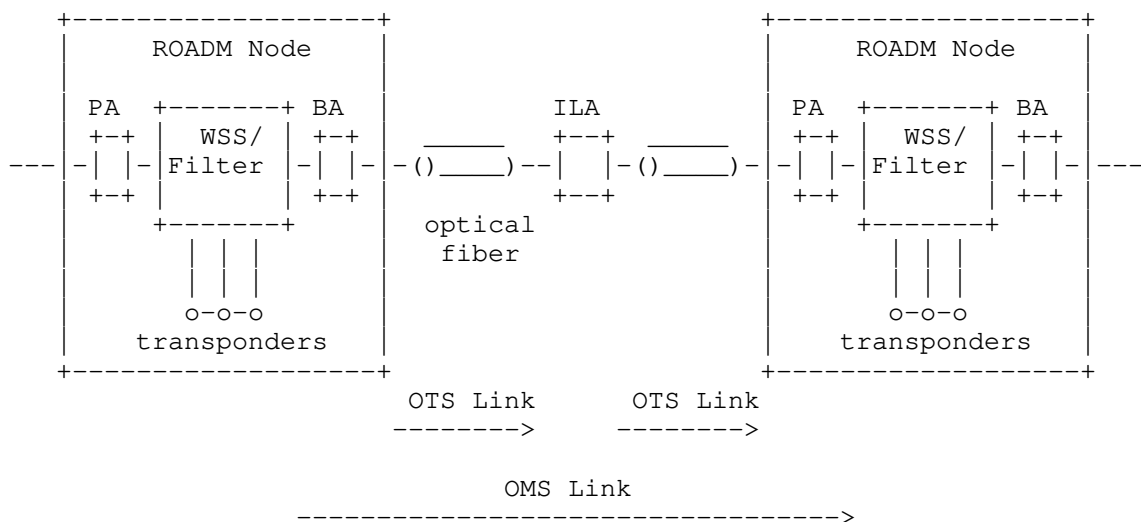
Figure 1. Control Plane Architecture

The models developed in this document is an abstracted Yang model that may be used in the interfaces between the MDSC and the Optical Domain Controller (aka MPI) and between the Optical Domain Controller and the Optical Device (aka SBI) in Figure 1. It is not intended to support a detailed low-level DWDM interface model. DWDM interface model is supported by the models presented in [draft-ietf-ccamp-dwdm-if-parameter-yang].

2.2. Transport Data Plane

This section provides the description of the reference optical network architecture and its relevant components to support optical impairment-aware path computation.

Figure 2 shows the reference architecture.



PA: Pre-Amplifier
 BA: Booster Amplifier
 ILA: In-Line Amplifier

Figure 2. Reference Architecture for Optical Transport Network

BA (on the left side ROADM) is the ingress Amplifier and PA (on the right side ROADM) is the egress amplifier for the OMS link shown in the Figure.

2.3. OMS Media Links

According to [G.872], OMS Media Link represents a media link between two ROADMs. Specifically, it originates at the ROADM's Filter in the source ROADM and terminates at the ROADM's Filter in the destination ROADM.

OTS Media Link represents a media link:

- (i) between ROADM's BA and ILA;
- (ii) between a pair of ILAs;
- (iii) between ILA and ROADM's PA.

OMS Media link can be decomposed in a sequence of OTS links type (i), (ii), and (iii) as discussed above. OMS Media link would give an abstracted view of impairment data (e.g., power, OSNR, etc.) to the network controller.

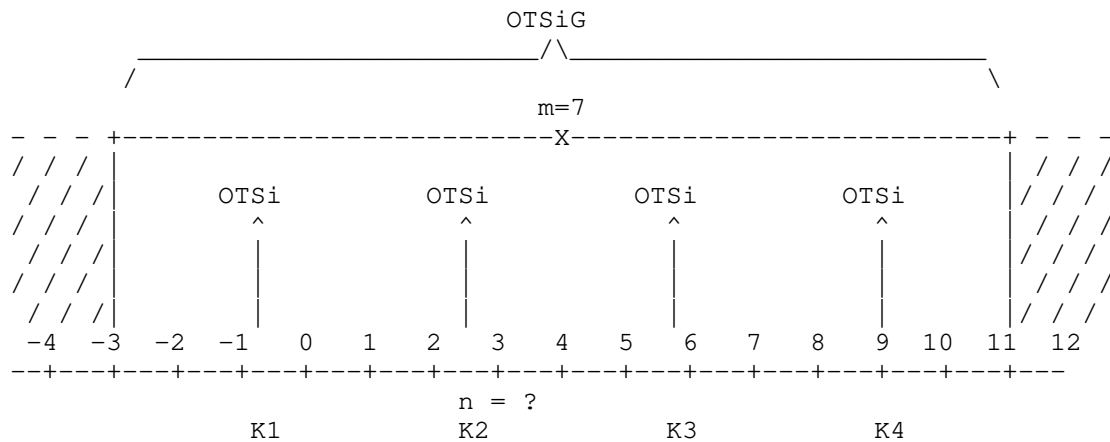
For the sake of optical impairment evaluation OMS Media link can be also decomposed in a sequence of elements such as BA, fiber section, ILA, concentrated loss and PA.

2.3.1. Optical Tributary Signal (OTSi)

The OTSi is defined in ITU-T Recommendation G.959.1, section 3.2.4 [G.959.1]. The YANG model defined below assumes that a single OTSi consists of a single modulated optical carrier. This single modulated optical carrier conveys digital information. Characteristics of the OTSi signal are modulation scheme (e.g. QPSK, 8-QAM, 16-QAM, etc.), baud rate (measure of the symbol rate), pulse shaping (e.g. raised cosine - complying with the Nyquist inter symbol interference criterion), etc.

2.3.2. Optical Tributary Signal Group (OTSiG)

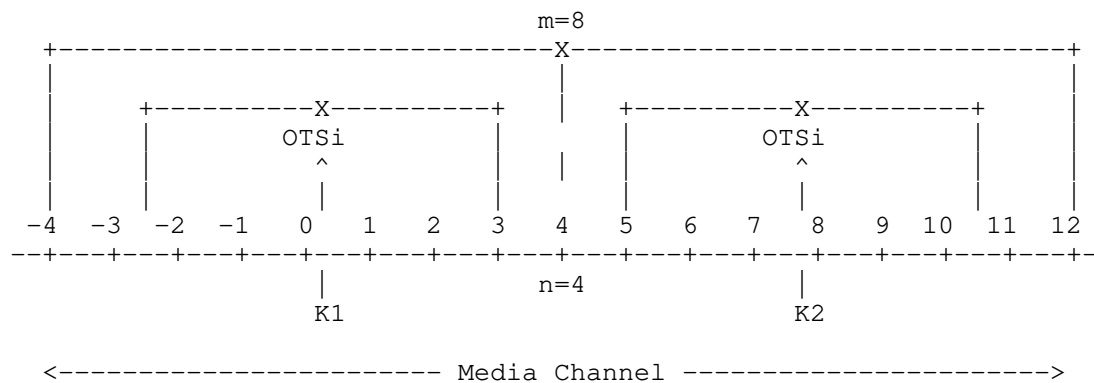
The definition of the OTSiG is currently being moved from ITU-T Recommendation G.709 [G.709] to the new draft Recommendation G.807 (still work in progress) [G.807]. The OTSiG is an electrical signal that is carried by one or more OTSi's. The relationship between the OTSiG and the the OTSi's is described in ITU-T draft Recommendation G.807, section 10.2 [G.807]. The YANG model below supports both cases: the single OTSi case where the OTSiG contains a single OTSi (see ITU-T draft Recommendation G.807, Figure 10-2) and the multiple OTSi case where the OTSiG consists of more than one OTSi (see ITU-T draft Recommendation G.807, Figure 10-3). From a layer 0 topology YANG model perspective, the OTSiG is a logical construct that associates the OTSi's, which belong to the same OTSiG. The typical application of an OTSiG consisting of more than one OTSi is inverse multiplexing. Constraints exist for the OTSi's belonging to the same OTSiG such as: (i) all OTSi's must be co-routed over the same optical fibers and nodes and (ii) the differential delay between the different OTSi's may not exceed a certain limit. Example: a 400Gbps client signal may be carried by 4 OTSi's where each OTSi carries 100Gbps of client traffic.



2.3.3 Media Channel (MC)

The definition of the MC is currently being moved from ITU-T Recommendation G.872 [G.872] to the new draft Recommendation G.807 (still work in progress) [G.807]. Section 3.2.2 defines the term MC and section 7.1.2 provides a more detailed description with some examples. The definition of the MC is very generic (see ITU-T draft Recommendation G.807, Figure 7-1). In the YANG model below, the MC is used with the following semantics:

The MC is an end-to-end topological network construct and can be considered as an "optical pipe" with a well-defined frequency slot between one or more optical transmitters each generating an OTSi and the corresponding optical receivers terminating the OTSi's. If the MC carries more than one OTSi, it is assumed that these OTSi's belong to the same OTSiG.



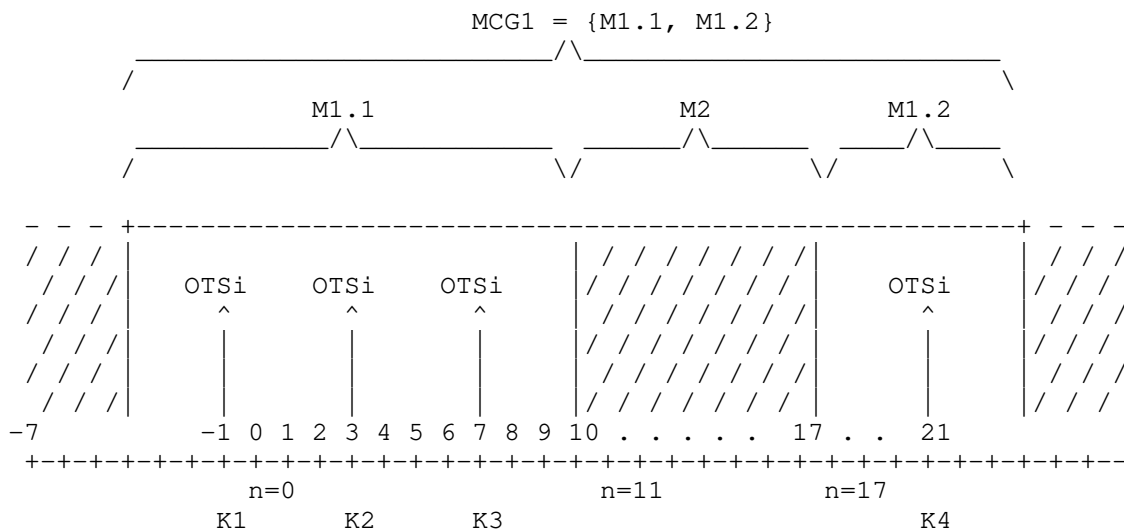
The frequency slot of the MC is defined by the n value defining the central frequency of the MC and the m value that defines the width of the MC following the flexible grid definition in ITU-T Recommendation G.694.1 [G.694.1]. In this model, the effective frequency slot as defined in ITU-T draft Recommendation G.807 is equal to the frequency slot of this end-to-end MC. It is also assumed that ROADMs can switch MCs. For various reasons (e.g. differential delay), it is preferred to use a single MC for all OTSi's of the same OTSiG. It may however not always be possible to

find a single MC for carrying all OTSi's of an OTSiG due to spectrum occupation along the OTSiG path.

2.3.3. Media Channel Group (MCG)

The definition of the MCG is currently work in progress in ITU-T and is defined in section 7.1.3 of the new ITU-T draft Recommendation G.807 (still work in progress) [G.807]. The YANG model below assumes that the MCG is a logical grouping of one or more MCs that are used to to carry all OTSi's belonging to the same OTSiG.

The MCG can be considered as an association of MCs without defining a hierarchy where each MC is defined by its (n,m) value pair. An MCG consists of more than one MC when no single MC can be found from source to destination that is wide enough to accommodate all OTSi's (modulated carriers) that belong to the same OTSiG. In such a case the set of OTSi's belonging to a single OTSiG have to be split across 2 or more MCs.



The MCG is relevant for path computation because all end-to-end MCs belonging to the same MCG have to be co-routed, i.e., have to follow the same path. Additional constraints may exist (e.g. differential delay).

2.4. Amplifiers

Optical amplifiers are in charge of amplifying the optical signal in the optical itself without any electrical conversion. There are three main technologies to build amplifiers: Erbium Doped Fiber Amplifier (EDFA), Raman Fiber Amplifier (RFA), and Semiconductor Optical Amplifier (SOA). Nowadays, most of optical networks uses EDFAs. However, RFA has an attractive feature that it works in any wavelength band with a similar or lower noise figures compared to EDFA. On the other hand, RFAs consumes more power and are more expensive than EDFAs.

Amplifiers can be classified according to their location in the communication link. There are three basic types of amplifiers: ILA, Pre-Amplifier and Booster. ILA is In-Line Amplifier which is a separate node type while Pre-Amplifier and Booster Amplifier are integral elements of ROADM node. From a data modeling perspective, Pre-Amplifier and Booster Amplifier are internal functions of a ROADM node and as such these elements are hidden within ROADM node. In this document, we would avoid internal node details, but attempt to abstract as much as possible.

One modeling consideration of the ROADM internal is to model power parameter through the ROADM, factoring the output power from the Pre-Amplifier minus the ROADM power loss would give the input power to the Booster Amplifier. In other words, $\text{Power_in (@ ROADM Booster)} = \text{Power_out (@ ROADM Pre-Amplifier)} - \text{Power_loss (@ ROADM WSS/Filter)}$.

2.5. Transponders

A Transponder is the element that sends and receives the optical signal from a fiber. A transponder is typically characterized by its data rate and the maximum distance the signal can travel. Channel frequency, per channel input power, FEC and Modulation are also associated with a transponder. From a path computation point of view, the selection of the compatible source and destination

transponders is an important factor for optical signal to traverse through the fiber. There are three main approaches to determine optical signal compatibility. Application Code based on G.698.2 is one approach that only checks the code at both ends of the link. Another approach is organization codes that are specific to an organization or a vendor. The third approach is specify all the relevant parameters explicitly, e.g., FEC type, Modulation type, etc.

[Editor's Note: The current YANG model described in Section 3 with respect to the relationship between the transponder attributes and the OTSi will need to be investigated in the future revision]

2.6. WSS/Filter

WSS separates the incoming light input spectrally as well as spatially, then chooses the wavelength that is of interest by deflecting it from the original optical path and then couple it to another optical fibre port. WSS/Filter is internal to ROADM. So this document does not model the inside of ROADM.

2.7. Optical Fiber

There are various optical fiber types defined by ITU-T. There are several fiber-level parameters that need to be factored in, such as, fiber-type, length, loss coefficient, pmd, connectors (in/out).

ITU-T G.652 defines Standard Singlemode Fiber; G.654 Cutoff Shifted Fiber; G.655 Non-Zero Dispersion Shifted Fiber; G.656 Non-Zero Dispersion for Wideband Optical Transport; G.657 Bend-Insensitive Fiber. There may be other fiber-types that need to be considered.

2.8. ROADM Node Architectures

The ROADM node architectures in today's dense wavelength division multiplexing (DWDM) networks can be categorized as follows:

- o Integrated ROADM architecture with integrated optical transponders
- o Integrated ROADM architecture with integrated optical transponders and single channel add/drop ports for remote optical transponders
- o Disaggregated ROADM architecture where the ROADM is subdivided into degree, add/drop, and optical transponder subsystems handled as separate network elements

The TE topology YANG model augmentations including optical impairments for DWDM networks defined below intend to cover all the 3 categories of ROADM architectures listed above. In the case of a disaggregated ROADM architecture, it is assumed that optical domain controller already performs some form of abstraction and presents the TE-node representing the disaggregated ROADM in the same way as an integrated ROADM with integrated optical transponders if the optical transponder subsystems and the add/drop subsystems are collocated (short fiber links not imposing significant optical impairments).

The different ROADM architectures are briefly described and illustrated in the following subsections.

[Editor's Note: The modeling of remote optical transponders located for example in the client device with a single channel link between the OT and the add/drop port of the ROADM requires further investigations and will be addressed in a future revision of this document.]

2.8.1. Integrated ROADM architecture with integrated transponders

Figure 2 and Figure <A1> below show the typical architecture of an integrated ROADM node, which contains the optical transponders as an integral part of the ROADM node. Such an integrated ROADM node provides DWDM interfaces as external interfaces for interconnecting the device with its neighboring ROADMs (see OTS link above). The number of these interfaces denote also the degree of the ROADM. A degree 3 ROADM for example has 3 DWDM links that interconnect the ROADM node with 3 neighboring ROADMs. Additionally, the ROADM provides client interfaces for interconnecting the ROADM with client devices such as IP routers or Ethernet switches. These client interfaces are the client interfaces of the integrated optical transponders.

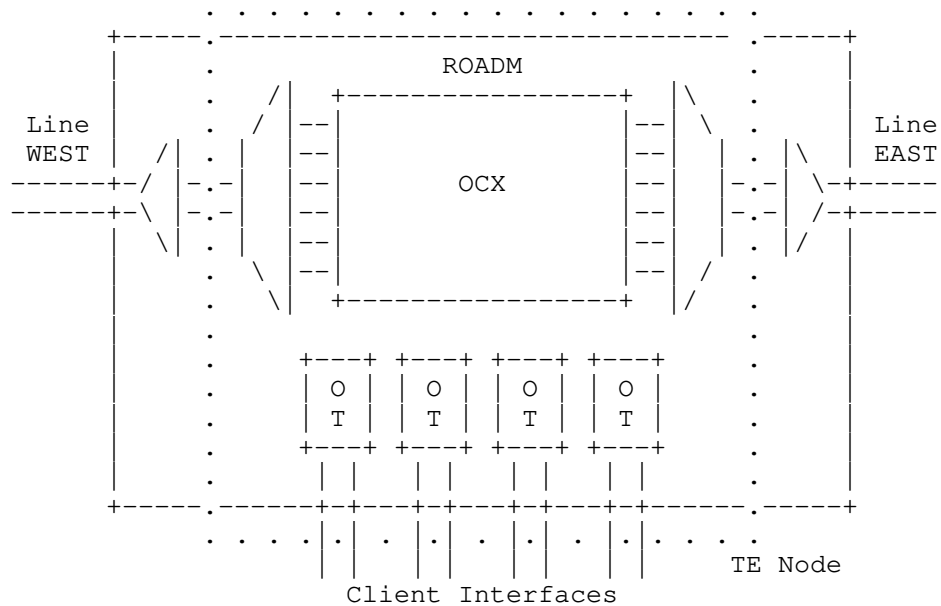


Figure <A1>: ROADM architecture with integrated transponders

2.8.2. Integrated ROADMs with integrated optical transponders and single channel add/drop interfaces for remote optical transponders

Figure <A2> below shows the extreme case where all optical transponders are not integral parts of the ROADM but are separate devices that are interconnected with add/drop ports of the ROADM. If the optical transponders and the ROADM are collocated and if short single channel fiber links are used to interconnect the optical transponders with an add/drop port of the ROADM, the optical domain controller may present these optical transponders in the same way as integrated optical transponders. If, however, the optical impairments of the single channel fiber link between the optical transponder and the add/drop port of the ROADM cannot be neglected, it is necessary to represent the fiber link with its optical impairments in the topology model. This also implies that the optical transponders belong to a separate TE node [Editor's Note: this requires further study].

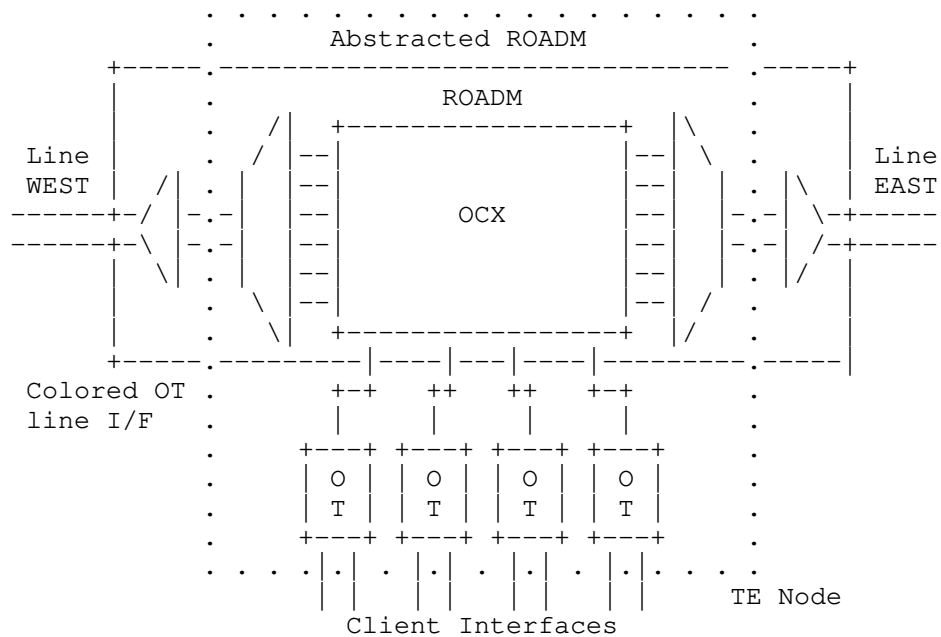


Figure <A2>: ROADM architecture with remote transponders

2.8.3. Disaggregated ROADMs that are subdivided into degree, add/drop, and optical transponder subsystems

Recently, some DWDM network operators started demanding ROADM subsystems from their vendors. An example is the OpenROADM project where multiple operators and vendors are developing related YANG models. The subsystems of a disaggregated ROADM are: single degree subsystems, add/drop subsystems and optical transponder subsystems. These subsystems separate network elements and each network element provides a separate management and control interface. The subsystems are typically interconnected using short fiber patch cables and form together a disaggregated ROADM node. This disaggregated ROADM architecture is depicted in Figure <A3> below.

As this document defines TE topology YANG model augmentations [TE-TOPO] for the TE topology YANG model provided at the north-bound interface of the optical domain controller, it is a valid assumption that the optical domain controller abstracts the subsystems of a disaggregated ROADM and presents the disaggregated ROADM in the same

way as an integrated ROADM hiding all the interconnects that are not relevant from an external TE topology view.

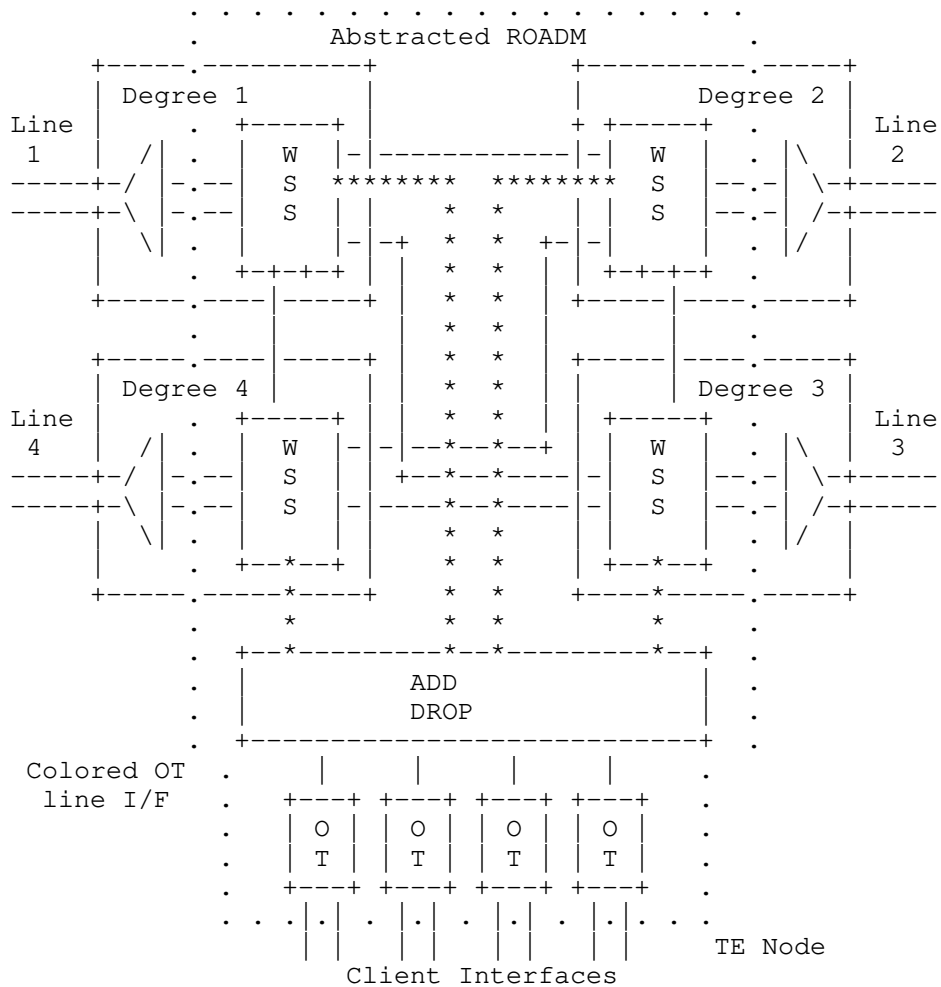


Figure <A3>: ROADM architecture with remote transponders

3. YANG Model (Tree Structure)

```

module: ietf-optical-impairment-topology
  augment /nw:networks/nw:network/nw:network-types/tet:te-topology:
    +--rw optical-impairment-topology!
  augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-attributes:
    +--ro OMS-attributes
      +--ro generalized-snr?                decimal64
      +--ro equalization-mode                identityref
      +--ro (power-param)?
        +---:(channel-power)
          |   +--ro nominal-channel-power?    decimal64
          +---:(power-spectral-density)
            +--ro nominal-power-spectral-density? decimal64
      +--ro media-channel-group* [i]
        +--ro i                               int16
        +--ro media-channels* [flexi-n]
          +--ro flexi-n                       uint16
          +--ro flexi-m?                      uint16
          +--ro OTSiG-ref?                    leafref
          +--ro OTSi-ref?                     leafref
      +--ro OMS-elements* [elt-index]
        +--ro elt-index                      uint16
        +--ro uid?                          string
        +--ro type                          identityref
        +--ro element
          +--ro (element)?
            +---:(amplifier)
              +--ro amplifier
                +--ro type_variety            string
                +--ro operational
                  +--ro actual-gain
                    |   decimal64
                  +--ro tilt-target
                    |   decimal64
                  +--ro out-voa
                    |   decimal64
                  +--ro in-voa
                    |   decimal64
                  +--ro (power-param)?
                    +---:(channel-power)
                      |   +--ro nominal-channel-power?    decimal64
                      +---:(power-spectral-density)
                        +--ro nominal-power-spectral-density? decimal64

```

```

      +---:(fiber)
      |   +---ro fiber
      |       +---ro type_variety      string
      |       +---ro length             decimal64
      |       +---ro loss_coef          decimal64
      |       +---ro total_loss         decimal64
      |       +---ro pmd?               decimal64
      |       +---ro conn_in?          decimal64
      |       +---ro conn_out?         decimal64
      +---:(concentratedloss)
      |   +---ro concentratedloss
      |       +---ro loss?             decimal64
augment /nw:networks/nw:network/nw:node/tet:te
      /tet:tunnel-termination-point:
+---ro OTSiG-element* [OTSiG-identifier]
|   +---ro OTSiG-identifier      int16
|   +---ro OTSiG-container
|       +---ro OTSi* [OTSi-carrier-id]
|           +---ro OTSi-carrier-id      int16
|           +---ro OTSi-carrier-frequency? decimal64
|           +---ro OTSi-signal-width?   decimal64
|           +---ro channel-delta-power? decimal64
+---ro transponders-list* [transponder-id]
|   +---ro transponder-id      uint32
|   +---ro (mode)?
|       +---:(G.692.2)
|       |   +---ro standard_mode?      layer0-types:standard-mode
|       +---:(organizational_mode)
|       |   +---ro operational-mode?
|       |       |   layer0-types:operational-mode
|       |       +---ro organization-identifier?
|       |           |   layer0-types:vendor-identifier
|       +---:(explicit_mode)
|           +---ro available-modulation*      identityref
|           +---ro modulation-type?           identityref
|           +---ro available-baud-rates*      uint32
|           +---ro configured-baud-rate?      uint32
|           +---ro available-FEC*             identityref
|           +---ro FEC-type?                  identityref
|           +---ro FEC-code-rate?             decimal64
|           +---ro FEC-threshold?             decimal64
|   +---ro power?                           int32
|   +---ro power-min?                        int32
|   +---ro power-max?                        int32
augment /nw:networks/nw:network/nw:node/tet:te
      /tet:tunnel-termination-point:
+---ro transponder-list* [carrier-id]

```

```
    +--ro carrier-id      uint32
```

4. Optical Impairment Topology YANG Model

```
<CODE BEGINS> file ietf-optical-impairment-topology@2018-05-22.yang
module ietf-optical-impairment-topology {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-optical-impairment-topology";

  prefix "optical-imp-topo";

  import ietf-network {
    prefix "nw";
  }

  import ietf-network-topology {
    prefix "nt";
  }

  import ietf-te-topology {
    prefix "tet";
  }

  import ietf-layer0-types {
    prefix "layer0-types";
  }

  organization
    "IETF CCAMP Working Group";

  contact
    "Editor:    Young Lee <younglee.tx@gmail.com>
     Editor:    Haomian Zheng <zhenghaomian@huawei.com>
     Editor:    Nicola Sambo <nicosambo@gmail.com>
     Editor:    Victor Lopez <victor.lopezalvarez@telefonica.com>
     Editor:    Gabriele Galimberti <ggalimbe@cisco.com>
     Editor:    Giovanni Martinelli <giomarti@cisco.com>
     Editor:    Auge Jean-Luc <jeanluc.auge@orange.com>
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     Editor:    Italo Busi <Italo.Busi@huawei.com>
     Editor:    Dieter Beller <dieter.beller@nokia.com>
     Editor:    Sergio Belotti <Sergio.belotti@nokia.com>
     Editor:    Griseri Enrico <enrico.griseri@nokia.com>
     Editor:    Gert Grammel <ggrammel@juniper.net>";
```

description

"This module contains a collection of YANG definitions for impairment-aware optical networks.

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revision 2019-05-22 {

description

"Initial Version";

reference

"RFC XXXX: A Yang Data Model for Impairment-aware Optical Networks";

}

identity modulation {

description "base identity for modulation type";

}

identity QPSK {

base modulation;

description

"QPSK (Quadrature Phase Shift Keying) modulation";

}

identity DP_QPSK {

base modulation;

description

"DP-QPSK (Dual Polarization Quadrature Phase Shift Keying) modulation";

}

identity QAM8 {

base modulation;

description

"8QAM (8-State Quadrature Amplitude Modulation) modulation";

}

identity QAM16 {

base modulation;

description

"QAM16 (Quadrature Amplitude Modulation)";

}

identity DP_QAM8 {

```
    base modulation;
    description
        "DP-QAM8 (Dual Polarization Quadrature Amplitude Modulation)";
}
identity DC_DP_QAM8 {
    base modulation;
    description
        "DC DP-QAM8 (Dual Polarization Quadrature Amplitude Modulation)";
}
identity DP_QAM16 {
    base modulation;
    description
        "DP-QAM16 (Dual Polarization Quadrature Amplitude Modulation)";
}
identity DC_DP_QAM16 {
    base modulation;
    description
        "DC DP-QAM16 (Dual Polarization Quadrature Amplitude Modulation)";
}

identity FEC {
    description
        "Enumeration that defines the type of
        Forward Error Correction";
}
identity reed-solomon {
    base FEC;
    description
        "Reed-Solomon error correction";
}
identity hamming-code {
    base FEC;
    description
        "Hamming Code error correction";
}
identity golay {
    base FEC;
    description "Golay error correction";
}

typedef fiber-type {
    type enumeration {
        enum G.652 {
            description "G.652 Standard Singlemode Fiber";
        }
        enum G.654 {
            description "G.654 Cutoff Shifted Fiber";
        }
    }
}
```

```
    enum G.653 {
        description "G.653 Dispersion Shifted Fiber";
    }
    enum G.655 {
        description "G.655 Non-Zero Dispersion Shifted Fiber";
    }
    enum G.656 {
        description "G.656 Non-Zero Dispersion for Wideband
                    Optical Transport";
    }
    enum G.657 {
        description "G.657 Bend-Insensitive Fiber";
    }
}
description
    "ITU-T based fiber-types";
}

grouping transponder-attributes {
    description "Configuration of an optical transponder";

    leaf-list available-modulation {
        type identityref {
            base modulation;
        }
        config false;
    }
    description
        "List determining all the available modulations";
}

leaf modulation-type {
    type identityref {
        base modulation;
    }
    config false;
    description
        "Modulation configured for the transponder";
}

leaf-list available-baud-rates {
    type uint32;
    units Bd;
    config false;
    description
        "list of available baud-rates. Baud-rate is the unit for
        symbol rate or modulation rate in symbols per second or
        pulses per second. It is the number of distinct symbol
        changes (signaling events) made to the transmission medium
        per second in a digitally modulated signal or a line code";
}
```

```
    }

    leaf configured-baud-rate {
        type uint32;
        units Bd;
        config false;
        description "configured baud-rate";
    }

    leaf-list available-FEC {
        type identityref {
            base FEC;
        }
        config false;
        description "List determining all the available FEC";
    }

    leaf FEC-type {
        type identityref {
            base FEC;
        }
        config false;
        description
            "FEC type configured for the transponder";
    }

    leaf FEC-code-rate {
        type decimal64 {
            fraction-digits 8;
            range "0..max";
        }
        config false;
        description "FEC-code-rate";
    }

    leaf FEC-threshold {
        type decimal64 {
            fraction-digits 8;
            range "0..max";
        }
        config false;
        description
            "Threshold on the BER, for which FEC is able to correct errors";
    }
}

grouping sliceable-transponder-attributes {
    description
```



```
    "Configuration of a sliceable transponder.";
list transponder-list {
    key "carrier-id";
    config false;
    description "List of carriers";
    leaf carrier-id {
        type uint32;
        config false;
        description "Identifier of the carrier";
    }
}

grouping optical-fiber-data {
    description
    "optical link (fiber) attributes with impairment data";
    leaf fiber-type {
        type fiber-type;
        config false;
        description "fiber-type";
    }

    leaf span-length {
        type decimal64 {
            fraction-digits 2;
        }
        units "km";
        config false;
        description "the lenght of the fiber span in km";
    }

    leaf input-power {
        type decimal64 {
            fraction-digits 2;
        }
        units "dBm";
        config false;
        description
        "Average input power level estimated at the receiver
        of the link";
    }

    leaf output-power {
        type decimal64 {
            fraction-digits 2;
        }
        units "dBm";
        description
        "Mean launched power at the transmitter of the link";
    }
}
```

```
    }

    leaf pmd {
      type decimal64 {
        fraction-digits 8;
        range "0..max";
      }
      units "ps/(km)^0.5";
      config false;
      description
        "Polarization Mode Dispersion";
    }

    leaf cd {
      type decimal64 {
        fraction-digits 5;
      }
      units "ps/nm/km";
      config false;
      description
        "Cromatic Dispersion";
    }

    leaf osnr {
      type decimal64 {
        fraction-digits 5;
      }
      units "dB";
      config false;
      description
        "Optical Signal-to-Noise Ratio (OSNR) estimated
         at the receiver";
    }

    leaf sigma {
      type decimal64 {
        fraction-digits 5;
      }
      units "dB";
      config false;
      description
        "sigma in the Gaussian Noise Model";
    }
  }

  grouping optical-channel-data {
    description
      "optical impairment data per channel/wavelength";
    leaf bit-rate {
```

```
    type decimal64 {
      fraction-digits 8;
      range "0..max";
    }
    units "Gbit/s";
    config false;
    description
      "Gross bit rate";
  }

  leaf BER {
    type decimal64 {
      fraction-digits 18;
      range "0..max";
    }
    config false;
    description
      "BER (Bit Error Rate)";
  }

  leaf ch-input-power {
    type decimal64 {
      fraction-digits 2;
    }
    units "dBm";
    config false;
    description
      "Per channel average input power level
      estimated at the receiver of the link";
  }

  leaf ch-pmd {
    type decimal64 {
      fraction-digits 8;
      range "0..max";
    }
    units "ps/(km)^0.5";
    config false;
    description
      "per channel Polarization Mode Dispersion";
  }

  leaf ch-cd {
    type decimal64 {
      fraction-digits 5;
    }
    units "ps/nm/km";
    config false;
    description
```

```
    "per channel Chromatic Dispersion";
}

leaf ch-osnr {
  type decimal64 {
    fraction-digits 5;
  }
  units "dB";
  config false;
  description
    "per channel Optical Signal-to-Noise Ratio
     (OSNR) estimated at the receiver";
}

leaf q-factor {
  type decimal64 {
    fraction-digits 5;
  }
  units "dB";
  config false;
  description
    "q-factor estimated at the receiver";
}
}

grouping standard_mode {
  description
    "ITU-T G.698.2 standard mode that guarantees interoperability.
     It must be an string with the following format:
     B-DScW-ytz(v) where all these attributes are conformant
     to the ITU-T recommendation";

  leaf standard_mode {
    type layer0-types:standard-mode;
    config false;
    description
      "G.698.2 standard mode";
  }
}

grouping organizational_mode {
  description
    "Transponder operational mode supported by organizations or
     vendor";

  leaf operational-mode {
    type layer0-types:operational-mode;
    config false;
    description
```

```
        "configured organization- or vendor-specific
        application identifiers (AI) supported by the transponder";
    }

    leaf organization-identifier {
        type layer0-types:vendor-identifier;
        config false;
        description
            "organization identifier that uses organizational
            mode";
    }
}

/*
 * Identities
 */
identity type-element {
    description
        "Base identity for element type";
}

identity Fiber {
    base type-element;
    description
        "Fiber element";
}

identity Roadm {
    base type-element;
    description
        "Roadm element";
}

identity Edfa {
    base type-element;
    description
        "Edfa element";
}

identity Concentratedloss {
    base type-element;
    description
        "Concentratedloss element";
}

identity type-power-mode {
    description
        "power equalization mode used within the OMS and its elements";
}
```

```
}

identity power-spectral-density {
  base type-power-mode;
  description
    "all elements must use power spectral density (W/Hz)";
}

identity channel-power {
  base type-power-mode;
  description
    "all elements must use power (dBm)";
}

/*
 * Groupings
 */
grouping amplifier-params {
  description "describes parameters for an amplifier";
  container amplifier {
    description "amplifier type, operational parameters are described";
    leaf type_variety {
      type string ;
      mandatory true ;
      description
        "String identifier of amplifier type referencing
        a specification in a separate equipment catalog";
    }
    container operational {
      description "amplifier operational parameters";
      leaf actual-gain {
        type decimal64 {
          fraction-digits 2;
        }
        units dB ;
        mandatory true ;
        description "..";
      }
      leaf tilt-target {
        type decimal64 {
          fraction-digits 2;
        }
        mandatory true ;
        description "..";
      }
      leaf out-voa {
        type decimal64 {
          fraction-digits 2;
        }
      }
    }
  }
}
```

```

        units dB;
    mandatory true;
    description "..";
}
leaf in-voa {
    type decimal64 {
        fraction-digits 2;
    }
    units dB;
    mandatory true;
    description "..";
}
uses power-param;
}
}

grouping fiber-params {
    description "String identifier of fiber type referencing a specification in
a
separate equipment catalog";
    container fiber {
        description "fiber characteristics";
        leaf type_variety {
            type string ;
            mandatory true ;
            description "fiber type";
        }
        leaf length {
            type decimal64 {
                fraction-digits 2;
            }
            units km;
            mandatory true ;
            description "length of fiber";
        }
        leaf loss_coef {
            type decimal64 {
                fraction-digits 2;
            }
            units dB/km;
            mandatory true ;
            description "loss coefficient of the fiber";
        }
        leaf total_loss {
            type decimal64 {
                fraction-digits 2;
            }
            units dB;
            mandatory true ;

```

```
        description
            "includes all losses: fiber loss and conn_in and conn_out losses";
    }
    leaf pmd{
        type decimal64 {
            fraction-digits 2;
        }
        units sqrt(ps);
        description "pmd of the fiber";
    }
    leaf conn_in{
        type decimal64 {
            fraction-digits 2;
        }
        units dB;
        description "connector-in";
    }
    leaf conn_out{
        type decimal64 {
            fraction-digits 2;
        }
        units dB;
        description "connector-out";
    }
}

grouping roadm-params{
    description "roadm parameters description";
    container roadm{
        description "roadm parameters";
        leaf type_variety {
            type string ;
            mandatory true ;
            description "String identifier of roadm type referencing a specification
in a
separate equipment catalog";
        }
        leaf loss {
            type decimal64 {
                fraction-digits 2;
            }
            units dB ;
            description "..";
        }
    }
}

grouping concentratedloss-params{
    description "concentrated loss";
```



```

    container concentratedloss{
    description "concentrated loss";
    leaf loss {
        type decimal64 {
            fraction-digits 2;
        }
        units dB ;
        description "..";
    }
    }
}

grouping power-param{
    description
        "optical power or PSD after the ROADM or after the out-voa";
    choice power-param {
        description
            "select the mode: channel power or power spectral density";
        case channel-power {
/*
            when "equalization-mode='channel-power'"; */
            leaf nominal-channel-power{
                type decimal64 {
                    fraction-digits 1;
                }
                units dBm ;
                description
                    " Reference channel power after the ROADM or after the out-voa. ";
            }
        }
        case power-spectral-density{
/*
            when "equalization-mode='power-spectral-density'"; */
            leaf nominal-power-spectral-density{
                type decimal64 {
                    fraction-digits 16;
                }
                units W/Hz ;
                description
                    " Reference power spectral density after the ROADM or after the out-
voa.
                    Typical value : 3.9 E-14, resolution 0.1nW/MHz";
            }
        }
    }
}

grouping oms-general-optical-params {
    description "OMS link optical parameters";
    leaf generalized-snr {
        type decimal64 {
            fraction-digits 5;

```

```
    }
    units "dB@0.1nm";
    description "generalized snr";
  }
  leaf equalization-mode{
    type identityref {
      base type-power-mode;
    }
    mandatory true;
    description "equalization mode";
  }
  uses power-param;
}

grouping OTSiG {
  description "OTSiG definition , representing client digital information stream
supported by 1 or more OTSi";

  container OTSiG-container {
    config false;
    description
      "the container contains the related list of OTSi.
      The list could also be of only 1 element";
    list OTSi {
      key "OTSi-carrier-id";
      description
        "list of OTSi's under OTSi-G";
      leaf OTSi-carrier-id {
        type int16;
        description "OTSi carrier-id";
      }
      leaf OTSi-carrier-frequency {
        type decimal64 {
          fraction-digits 3;
        }
        units GHz;
        config false;
        description
          "OTSi carrier frequency";
      }
      leaf OTSi-signal-width {
        type decimal64 {
          fraction-digits 3;
        }
        units GHz;
        config false;
        description
          "OTSi signal width";
      }
    }
  }
}
```

```

    leaf channel-delta-power {
        type decimal64 {
            fraction-digits 2;
        }
        units dB;
        config false;
        description
            "optional ; delta power to ref channel input-power applied
            to this media channel";
    }

}
} // OTSiG container
} // OTSiG grouping

grouping media-channel-groups {
    description "media channel groups";
    list media-channel-group {
        key "i";
        description
            "list of media channel groups";
        leaf i {
            type int16;
            description "index of media channel group member";
        }
    }

    list media-channels {
        key "flexi-n";
        description
            "list of media channels represented as (n,m)";
        uses layer0-types:flexi-grid-channel;
        leaf OTSiG-ref {
            type leafref {
                path "/nw:networks/nw:network/nw:node/tet:te" +
                    "/tet:tunnel-termination-point/OTSiG-element/OTSiG-identifier" ;
            }
            description
                "Reference to the OTSiG list to get OTSiG identifier of the
                OSiG carried by this media channel that reports the transient stat
";
        }
        leaf OTSi-ref {
            type leafref {
                path "/nw:networks/nw:network/nw:node/tet:te" +
                    "/tet:tunnel-termination-point/OTSiG-element[OTSiG-
identifier=current()/../OTSiG-ref]/"+
                    "OTSiG-container/OTSi/OTSi-carrier-id" ;
            }
            description

```

```

        "Reference to the OTSi list supporting the related OTSiG" ;
    }

    } // media channels list
  } // media-channel-groups list
} // media media-channel-groups grouping

grouping oms-element {
  description "OMS description";
  list OMS-elements {
    key "elt-index";
    description
      "defines the spans and the amplifier blocks of the amplified lines";
    leaf elt-index {
      type uint16;
      description
        "ordered list of Index of OMS element (whether it's a Fiber, an EDFA
or a
Concentratedloss)";
    }
    leaf uid {
      type string;
      description
        "unique id of the element if it exists";
    }
    leaf type {
      type identityref {
        base type-element;
      }
    }
    mandatory true;
    description "element type";
  }

  container element {
    description "element of the list of elements of the OMS";
    choice element {
      description "OMS element type";
      case amplifier {
/*          when "type = 'Edfa'"; */
          uses amplifier-params ;
      }
      case fiber {
/*          when "type = 'Fiber'"; */
          uses fiber-params ;
      }
      case concentratedloss {
/*          when "type = 'Concentratedloss'"; */
          uses concentratedloss-params ;
      }
    }
  }
}

```

```
    }
  }
}

/* Data nodes */

augment "/nw:networks/nw:network/nw:network-types"
+ "/tet:te-topology" {
  description "optical-impairment topology augmented";
  container optical-impairment-topology {
    presence "indicates an impairment-aware topology of optical networks";
    description
      "Container to identify impairment-aware topology type";
  }
}

augment "/nw:networks/nw:network/nt:link/tet:te"
+ "/tet:te-link-attributes" {
  when "/nw:networks/nw:network/nw:network-types"
  + "/tet:te-topology/optical-imp-topo:optical-impairment-topology" {
    description
      "This augment is only valid for Optical Impairment.";
  }
  description "Optical Link augmentation for impairment data.";
  container OMS-attributes {
    config false;
    description "OMS attributes";
    uses oms-general-optical-params;
    uses media-channel-groups;
    uses oms-element;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te"
+ "/tet:tunnel-termination-point" {
  when "/nw:networks/nw:network/nw:network-types"
  + "/tet:te-topology/optical-imp-topo:optical-impairment-topology" {
    description
      "This augment is only valid for Impairment with non-sliceable
      transponder model";
  }
  description
    "Tunnel termination point augmentation for non-sliceable
    transponder model.";

  list OTSiG-element {
    key "OTSiG-identifier";
    config false;
  }
}
```

```
    description
    "the list of possible OTSiG representing client digital stream";

    leaf OTSiG-identifier {
        type int16;
        description "index of OTSiG element";
    }
    uses OTSiG;
}

list transponders-list {
    key "transponder-id";
    config false;
    description "list of transponders";
    leaf transponder-id {
        type uint32;
        description "transponder identifier";
    }

    choice mode {
        description "standard mode, organizational mode or explicit mode";

        case G.692.2 {
            uses standard_mode;
        }

        case organizational_mode {
            uses organizational_mode;
        }

        case explicit_mode {
            uses transponder-attributes;
        }
    }

    leaf power {
        type int32;
        units "dBm";
        config false;
        description "per channel power";
    }

    leaf power-min {
        type int32;
        units "dBm";
        config false;
        description "minimum power of the transponder";
    }
}
```

```
        leaf power-max {
            type int32;
            units "dBm";
            config false;
            description "maximum power of the transponder";
        }
    }
}

augment "/nw:networks/nw:network/nw:node/tet:te"
+ "/tet:tunnel-termination-point" {
    when "/nw:networks/nw:network/nw:network-types"
    + "/tet:te-topology/optical-imp-topo:optical-impairment-topology" {
        description
            "This augment is only valid for optical impairment with sliceable
            transponder model";
    }
    description
        "Tunnel termination point augmentation for sliceable transponder model.";
    uses sliceable-transponder-attributes;
}
}
<CODE ENDS>
```

5. Security Considerations

The configuration, state, and action data defined in this document are designed to be accessed via a management protocol with a secure transport layer, such as NETCONF [RFC6241]. The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF users to a preconfigured subset of all available NETCONF protocol operations and content.

A number of configuration data nodes defined in this document are read-only; however, these data nodes may be considered sensitive or vulnerable in some network environments (TBD).

6. IANA Considerations

This document registers the following namespace URIs in the IETF XML registry [RFC3688]:

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

This document registers the following YANG modules in the YANG
Module Names registry [RFC7950]:

name: ietf-optical-impairment-topology
namespace: urn:ietf:params:xml:ns:yang:ietf-optical-impairment-
 topology
prefix: optical-imp-topo
reference: RFC XXXX (TDB)

7. Acknowledgments

We thank Daniele Ceccarelli and Oscar G. De Dios for useful
discussions and motivation for this work.

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9. Contributors

Jonas Martensson
RISE

Email: jonas.martensson@ri.se

Aihua Guo
Huawei Technologies

Email: aguo@futurewei.com

Authors' Addresses

Young Lee
SKKU (Sung Kyun Kwan University)

Email: younglee.tx@gmail.com

Haomian Zheng
Huawei Technologies

Email: zhenghaomian@huawei.com

Italo Busi
Huawei Technologies

Email: Italo.Busi@huawei.com

Nicola Sambo
Scuola Superiore Sant'Anna

Email: nicosambo@gmail.com

Victor Lopez
Telefonica

Email: victor.lopezalvarez@telefonica.com

G. Galimberti
Cisco

Email: ggalimbe@cisco.com

Giovanni Martinelli
Cisco
Email: giomarti@cisco.com

Jean Luc Auge
Orange

Email: jeanluc.auge@orange.com

Esther Le Rouzic
Orange

Email: esther.lerouzic@orange.com

Julien Meuric
Orange

Email: julien.meuric@orange.com

Dieter Beller
Nokia

Email: dieter.beller@nokia.com

Sergio Belotti
Nokia

Email: Sergio.belotti@nokia.com

Griseri Enrico
Nokia

Email: enrico.griseri@nokia.com

Gert Grammel
Juniper

Email: ggrammel@juniper.net

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H. Zheng
I. Busi
Huawei Technologies
X. Liu
Volta Networks
S. Belotti
Nokia
O. Gonzalez de Dios
Telefonica
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A YANG Data Model for Optical Transport Network Topology
draft-ietf-ccamp-otn-topo-yang-09

Abstract

This document describes a YANG data model to describe the topologies of an Optical Transport Network (OTN). It is independent of control plane protocols and captures topological and resource related information pertaining to OTN. This model enables clients, which interact with a transport domain controller, for OTN topology related operations such as obtaining the relevant topology resource information.

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 [RFC2119].

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Table of Contents

1. Introduction	2
2. Terminology and Notations	3
3. YANG Data Model for OTN Topology	4
3.1. OTN Topology Data Model Overview	4
3.2. YANG Tree for OTN topology	5
4. The YANG Code	26
5. IANA Considerations	64
6. Security Considerations	64
7. Acknowledgements	65
8. Contributors	65
9. References	66
9.1. Normative References	66
9.2. Informative References	68
Authors' Addresses	69

1. Introduction

A transport network is a server-layer network designed to provide connectivity services for a client-layer network to carry the client traffic transparently across the server-layer network resources. A transport network can be constructed of equipments utilizing any of a number of different transport technologies such as the Optical Transport Networks (OTN) or packet transport such as provided by the MPLS-Transport Profile (MPLS-TP).

This document defines a data model of an OTN network topology, using YANG [RFC7950]. The model can be used by an application exposing to a transport controller. Furthermore, it can be used by an application for the following purposes (but not limited to):

- o To obtain a whole view of the network topology information of its interest;
- o To receive notifications with regard to the information change of the OTN topology;
- o To enforce the establishment and update of a network topology with the characteristic specified in the data model, e.g., by a client controller;

The YANG model defined in this document is independent of control plane protocols and captures topology related information pertaining to an Optical Transport Networks (OTN) electrical layer, as the scope specified by [RFC7062] and [RFC7138]. Furthermore, it is not a stand-alone model, but augmenting from the TE topology YANG model defined in [I-D.ietf-teas-yang-te-topo]. Following TE topology YANG model, the YANG model defined in this document is interface independent. The model is included in [I-D.ietf-teas-actn-yang], which indicates the typical usage of IETF YANG models in ACTN architecture specified by [RFC8453]. More specifically, the usage of this model between transport controllers is described in [I-D.ietf-ccamp-transport-nbi-app-statement].

Optical network technologies, including fixed Dense Wavelength Switched Optical Network (WSON) and flexible optical networks (a.k.a., flexi-grid networks), are covered in [I-D.ietf-ccamp-wson-yang] and [I-D.ietf-ccamp-flexigrid-yang], respectively.

2. Terminology and Notations

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in the YANG data tree presented later in this document is defined in [RFC8340]. They are provided below for reference.

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write) and "ro" state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.
- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").

- o Ellipsis ("...") stands for contents of subtrees that are not shown.
- o Some of the key terms used in this document are listed as follow.
- o TS: Tributary Slot.
- o TSG: Tributary Slot Granularity.
- o TPN: Tributary Port Number.

3. YANG Data Model for OTN Topology

3.1. OTN Topology Data Model Overview

This document aims to describe the data model for OTN topology. As a classic Traffic-engineering (TE) technology, OTN provide TDM switching in transport network [ITU-T]. Therefore the YANG module presented in this document augments from a more generic Traffic Engineered (TE) network topology data model, i.e., the `ietf-te-topology.yang`, as specified in [I-D.ietf-teas-yang-te-topo]. In section 6 of [I-D.ietf-teas-yang-te-topo], the guideline for augmenting TE topology model was provided, and in this draft we respectively augment the OTN attributes, TE bandwidth and TE label. [RFC8345] should also be mentioned, which describe a network topology model and provide the fundamental model for [I-D.ietf-teas-yang-te-topo]. However, this work is not directly augmenting [RFC8345].

The entities and TE attributes, such as node, termination points and links, are still applicable for describing an OTN topology and the model presented in this document only specifies with technology-specific attributes/information. In OTN attributes augmentation, mainly OTN-specific parameters are included such as Tributary Slot Granularity (TSG), payload type and so on.

For different order of ODU in OTN technology, the `te-bandwidth` is augmented to allow specifying the type of ODU container and the number a link can support per priority level. For example, for a ODU3 link, it may advertise 32*ODU0, 16*ODU1, 4*ODU2 available, assuming only a single priority level is supported. If one of ODU2 resource is taken to establish a ODU path, then the availability of this ODU link is updated as 24*ODU0, 12*ODU1, 3*ODU2 available. If there are equipment hardware limitations, then a subset of potential ODU type SHALL be advertised. For instance, an ODU3 link may only support 4*ODU2.

The types of OTN label can be divided into the tributary ports and the tributary slots, represented by TPN or TS list respectively. In the TE-label augmentation, two optional label formats are available for label representation. It is also worth noting that for the parameter "label-step" in TE topology models, the value is always set to 1 as the granularity of OTN resources is measured by 'tributary slot'. In this model we specify the 'otn-label-step', which is used to align with TE topology only.

Note the model in this document re-uses some attributes defined in `ietf-otn-types.yang`, which is specified in [I-D.ietf-ccamp-otn-tunnel-model].

The YANG module `ietf-otn-topology` defined in this document conforms to the Network Management Datastore Architecture (NMDA) defined in [RFC8342].

3.2. YANG Tree for OTN topology

```
module: ietf-otn-topology
  augment /nw:networks/nw:network/nw:network-types
    /tet:te-topology:
      +--rw otn-topology!
  augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes:
      +--rw tsg?          identityref
      +--rw distance?    uint32
  augment /nw:networks/nw:network/nw:node
    /nt:termination-point/tet:te:
      +--rw client-svc!
      +--rw client-facing?          boolean
      +--rw supported-client-signal* identityref
  augment /nw:networks/nw:network/nw:node
    /nt:termination-point/tet:te
      /tet:interface-switching-capability
      /tet:max-lsp-bandwidth/tet:te-bandwidth
      /tet:technology:
      +--:(otn)
      +--rw odu-type?  identityref
  augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
    +--:(otn)
    +--rw odulist* [odu-type]
      +--rw odu-type  identityref
      +--rw number?   uint16
```

```

augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:path-constraints
  /tet:te-bandwidth/tet:technology:
+--:(otn)
  +--rw odulist* [odu-type]
    +--rw odu-type      identityref
    +--rw number?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices/tet:path-constraints
  /tet:te-bandwidth/tet:technology:
+--:(otn)
  +--ro odulist* [odu-type]
    +--ro odu-type      identityref
    +--ro number?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:path-constraints
  /tet:te-bandwidth/tet:technology:
+--:(otn)
  +--ro odulist* [odu-type]
    +--ro odu-type      identityref
    +--ro number?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:client-layer-adaptation
  /tet:switching-capability/tet:te-bandwidth
  /tet:technology:
+--:(otn)
  +--rw odulist* [odu-type]
    +--rw odu-type      identityref
    +--rw number?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities
  /tet:path-constraints/tet:te-bandwidth
  /tet:technology:
+--:(otn)
  +--rw odulist* [odu-type]
    +--rw odu-type      identityref
    +--rw number?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities
  /tet:local-link-connectivity

```

```

        /tet:path-constraints/tet:te-bandwidth
        /tet:technology:
+---:(otn)
    +--rw odulist* [odu-type]
        +--rw odu-type    identityref
        +--rw number?     uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +--rw odu-type?    identityref
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:max-link-bandwidth
    /tet:te-bandwidth/tet:technology:
+---:(otn)
    +--rw odulist* [odu-type]
        +--rw odu-type    identityref
        +--rw number?     uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes
    /tet:max-resv-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +--rw odulist* [odu-type]
        +--rw odu-type    identityref
        +--rw number?     uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:unreserved-bandwidth
    /tet:te-bandwidth/tet:technology:
+---:(otn)
    +--rw odulist* [odu-type]
        +--rw odu-type    identityref
        +--rw number?     uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +--ro odu-type?    identityref
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:max-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +--ro odulist* [odu-type]

```

```

        +---ro odu-type      identityref
        +---ro number?      uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:max-resv-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +---ro odulist* [odu-type]
    +---ro odu-type      identityref
    +---ro number?      uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:unreserved-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +---ro odulist* [odu-type]
    +---ro odu-type      identityref
    +---ro number?      uint16
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +---rw odu-type?      identityref
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:max-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +---rw odulist* [odu-type]
    +---rw odu-type      identityref
    +---rw number?      uint16
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:max-resv-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +---rw odulist* [odu-type]
    +---rw odu-type      identityref
    +---rw number?      uint16
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:unreserved-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(otn)
    +---rw odulist* [odu-type]
    +---rw odu-type      identityref

```

```

        +---rw number?          uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction:
+---rw range-type?            identityref
+---rw tsg?                   identityref
+---rw odu-type-list*         identityref
+---rw priority?              uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?          uint16
    +---:(tributary-slot)
    |   +---rw ts?           uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?          uint16
    +---:(tributary-slot)
    |   +---rw ts?           uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?          uint16
    +---:(tributary-slot)
    |   +---rw ts?           uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:

```

```

+---:(otn)
  +---rw tpn?          uint16
  +---rw tsg?          identityref
  +---rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices/tet:underlay
  /tet:backup-path/tet:path-element/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(otn)
  +---rw tpn?          uint16
  +---rw tsg?          identityref
  +---rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-exclude-objects
  /tet:route-object-exclude-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(otn)
  +---rw tpn?          uint16
  +---rw tsg?          identityref
  +---rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-include-objects
  /tet:route-object-include-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(otn)
  +---rw tpn?          uint16
  +---rw tsg?          identityref
  +---rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices/tet:path-properties
  /tet:path-route-objects/tet:path-route-object
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(otn)
  +---ro tpn?          uint16

```



```

    +--ro tsg?          identityref
    +--ro ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:from
    /tet:label-restrictions/tet:label-restriction:
+--rw range-type?      identityref
+--rw tsg?             identityref
+--rw odu-type-list*   identityref
+--rw priority?        uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:from
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?      uint16
    +--:(tributary-slot)
    |   +--rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:from
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?      uint16
    +--:(tributary-slot)
    |   +--rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:from
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?      uint16
    +--:(tributary-slot)
    |   +--rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te

```

```

        /tet:te-node-attributes
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:to
        /tet:label-restrictions/tet:label-restriction:
+--rw range-type?      identityref
+--rw tsg?             identityref
+--rw odu-type-list*   identityref
+--rw priority?        uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?      uint16
    +--:(tributary-slot)
    |   +--rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?      uint16
    +--:(tributary-slot)
    |   +--rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?      uint16
    +--:(tributary-slot)
    |   +--rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:underlay

```

```

        /tet:primary-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---:(otn)
  +--rw tpn?          uint16
  +--rw tsg?          identityref
  +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:underlay
  /tet:backup-path/tet:path-element/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(otn)
  +--rw tpn?          uint16
  +--rw tsg?          identityref
  +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-exclude-objects
  /tet:route-object-exclude-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(otn)
  +--rw tpn?          uint16
  +--rw tsg?          identityref
  +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-include-objects
  /tet:route-object-include-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(otn)
  +--rw tpn?          uint16
  +--rw tsg?          identityref
  +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes

```

```

        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:path-properties
        /tet:path-route-objects/tet:path-route-object
        /tet:type/tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(otn)
        +--ro tpn?          uint16
        +--ro tsg?          identityref
        +--ro ts-list?      string
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction:
    +--ro range-type?      identityref
    +--ro tsg?              identityref
    +--ro odu-type-list*    identityref
    +--ro priority?         uint8
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction
        /tet:label-start/tet:te-label/tet:technology:
    +---:(otn)
        +--ro (otn-label-type)?
        +---:(tributary-port)
            | +--ro tpn?      uint16
        +---:(tributary-slot)
            +--ro ts?        uint16
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction
        /tet:label-end/tet:te-label/tet:technology:
    +---:(otn)
        +--ro (otn-label-type)?
        +---:(tributary-port)
            | +--ro tpn?      uint16
        +---:(tributary-slot)
            +--ro ts?        uint16
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction
        /tet:label-step/tet:technology:
    +---:(otn)
        +--ro (otn-label-type)?
        +---:(tributary-port)
            | +--ro tpn?      uint16

```

```

    +---:(tributary-slot)
        +---ro ts?      uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---ro tpn?        uint16
    +---ro tsg?        identityref
    +---ro ts-list?    string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---ro tpn?        uint16
    +---ro tsg?        identityref
    +---ro ts-list?    string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---ro tpn?        uint16
    +---ro tsg?        identityref
    +---ro ts-list?    string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---ro tpn?        uint16
    +---ro tsg?        identityref
    +---ro ts-list?    string

```

```

augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices/tet:path-properties
  /tet:path-route-objects/tet:path-route-object
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(otn)
  +--ro tpn?          uint16
  +--ro tsg?          identityref
  +--ro ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction:
+--ro range-type?      identityref
+--ro tsg?              identityref
+--ro odu-type-list*    identityref
+--ro priority?         uint8
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+--:(otn)
  +--ro (otn-label-type)?
  +--:(tributary-port)
  |   +--ro tpn?      uint16
  +--:(tributary-slot)
  |   +--ro ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+--:(otn)
  +--ro (otn-label-type)?
  +--:(tributary-port)
  |   +--ro tpn?      uint16
  +--:(tributary-slot)
  |   +--ro ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction

```

```

        /tet:label-step/tet:technology:
+---: (otn)
    +---ro (otn-label-type)?
        +---: (tributary-port)
            | +---ro tpn?    uint16
        +---: (tributary-slot)
            +---ro ts?      uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction:
+---ro range-type?          identityref
+---ro tsg?                  identityref
+---ro odu-type-list*       identityref
+---ro priority?            uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---: (otn)
    +---ro (otn-label-type)?
        +---: (tributary-port)
            | +---ro tpn?    uint16
        +---: (tributary-slot)
            +---ro ts?      uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---: (otn)
    +---ro (otn-label-type)?
        +---: (tributary-port)
            | +---ro tpn?    uint16
        +---: (tributary-slot)
            +---ro ts?      uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---: (otn)
    +---ro (otn-label-type)?

```

```

    +---:(tributary-port)
    |   +---ro tpn?      uint16
    +---:(tributary-slot)
        +---ro ts?      uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---ro tpn?          uint16
    +---ro tsg?          identityref
    +---ro ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---ro tpn?          uint16
    +---ro tsg?          identityref
    +---ro ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---ro tpn?          uint16
    +---ro tsg?          identityref
    +---ro ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type

```



```

        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---:(otn)
    +--ro tpn?          uint16
    +--ro tsg?          identityref
    +--ro ts-list?     string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:path-properties
    /tet:path-route-objects/tet:path-route-object
    /tet:type/tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +--ro tpn?          uint16
    +--ro tsg?          identityref
    +--ro ts-list?     string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:label-restrictions/tet:label-restriction:
+---rw range-type?     identityref
+---rw tsg?            identityref
+---rw odu-type-list*  identityref
+---rw priority?       uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?      uint16
    +---:(tributary-slot)
    |   +---rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?      uint16
    +---:(tributary-slot)
    |   +---rw ts?       uint16
augment /nw:networks/nw:network/nw:node/tet:te

```

```

        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction
        /tet:label-step/tet:technology:
+---:(otn)
+---rw (otn-label-type)?
+---:(tributary-port)
|   +---rw tpn?      uint16
+---:(tributary-slot)
+---rw ts?          uint16
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities/tet:underlay
        /tet:primary-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---:(otn)
+---rw tpn?          uint16
+---rw tsg?          identityref
+---rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities/tet:underlay
        /tet:backup-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---:(otn)
+---rw tpn?          uint16
+---rw tsg?          identityref
+---rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities/tet:optimizations
        /tet:algorithm/tet:metric
        /tet:optimization-metric
        /tet:explicit-route-exclude-objects
        /tet:route-object-exclude-object/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---:(otn)
+---rw tpn?          uint16
+---rw tsg?          identityref
+---rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities/tet:optimizations
        /tet:algorithm/tet:metric
        /tet:optimization-metric

```

```

        /tet:explicit-route-include-objects
        /tet:route-object-include-object/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---:(otn)
  +--rw tpn?          uint16
  +--rw tsg?          identityref
  +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities
  /tet:path-properties/tet:path-route-objects
  /tet:path-route-object/tet:type/tet:label
  /tet:label-hop/tet:te-label/tet:technology:
+---:(otn)
  +--ro tpn?          uint16
  +--ro tsg?          identityref
  +--ro ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities
  /tet:local-link-connectivity
  /tet:label-restrictions/tet:label-restriction:
+---rw range-type?    identityref
+---rw tsg?           identityref
+---rw odu-type-list* identityref
+---rw priority?      uint8
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities
  /tet:local-link-connectivity
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+---:(otn)
  +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?      uint16
    +---:(tributary-slot)
    +---rw ts?          uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities
  /tet:local-link-connectivity
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+---:(otn)
  +---rw (otn-label-type)?
    +---:(tributary-port)

```

```

        |   +--rw tpn?    uint16
    +---:(tributary-slot)
        +--rw ts?      uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(otn)
    +--rw (otn-label-type)?
    +---:(tributary-port)
        |   +--rw tpn?    uint16
    +---:(tributary-slot)
        +--rw ts?      uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +--rw tpn?          uint16
    +--rw ts?           identityref
    +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +--rw tpn?          uint16
    +--rw ts?           identityref
    +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)

```

```

    +--rw tpn?          uint16
    +--rw tsg?          identityref
    +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(otn)
    +--rw tpn?          uint16
    +--rw tsg?          identityref
    +--rw ts-list?      string
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:path-properties
    /tet:path-route-objects/tet:path-route-object
    /tet:type/tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(otn)
    +--ro tpn?          uint16
    +--ro tsg?          identityref
    +--ro ts-list?      string
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(otn)
    +--rw tpn?          uint16
    +--rw tsg?          identityref
    +--rw ts-list?      string
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(otn)
    +--rw tpn?          uint16
    +--rw tsg?          identityref
    +--rw ts-list?      string
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions

```

```

        /tet:label-restriction:
+---rw range-type?          identityref
+---rw tsg?                 identityref
+---rw odu-type-list*       identityref
+---rw priority?           uint8
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions
    /tet:label-restriction/tet:label-start
    /tet:te-label/tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?         uint16
    +---:(tributary-slot)
    +---rw ts?             uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions
    /tet:label-restriction/tet:label-end
    /tet:te-label/tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?         uint16
    +---:(tributary-slot)
    +---rw ts?             uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions
    /tet:label-restriction/tet:label-step
    /tet:technology:
+---:(otn)
    +---rw (otn-label-type)?
    +---:(tributary-port)
    |   +---rw tpn?         uint16
    +---:(tributary-slot)
    +---rw ts?             uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:label-restrictions/tet:label-restriction:
+---ro range-type?          identityref
+---ro tsg?                 identityref
+---ro odu-type-list*       identityref
+---ro priority?           uint8
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(otn)
    +---ro (otn-label-type)?

```

```

    +---:(tributary-port)
    |   +---ro tpn?    uint16
    +---:(tributary-slot)
        +---ro ts?    uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(otn)
    +---ro (otn-label-type)?
    +---:(tributary-port)
    |   +---ro tpn?    uint16
    +---:(tributary-slot)
        +---ro ts?    uint16
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(otn)
    +---ro (otn-label-type)?
    +---:(tributary-port)
    |   +---ro tpn?    uint16
    +---:(tributary-slot)
        +---ro ts?    uint16
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:underlay/tet:primary-path/tet:path-element
    /tet:type/tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---rw tpn?        uint16
    +---rw tsg?        identityref
    +---rw ts-list?    string
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:underlay/tet:backup-path/tet:path-element
    /tet:type/tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(otn)
    +---rw tpn?        uint16
    +---rw tsg?        identityref
    +---rw ts-list?    string
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction:
+---rw range-type?    identityref
+---rw tsg?            identityref
+---rw odu-type-list*  identityref

```

```

    +--rw priority?          uint8
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?          uint16
    +--:(tributary-slot)
    |   +--rw ts?           uint16
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?          uint16
    +--:(tributary-slot)
    |   +--rw ts?           uint16
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+--:(otn)
    +--rw (otn-label-type)?
    +--:(tributary-port)
    |   +--rw tpn?          uint16
    +--:(tributary-slot)
    |   +--rw ts?           uint16

```

4. The YANG Code

```

<CODE BEGINS> file "ietf-otn-topology@2019-11-02.yang"
module ietf-otn-topology {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-otn-topology";
  prefix "otntopo";

  import ietf-network {
    prefix "nw";
    reference "RFC 8345: A YANG Data Model for Network Topologies";

```



```
}

import ietf-network-topology {
  prefix "nt";
  reference "RFC 8345: A YANG Data Model for Network Topologies";
}

import ietf-te-topology {
  prefix "tet";
  reference
    "I-D.ietf-teas-yang-te-topo: YANG Data Model for
    Traffic Engineering (TE) Topologies";
}

import ietf-layer1-types {
  prefix "layer1-types";
  reference
    "I-D.ietf-ccamp-layer1-types: A YANG Data Model
    for Layer 1 Types";
}

organization
  "IETF CCAMP Working Group";
contact
  "WG Web: <http://tools.ietf.org/wg/ccamp/>
  WG List: <mailto:ccamp@ietf.org>

  Editor: Haomian Zheng
        <mailto:zhenghaomian@huawei.com>

  Editor: Italo Busi
        <mailto:italo.busi@huawei.com>

  Editor: Xufeng Liu
        <mailto:xufeng.liu.ietf@gmail.com>

  Editor: Sergio Belotti
        <mailto:sergio.belotti@nokia.com>

  Editor: Oscar Gonzalez de Dios
        <mailto:oscar.gonzalezdedios@telefonica.com>";

description
  "This module defines a protocol independent Layer 1/ODU topology
  data model. The model fully conforms
  to the Network Management Datastore Architecture (NMDA).

  Copyright (c) 2019 IETF Trust and the persons
```

identified as authors of the code. All rights reserved.

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

```
revision 2019-11-02 {
  description
    "Initial Revision";
  reference
    "RFC XXXX: A YANG Data Model for Optical Transport Network
    Topology";
  // RFC Ed.: replace XXXX with actual RFC number, update date
  // information and remove this note
}

/*
 * Groupings
 */

grouping otn-link-attributes {
  description "link attributes for OTN";

  leaf tsg {
    type identityref {
      base layer1-types:tributary-slot-granularity;
    }
    description "Tributary slot granularity.";
    reference
      "G.709/Y.1331, February 2016: Interfaces for the
      Optical Transport Network (OTN)";
  }
  leaf distance {
    type uint32;
    description "distance in the unit of kilometers";
  }
}

grouping otn-tp-attributes {
  description "tp attributes for OTN";

  container client-svc {
    presence "client-facing LTP.";
```

```
    description
      "OTN LTP Service attributes.";

    leaf client-facing {
      type boolean;
      default 'false';
      description
        "Indicates whether this LTP is a client-facing LTP.";
    }
    leaf-list supported-client-signal {
      type identityref {
        base layer1-types:client-signal;
      }
      description
        "List of client signal types supported by the LTP.";
    }
  }
}

/*
 * Data nodes
 */
augment "/nw:networks/nw:network/nw:network-types/"
  + "tet:te-topology" {
  container otn-topology {
    presence "indicates a topology type of Optical Transport
      Network (OTN)-electrical layer.";
    description "otn topology type";
  }
  description "augment network types to include otn network";
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment only for otn network.";
  }
  description "Augment link configuration";
  uses otn-link-attributes;
}

augment "/nw:networks/nw:network/nw:node/nt:termination-point/"
  + "tet:te" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment only for otn network";
  }
}
```

```

    description "OTN TP attributes config in ODU topology.";
    uses otn-tp-attributes;
}

/*
 * Augment TE bandwidth
 */

/* Augment maximum LSP bandwidth of link terminationpoint (LTP) */
augment "/nw:networks/nw:network/nw:node/nt:termination-point/"
    + "tet:te/"
    + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE bandwidth";
    }
    description "OTN bandwidth.";
    case otn {
        uses layer1-types:otn-path-bandwidth;
    }
}

/* Augment bandwidth path constraints of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE bandwidth";
    }
    description "OTN bandwidth.";
    case otn {
        uses layer1-types:otn-link-bandwidth;
    }
}

/* Augment bandwidth path constraints of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE bandwidth";
    }
    description "OTN bandwidth.";
    case otn {
        uses layer1-types:otn-link-bandwidth;
    }
}

```

```

    }
  }

/* Augment bandwidth path constraints of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
  + "otntopo:otn-topology" {
    description "Augment OTN TE bandwidth";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment bandwidth path constraints of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
  + "otntopo:otn-topology" {
    description "Augment OTN TE bandwidth";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment client bandwidth of tunnel termination point (TTP) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:client-layer-adaptation/tet:switching-capability/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
  + "otntopo:otn-topology" {
    description "Augment OTN TE bandwidth";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

```

```
/* Augment bandwidth path constraints of
 * local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/tet:path-constraints/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE bandwidth";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment bandwidth path constraints of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/tet:path-constraints/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE bandwidth";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment maximum LSP bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "OTN TE bandwidth.";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-path-bandwidth;
  }
}
```

```
/* Augment maximum bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "OTN TE bandwidth.";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment maximum reservable bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-resv-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "OTN TE bandwidth.";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment unreserved bandwidth of TE Link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:unreserved-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "OTN TE bandwidth.";
  }
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment maximum LSP bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:interface-switching-capability/"
```

```

    + "tet:max-lsp-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "OTN TE bandwidth.";
    }
description "OTN bandwidth.";
case otn {
    uses layer1-types:otn-path-bandwidth;
}
}

/* Augment maximum bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:max-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "OTN TE bandwidth.";
    }
description "OTN bandwidth.";
case otn {
    uses layer1-types:otn-link-bandwidth;
}
}

/*Augment maximum reservable BW of TE link information-source*/
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:max-resv-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "OTN TE bandwidth.";
    }
description "OTN bandwidth.";
case otn {
    uses layer1-types:otn-link-bandwidth;
}
}

/* Augment unreserved bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:unreserved-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../..../..../nw:network-types/tet:te-topology/"

```



```
        + "otntopo:otn-topology" {
          description "OTN TE bandwidth.";
        }
      description "OTN bandwidth.";
      case otn {
        uses layer1-types:otn-link-bandwidth;
      }
    }

/* Augment maximum LSP bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:interface-switching-capability/"
  + "tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
/*
  when "../..//../..//../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
      description "OTN TE bandwidth.";
    }
*/
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-path-bandwidth;
  }
}

/* Augment maximum bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:max-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
/*
  when "../..//../..//../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
      description "OTN TE bandwidth.";
    }
*/
  description "OTN bandwidth.";
  case otn {
    uses layer1-types:otn-link-bandwidth;
  }
}

/* Augment maximum reservable bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:max-resv-link-bandwidth/"
```

```

        + "tet:te-bandwidth/tet:technology" {
/*
    when "../../../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "OTN TE bandwidth.";
    }
*/
    description "OTN bandwidth.";
    case otn {
        uses layer1-types:otn-link-bandwidth;
    }
}

/* Augment unreserved bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:unreserved-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
/*
    when "../../../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "OTN TE bandwidth.";
    }
*/
    description "OTN bandwidth.";
    case otn {
        uses layer1-types:otn-link-bandwidth;
    }
}

/*
* Augment TE label.
*/

/* Augment label restrictions of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:label-restrictions/tet:label-restriction" {
    when "../../../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description
        "OTN label restriction, represented by otn-label-range-info.";
    uses layer1-types:otn-label-range-info;
}

/* Augment label restrictions start of connectivity-matrices */

```

```

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
when "../..//../..//../..//../..//nw:network-types/tet:te-topology/"
  + "otntopo:otn-topology" {
  description "Augment OTN TE label";
}
description "OTN label.";
case otn {
  uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions end of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-end/"
  + "tet:te-label/tet:technology" {
when "../..//../..//../..//../..//nw:network-types/tet:te-topology/"
  + "otntopo:otn-topology" {
  description "Augment OTN TE label";
}
description "OTN label.";
case otn {
  uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions step of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
when "../..//../..//../..//../..//nw:network-types/tet:te-topology/"
  + "otntopo:otn-topology" {
  description "Augment OTN TE label";
}
description "OTN label.";
case otn {
  uses layer1-types:otn-label-step;
}
}

/* Augment label hop of underlay primary path
 * of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"

```

```

    + "tet:underlay/tet:primary-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}
/* Augment label hop of underlay backup path
 * of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:underlay/tet:backup-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of route-exclude of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

```

```

}
}

/* Augment label hop of route-include of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:te-node-attributes/tet:connectivity-matrices/"
+ "tet:optimizations/tet:algorithm/tet:metric/"
+ "tet:optimization-metric/"
+ "tet:explicit-route-include-objects/"
+ "tet:route-object-include-object/"
+ "tet:type/tet:label/tet:label-hop/"
+ "tet:te-label/tet:technology" {
when "../../../../../../../../../../../"
+ "nw:network-types/tet:te-topology/"
+ "otntopo:otn-topology" {
description "Augment OTN TE label";
}
description "OTN label.";
case otn {
uses layer1-types:otn-label-hop;
}
}

/* Augment label hop of path-route of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:te-node-attributes/tet:connectivity-matrices/"
+ "tet:path-properties/tet:path-route-objects/"
+ "tet:path-route-object/tet:type/tet:label/tet:label-hop/"
+ "tet:te-label/tet:technology" {
when "../../../../../../../../../../../"
+ "nw:network-types/tet:te-topology/"
+ "otntopo:otn-topology" {
description "Augment OTN TE label";
}
description "OTN label.";
case otn {
uses layer1-types:otn-label-hop;
}
}

/* Augment ingress label restrictions of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:te-node-attributes/tet:connectivity-matrices/"
+ "tet:connectivity-matrix/tet:from/"
+ "tet:label-restrictions/tet:label-restriction" {
when "../../../../../../../../../../../nw:network-types/tet:te-topology/"
+ "otntopo:otn-topology" {
description "Augment OTN TE label";
}
}

```

```

    }
    description "OTN label.";
    uses layer1-types:otn-label-range-info;
}

/* Augment ingress label restrictions start of
 * connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:from/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment ingress label restrictions end of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:from/"
    + "tet:label-restrictions/tet:label-restriction/tet:label-end/"
    + "tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment ingress label restrictions step of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:from/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
    when "../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"

```

```
    + "otntopo:otn-topology" {
      description "Augment OTN TE label";
    }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-step;
  }
}

/* Augment egress label restrictions of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  uses layer1-types:otn-label-range-info;
}

/* Augment egress label restrictions start of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-start-end;
  }
}

/* Augment egress label restrictions end of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-end/"
  + "tet:te-label/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
```

```

        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment egress label restrictions step of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:to/"
    + "tet:label-restrictions/tet:label-restriction/tet:label-step/"
    + "tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-step;
}
}

/* Augment label hop of underlay primary path of
 * connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:primary-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-hop;
}
}

/* Augment label hop of underlay backup path of
 * connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"

```



```

    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:backup-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of route-exclude of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:optimizations/"
    + "tet:algorithm/tet:metric/tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of route-include of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:optimizations/"
    + "tet:algorithm/tet:metric/tet:optimization-metric/"
    + "tet:explicit-route-include-objects/"
    + "tet:route-object-include-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";

```

```

    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of path-route of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-properties/tet:path-route-objects/"
    + "tet:path-route-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label range information of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/"
    + "tet:connectivity-matrices/tet:label-restrictions/"
    + "tet:label-restriction" {
    when "../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    uses layer1-types:otn-label-range-info;
}

/* Augment label restrictions start of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/"
    + "tet:connectivity-matrices/tet:label-restrictions/"
    + "tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
}

```

```

}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions end of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/"
    + "tet:connectivity-matrices/tet:label-restrictions/"
        + "tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
when ".../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions step of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/"
    + "tet:connectivity-matrices/tet:label-restrictions/"
        + "tet:label-restriction/"
    + "tet:label-step/tet:technology" {
when ".../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-step;
}
}

/* Augment label hop of underlay primary path of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"

```

```

    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-hop;
}
}

/* Augment label hop of underlay backup path of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-hop;
}
}

/* Augment label hop of route-exclude of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-hop;
}
}

```

```
/* Augment label hop of route-include of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label hop of path-route of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment ingress label restrictions of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/tet:label-restriction" {
  when "../..../..../..../..../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
}
```

```

    description "OTN label.";
    uses layer1-types:otn-label-range-info;
}

/* Augment ingress label restrictions start of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:from/tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment ingress label restrictions end of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:from/tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment ingress label restrictions step of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:from/tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
    when "../.../.../.../.../.../.../.../.../..."

```

```

        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-step;
    }
}

/* Augment egress label restrictions of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:to/tet:label-restrictions/tet:label-restriction" {
    when "../..//..//..//..//..//..//nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    uses layer1-types:otn-label-range-info;
}

/* Augment egress label restrictions start of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:to/tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
    when "../..//..//..//..//..//..//nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment egress label restrictions end of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:to/tet:label-restrictions/tet:label-restriction/"

```

```

        + "tet:label-end/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment egress label restrictions step of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:to/tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-step;
    }
}

/* Augment label hop of underlay primary path of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

```



```

/* Augment label hop of underlay backup path of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
      description "Augment OTN TE label";
    }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label hop of route-exclude of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-exclude-objects/"
  + "tet:route-object-exclude-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
      description "Augment OTN TE label";
    }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label hop of route-include of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"

```

```

    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of path-route of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-properties/tet:path-route-objects/"
    + "tet:path-route-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label restrictions of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:label-restrictions/tet:label-restriction" {
when "../..../..../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
    description "OTN label.";
    uses layer1-types:otn-label-range-info;
}

/* Augment label restrictions start of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:label-restrictions/tet:label-restriction/"

```

```

    + "tet:label-start/tet:te-label/tet:technology" {
when "../..../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions end of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology"{
when "../..../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions step of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology"{
when "../..../..../..../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
}
description "OTN label.";
case otn {
    uses layer1-types:otn-label-step;
}
}

/* Augment label hop of underlay primary path
 * of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"

```

```

    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-hop;
}
}

/* Augment label hop of underlay backup path
 * of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-hop;
}
}

/* Augment label hop of route-exclude of
 * local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {

```

```

    uses layer1-types:otn-label-hop;
  }
}

/* Augment label hop of route-include of
 * local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../../../../../../../../../../../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label hop of path-route of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../../../../../../../../../../../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label restrictions of local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"

```

```

    + "tet:label-restrictions/tet:label-restriction" {
when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
uses layer1-types:otn-label-range-info;
}

/* Augment label start of local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-start-end;
}
}

/* Augment label end of local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-start-end;
}
}

/* Augment label step of local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"

```

```

    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-step;
}
}

/* Augment label hop of underlay primary path
 * of local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";
case otn {
    uses layer1-types:otn-label-hop;
}
}

/* Augment label hop of underlay backup path of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
    }
description "OTN label.";

```

```

    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of route-exclude of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../..../..../..../..../..../..../..../..../"
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of route-include of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-include-objects/"
    + "tet:route-object-include-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../..../..../..../..../..../..../..../..../"
        + "nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

```



```

/* Augment label hop of path-route of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label hop of underlay primary path of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label hop of underlay backup path of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {

```

```
    uses layer1-types:otn-label-hop;
  }
}

/* Augment label restrictions of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  uses layer1-types:otn-label-range-info;
}

/* Augment label restrictions start of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-start-end;
  }
}

/* Augment label restrictions end of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-start-end;
  }
}

/* Augment label restrictions step of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
```

```

+ "tet:te-link-attributes/"
+ "tet:label-restrictions/tet:label-restriction/"
+ "tet:label-step/tet:technology" {
when "../.../../.../../nw:network-types/tet:te-topology/"
+ "otntopo:otn-topology" {
description "Augment OTN TE label";
}
description "OTN label.";
case otn {
uses layer1-types:otn-label-step;
}
}

/* Augment label restrictions of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
+ "tet:information-source-entry/"
+ "tet:label-restrictions/tet:label-restriction" {
when "../.../../.../../nw:network-types/tet:te-topology/"
+ "otntopo:otn-topology" {
description "Augment OTN TE label";
}
description "OTN label.";
uses layer1-types:otn-label-range-info;
}

/* Augment label restrictions start of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
+ "tet:information-source-entry/"
+ "tet:label-restrictions/tet:label-restriction/"
+ "tet:label-start/tet:te-label/tet:technology" {
when "../.../../.../../.../../nw:network-types/tet:te-topology/"
+ "otntopo:otn-topology" {
description "Augment OTN TE label";
}
description "OTN label.";
case otn {
uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions end of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
+ "tet:information-source-entry/"
+ "tet:label-restrictions/tet:label-restriction/"
+ "tet:label-end/tet:te-label/tet:technology" {
when "../.../../.../../.../../nw:network-types/tet:te-topology/"
+ "otntopo:otn-topology" {
description "Augment OTN TE label";
}
}

```

```

description "OTN label.";
case otn {
    uses layer1-types:otn-label-start-end;
}
}

/* Augment label restrictions step of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
    when "../../../../../../../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-step;
    }
}

/* Augment label hop of underlay primary path of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
/*
    when "../../../../../../../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
*/
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label hop of underlay backup path of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
/*
    when "../../../../../../../nw:network-types/"
        + "tet:te-topology/otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
*/
}

```

```

    }
    */
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-hop;
    }
}

/* Augment label restrictions of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:label-restrictions/tet:label-restriction" {
/*
    when "../.../.../.../.../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
*/
    description "OTN label.";
    uses layer1-types:otn-label-range-info;
}

/* Augment label restrictions start of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
/*
    when "../.../.../.../.../.../.../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
*/
    description "OTN label.";
    case otn {
        uses layer1-types:otn-label-start-end;
    }
}

/* Augment label restrictions end of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
/*
    when "../.../.../.../.../.../.../nw:network-types/tet:te-topology/"
        + "otntopo:otn-topology" {
        description "Augment OTN TE label";
    }
*/
}

```

```
    }
  */
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-start-end;
  }
}

/* Augment label restrictions step of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
/*
  when "../..../nw:network-types/tet:te-topology/"
    + "otntopo:otn-topology" {
    description "Augment OTN TE label";
  }
*/
  description "OTN label.";
  case otn {
    uses layer1-types:otn-label-step;
  }
}
}
<CODE ENDS>
```

5. IANA Considerations

It is proposed that IANA should assign new URIs from the "IETF XML Registry" [RFC3688] as follows: URI:
urn:ietf:params:xml:ns:yang:ietf-otn-topology Registrant Contact: The IESG XML: N/A; the requested URI is an XML namespace. This document registers a YANG module in the YANG Module Names registry [RFC7950].
name: ietf-otn-topology namespace: urn:ietf:params:xml:ns:yang:ietf-otn-topology prefix: otntopo reference: RFC XXXX

6. Security Considerations

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

The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

```
/nw:networks/nw:network/nw:network-types/tet:te-topology
/nw:networks/nw:network/nt:link/tet:te/tet:te-link-attributes
/nw:networks/nw:network/nw:node/nt:termination-point/tet:te
/nw:networks/nw:network/.../tet:te-bandwidth/tet:technology
/nw:networks/nw:network/nw:node/tet:te/.../tet:label-restriction
/nw:networks/nw:network/nw:node/.../tet:te-label/tet:technology
Editors note: we are using simplified description by folding similar
branches to avoid repetition.
```

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

Editors note: Currently there is no such data nodes, temporarily kept for review.

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8. Contributors

Aihua Guo
Individual
Email: aihuaguo.ietf@gmail.com

Anurag Sharma
Google
Email: ansha@google.com

Yunbin Xu
CAICT

Email: xuyunbin@caict.ac.cn

Lei Wang
China Mobile
Email: wangleiyj@chinamobile.com

Baoquan Rao
Huawei Technologies
Email: raobaoquan@huawei.com

Xian Zhang
Huawei Technologies
Email: zhang.xian@huawei.com

Huub van Helvoort
Hai Gaoming BV
the Netherlands
Email: huubatwork@gmail.com

Victor Lopez
Telefonica
Email: victor.lopezalvarez@telefonica.com

Yunbo Li
China Mobile
Email: liyunbo@chinamobile.com

Dieter Beller
Nokia
Email: dieter.beller@nokia.com

Yanlei Zheng
China Unicom
Email: zhengyanlei@chinaunicom.cn

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Authors' Addresses

Haomian Zheng
Huawei Technologies
H1-1-A043S Huawei Industrial Base, Songshanhu
Dongguan, Guangdong 523808
China

Email: zhenghaomian@huawei.com

Italo Busi
Huawei Technologies
HUAWEI TECHNOLOGIES ITALIA Srl Centro Direzionale Milano 2
Milan, Milan 20090
Italy

Email: Italo.Busi@huawei.com

Xufeng Liu
Volta Networks

Email: xufeng.liu.ietf@gmail.com

Sergio Belotti
Nokia

Email: sergio.belotti@nokia.com

Oscar Gonzalez de Dios
Telefonica

Email: oscar.gonzalezdedios@telefonica.com

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H. Zheng
Huawei Technologies
Y. Lee
SKKU
A. Guo
Individual
V. Lopez
Telefonica
D. King
University of Lancaster
November 4, 2019

A YANG Data Model for WSON (Wavelength Switched Optical Networks)
draft-ietf-ccamp-wson-yang-23

Abstract

This document provides a YANG data model for the routing and wavelength assignment (RWA) TE topology in wavelength switched optical networks (WSONs). The YANG data model defined in this document conforms to the Network Management Datastore Architecture (NMDA).

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Table of Contents

1. Introduction	2
1.1. Requirements Language	3
1.2. Terminology and Notations	3
1.3. Tree Diagram	4
1.4. Prefix in Data Node Names	4
2. YANG Model (Tree Structure) for WSON topology	4
3. The YANG Code for WSON topology	30
4. Security Considerations	70
5. IANA Considerations	71
6. Contributors	71
7. References	72
7.1. Normative References	72
7.2. Informative References	74
Authors' Addresses	74

1. Introduction

This document provides a YANG data model for the routing and wavelength assignment (RWA) Traffic Engineering (TE) topology in transparent wavelength switched optical networks (WSONs). The YANG model described in this document is a WSON technology-specific YANG model based on the information model developed in [RFC7446] and the two encoding documents [RFC7581] and [RFC7579] that developed protocol independent encodings based on [RFC7446].

[ITU-Tg6982] defines amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces. The YANG data model defined in this document refers to the standard application mode defined in [ITU-Tg6982].

What is not in scope of this document is both impairment-aware optical networks and flexi-grid. Refer to [I-D.ietf-ccamp-optical-impairment-topology-yang] for impairment-aware optical network topology model and [I-D.ietf-ccamp-flexigrid-yang] for flexi-grid optical network topology model.

Additionally, resource block models (e.g., 3R Regeneration) is not also in the scope of this document, which will be addressed in a separate document.

This document defines one YANG model: ietf-wson-topology (Section 3). This document augments the generic TE topology draft [I-D.ietf-teas-yang-te-topo].

There are multiple applications for the yang data model defined in this document. For example, nodes within the network can use the data model to capture their understanding of the overall WSON topology and expose it to a controller. A controller can further propagate the topology to other controllers. The YANG model is used by NETCONF [RFC6020], [RFC8341] or a RESTCONF [RFC8040] protocol. The YANG data model defined in this document conforms to the Network Management Datastore Architecture [RFC8342].

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.2. Terminology and Notations

Refer to [RFC7446] and [RFC7581] for the key terms used in this document. The following terms are defined in [RFC7950] and are not redefined here:

- o client
- o server
- o augment
- o data model
- o data node

The following terms are defined in [RFC6241] and are not redefined here:

- o configuration data
- o state data

The terminology for describing YANG data models is found in [RFC7950].

1.3. Tree Diagram

A simplified graphical representation of the data model is used in chapter 2 of this document. The meaning of the symbols in these diagrams is defined in [RFC8340].

1.4. Prefix in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules, as shown in the following table.

Prefix	YANG module	Reference
layer0-types	ietf-layer0-types	[ietf-ccamp-layer-types]
wson	ietf-wson-topology	[RFCXXXX]
nw	ietf-network	[RFC8345]
nt	ietf-network-topology	[RFC8345]
tet	ietf-te-topology	[ietf-teas-yang-te-topo]

Note: The RFC Editor will replace XXXX with the number assigned to the RFC once this draft becomes an RFC.

2. YANG Model (Tree Structure) for WSON topology

```

module: ietf-wson-topology
  augment /nw:networks/nw:network/nw:network-types
    /tet:te-topology:
      +--rw wson-topology!
  augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes:
  augment /nw:networks/nw:network/nw:node
    /nt:termination-point/tet:te:
      +--rw supported-payload-types* [index]
      |   +--rw index          uint16
      |   +--rw payload-type?  string
      +--rw client-facing?     boolean
  augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes:
      +--rw wson-node

```

```

    +--rw node-type?    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point:
+--rw supported-operational-modes*
|   layer0-types:operational-mode
+--rw configured-operational-modes?
|   layer0-types:operational-mode
+--rw supported-fec-types*          identityref
+--rw supported-termination-types*  identityref
+--rw supports-bit-stuffing?        boolean
+--rw is-tunable?                   boolean
+--rw max-subcarrier-channel-num?    uint8
augment /nw:networks/nw:network/nw:node
    /nt:termination-point/tet:te
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+--:(wson)
    +--rw bandwidth-type?    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+--:(wson)
    +--rw supported-bandwidth-list*    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+--:(wson)
    +--rw supported-bandwidth-list*    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+--:(wson)
    +--ro supported-bandwidth-list*    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+--:(wson)
    +--ro supported-bandwidth-list*    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:client-layer-adaptation

```



```

        /tet:switching-capability/tet:te-bandwidth
        /tet:technology:
    +--:(wson)
        +--rw supported-bandwidth-list*   identityref
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:path-constraints/tet:te-bandwidth
        /tet:technology:
    +--:(wson)
        +--rw supported-bandwidth-list*   identityref
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:local-link-connectivity
        /tet:path-constraints/tet:te-bandwidth
        /tet:technology:
    +--:(wson)
        +--rw supported-bandwidth-list*   identityref
augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes
        /tet:interface-switching-capability
        /tet:max-lsp-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(wson)
        +--rw bandwidth-type?   identityref
augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes/tet:max-link-bandwidth
        /tet:te-bandwidth/tet:technology:
    +--:(wson)
        +--rw supported-bandwidth-list*   identityref
augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes
        /tet:max-resv-link-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(wson)
        +--rw supported-bandwidth-list*   identityref
augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes/tet:unreserved-bandwidth
        /tet:te-bandwidth/tet:technology:
    +--:(wson)
        +--rw supported-bandwidth-list*   identityref
augment /nw:networks/nw:network/nt:link/tet:te
        /tet:information-source-entry
        /tet:interface-switching-capability
        /tet:max-lsp-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(wson)

```

```
    +--ro bandwidth-type?    identityref
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:max-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+--: (wson)
    +--ro supported-bandwidth-list*    identityref
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:max-resv-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+--: (wson)
    +--ro supported-bandwidth-list*    identityref
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:unreserved-bandwidth/tet:te-bandwidth
    /tet:technology:
+--: (wson)
    +--ro supported-bandwidth-list*    identityref
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+--: (wson)
    +--rw bandwidth-type?    identityref
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:max-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+--: (wson)
    +--rw supported-bandwidth-list*    identityref
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:max-resv-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+--: (wson)
    +--rw supported-bandwidth-list*    identityref
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:unreserved-bandwidth/tet:te-bandwidth
    /tet:technology:
+--: (wson)
    +--rw supported-bandwidth-list*    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction:
```

```

    +---rw grid-type?    identityref
    +---rw priority?     uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(wson)
    +---rw (grid-type)?
    +---:(dwdm)
    |   +---rw dwdm-n?    layer0-types:dwdm-n
    +---:(cwdm)
    |   +---rw cwdm-n?    layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(wson)
    +---rw (grid-type)?
    +---:(dwdm)
    |   +---rw dwdm-n?    layer0-types:dwdm-n
    +---:(cwdm)
    |   +---rw cwdm-n?    layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(wson)
    +---rw (layer0-grid-type)?
    +---:(dwdm)
    |   +---rw wson-dwdm?    identityref
    +---:(cwdm)
    |   +---rw wson-cwdm?    identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
    +---rw (grid-type)?
    +---:(dwdm)
    |   +---rw (single-or-super-channel)?
    |   |   +---:(single)
    |   |   |   +---rw dwdm-n?
    |   |   |       layer0-types:dwdm-n

```

```

    |         +---:(super)
    |         |         +---rw subcarrier-dwdm-n*   int16
+---:(cwdm)
    |         +---rw cwdm-n?
    |         |         layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    |         /tet:te-node-attributes
    |         /tet:connectivity-matrices/tet:underlay
    |         /tet:backup-path/tet:path-element/tet:type
    |         /tet:label/tet:label-hop/tet:te-label
    |         /tet:technology:
+---:(wson)
    |         +---rw (grid-type)?
    |         |         +---:(dwdm)
    |         |         |         +---rw (single-or-super-channel)?
    |         |         |         |         +---:(single)
    |         |         |         |         |         +---rw dwdm-n?
    |         |         |         |         |         |         layer0-types:dwdm-n
    |         |         |         |         +---:(super)
    |         |         |         |         |         +---rw subcarrier-dwdm-n*   int16
+---:(cwdm)
    |         +---rw cwdm-n?
    |         |         layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    |         /tet:te-node-attributes
    |         /tet:connectivity-matrices/tet:optimizations
    |         /tet:algorithm/tet:metric
    |         /tet:optimization-metric
    |         /tet:explicit-route-exclude-objects
    |         /tet:route-object-exclude-object/tet:type
    |         /tet:label/tet:label-hop/tet:te-label
    |         /tet:technology:
+---:(wson)
    |         +---rw (grid-type)?
    |         |         +---:(dwdm)
    |         |         |         +---rw (single-or-super-channel)?
    |         |         |         |         +---:(single)
    |         |         |         |         |         +---rw dwdm-n?
    |         |         |         |         |         |         layer0-types:dwdm-n
    |         |         |         |         +---:(super)
    |         |         |         |         |         +---rw subcarrier-dwdm-n*   int16
+---:(cwdm)
    |         +---rw cwdm-n?
    |         |         layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    |         /tet:te-node-attributes
    |         /tet:connectivity-matrices/tet:optimizations
    |         /tet:algorithm/tet:metric

```

```

    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
+--rw (grid-type)?
+---:(dwdm)
|   +--rw (single-or-super-channel)?
|   |   +---:(single)
|   |   |   +--rw dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---:(super)
|   |   |   +--rw subcarrier-dwdm-n*   int16
+---:(cwdm)
|   +--rw cwdm-n?
|   |   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:path-properties
    /tet:path-route-objects/tet:path-route-object
    /tet:type/tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
+--ro (grid-type)?
+---:(dwdm)
|   +--ro (single-or-super-channel)?
|   |   +---:(single)
|   |   |   +--ro dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---:(super)
|   |   |   +--ro subcarrier-dwdm-n*   int16
+---:(cwdm)
|   +--ro cwdm-n?
|   |   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:from
    /tet:label-restrictions/tet:label-restriction:
+--rw grid-type?   identityref
+--rw priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:from
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:

```

```

+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      | +--rw dwdm-n?   layer0-types:dwdm-n
    +--:(cwdm)
      +--rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      | +--rw dwdm-n?   layer0-types:dwdm-n
    +--:(cwdm)
      +--rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-step/tet:technology:
+--:(wson)
  +--rw (layer0-grid-type)?
    +--:(dwdm)
      | +--rw wson-dwdm?  identityref
    +--:(cwdm)
      +--rw wson-cwdm?  identityref
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:to
  /tet:label-restrictions/tet:label-restriction:
+--rw grid-type?  identityref
+--rw priority?   uint8
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:to
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      | +--rw dwdm-n?   layer0-types:dwdm-n
    +--:(cwdm)

```

```

      +--rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:to
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+--:(wson)
  +--rw (grid-type)?
  +--:(dwdm)
  |   +--rw dwdm-n?   layer0-types:dwdm-n
  +--:(cwdm)
  |   +--rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:to
  /tet:label-restrictions/tet:label-restriction
  /tet:label-step/tet:technology:
+--:(wson)
  +--rw (layer0-grid-type)?
  +--:(dwdm)
  |   +--rw wson-dwdm?   identityref
  +--:(cwdm)
  |   +--rw wson-cwdm?   identityref
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:underlay
  /tet:primary-path/tet:path-element/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(wson)
  +--rw (grid-type)?
  +--:(dwdm)
  |   +--rw (single-or-super-channel)?
  |   |   +--:(single)
  |   |   |   +--rw dwdm-n?
  |   |   |   |   layer0-types:dwdm-n
  |   |   +--:(super)
  |   |   |   +--rw subcarrier-dwdm-n*   int16
  +--:(cwdm)
  |   +--rw cwdm-n?
  |   |   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:underlay

```

```

        /tet:backup-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      |   +--rw (single-or-super-channel)?
      |   |   +--:(single)
      |   |   |   +--rw dwdm-n?
      |   |   |       layer0-types:dwdm-n
      |   |   +--:(super)
      |   |       +--rw subcarrier-dwdm-n*   int16
    +--:(cwdm)
      +--rw cwdm-n?
          layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-exclude-objects
  /tet:route-object-exclude-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      |   +--rw (single-or-super-channel)?
      |   |   +--:(single)
      |   |   |   +--rw dwdm-n?
      |   |   |       layer0-types:dwdm-n
      |   |   +--:(super)
      |   |       +--rw subcarrier-dwdm-n*   int16
    +--:(cwdm)
      +--rw cwdm-n?
          layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-include-objects
  /tet:route-object-include-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(wson)

```



```

    +--rw (grid-type)?
      +--:(dwdm)
        |   +--rw (single-or-super-channel)?
        |     +--:(single)
        |       |   +--rw dwdm-n?
        |       |     layer0-types:dwdm-n
        |     +--:(super)
        |       +--rw subcarrier-dwdm-n*   int16
      +--:(cwdm)
        +--rw cwdm-n?
          layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:path-properties
  /tet:path-route-objects/tet:path-route-object
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(wson)
  +--ro (grid-type)?
    +--:(dwdm)
      |   +--ro (single-or-super-channel)?
      |     +--:(single)
      |       |   +--ro dwdm-n?
      |       |     layer0-types:dwdm-n
      |     +--:(super)
      |       +--ro subcarrier-dwdm-n*   int16
    +--:(cwdm)
      +--ro cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:label-restrictions/tet:label-restriction:
+--ro grid-type?   identityref
+--ro priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+--:(wson)
  +--ro (grid-type)?
    +--:(dwdm)
      |   +--ro dwdm-n?   layer0-types:dwdm-n
    +--:(cwdm)
      +--ro cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te

```

```

        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction
        /tet:label-end/tet:te-label/tet:technology:
+---: (wson)
+---ro (grid-type)?
+---: (dwdm)
|   +---ro dwdm-n?   layer0-types:dwdm-n
+---: (cwdm)
+---ro cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction
        /tet:label-step/tet:technology:
+---: (wson)
+---ro (layer0-grid-type)?
+---: (dwdm)
|   +---ro wson-dwdm?   identityref
+---: (cwdm)
+---ro wson-cwdm?   identityref
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices/tet:underlay
        /tet:primary-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+---ro (grid-type)?
+---: (dwdm)
|   +---ro (single-or-super-channel)?
|   |   +---: (single)
|   |   |   +---ro dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---: (super)
|   |   +---ro subcarrier-dwdm-n*   int16
+---: (cwdm)
+---ro cwdm-n?
+---ro layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices/tet:underlay
        /tet:backup-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+---ro (grid-type)?
+---: (dwdm)

```

```

    |   +---ro (single-or-super-channel)?
    |   |   +---:(single)
    |   |   |   +---ro dwdm-n?
    |   |   |       layer0-types:dwdm-n
    |   |   +---:(super)
    |   |       +---ro subcarrier-dwdm-n*   int16
    |   +---:(cwdm)
    |       +---ro cwdm-n?
    |           layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
    +---ro (grid-type)?
    +---:(dwdm)
    |   +---ro (single-or-super-channel)?
    |   |   +---:(single)
    |   |   |   +---ro dwdm-n?
    |   |   |       layer0-types:dwdm-n
    |   |   +---:(super)
    |   |       +---ro subcarrier-dwdm-n*   int16
    |   +---:(cwdm)
    |       +---ro cwdm-n?
    |           layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
    +---ro (grid-type)?
    +---:(dwdm)
    |   +---ro (single-or-super-channel)?
    |   |   +---:(single)
    |   |   |   +---ro dwdm-n?
    |   |   |       layer0-types:dwdm-n
    |   |   +---:(super)
    |   |       +---ro subcarrier-dwdm-n*   int16
    |   +---:(cwdm)
    |       +---ro cwdm-n?
    |           layer0-types:cwdm-n

```

```

      +---:(cwdm)
        +---ro cwdm-n?
          layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices/tet:path-properties
  /tet:path-route-objects/tet:path-route-object
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(wson)
  +---ro (grid-type)?
    +---:(dwdm)
      |   +---ro (single-or-super-channel)?
      |     +---:(single)
      |       |   +---ro dwdm-n?
      |       |     layer0-types:dwdm-n
      |       +---:(super)
      |         +---ro subcarrier-dwdm-n*   int16
    +---:(cwdm)
      +---ro cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction:
+---ro grid-type?   identityref
+---ro priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+---:(wson)
  +---ro (grid-type)?
    +---:(dwdm)
      |   +---ro dwdm-n?   layer0-types:dwdm-n
    +---:(cwdm)
      +---ro cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+---:(wson)
  +---ro (grid-type)?

```

```

      +---:(dwdm)
      |   +---ro dwdm-n?   layer0-types:dwdm-n
      +---:(cwdm)
          +---ro cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:from
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(wson)
    +---ro (layer0-grid-type)?
        +---:(dwdm)
        |   +---ro wson-dwdm?   identityref
        +---:(cwdm)
            +---ro wson-cwdm?   identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction:
+---ro grid-type?   identityref
+---ro priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(wson)
    +---ro (grid-type)?
        +---:(dwdm)
        |   +---ro dwdm-n?   layer0-types:dwdm-n
        +---:(cwdm)
            +---ro cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(wson)
    +---ro (grid-type)?
        +---:(dwdm)
        |   +---ro dwdm-n?   layer0-types:dwdm-n
        +---:(cwdm)
            +---ro cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te

```

```

        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:to
        /tet:label-restrictions/tet:label-restriction
        /tet:label-step/tet:technology:
+---: (wson)
+--ro (layer0-grid-type)?
+---: (dwdm)
|   +--ro wson-dwdm?   identityref
+---: (cwdm)
|   +--ro wson-cwdm?   identityref
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:underlay
        /tet:primary-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+--ro (grid-type)?
+---: (dwdm)
|   +--ro (single-or-super-channel)?
|   |   +---: (single)
|   |   |   +--ro dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---: (super)
|   |   |   +--ro subcarrier-dwdm-n*   int16
+---: (cwdm)
|   +--ro cwdm-n?
|   |   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:underlay
        /tet:backup-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+--ro (grid-type)?
+---: (dwdm)
|   +--ro (single-or-super-channel)?
|   |   +---: (single)
|   |   |   +--ro dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---: (super)
|   |   |   +--ro subcarrier-dwdm-n*   int16
+---: (cwdm)
|   +--ro cwdm-n?

```

```

        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
+---ro (grid-type)?
+---:(dwdm)
|   +---ro (single-or-super-channel)?
|   |   +---:(single)
|   |   |   +---ro dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---:(super)
|   |   |   +---ro subcarrier-dwdm-n*   int16
+---:(cwdm)
+---ro cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
+---ro (grid-type)?
+---:(dwdm)
|   +---ro (single-or-super-channel)?
|   |   +---:(single)
|   |   |   +---ro dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---:(super)
|   |   |   +---ro subcarrier-dwdm-n*   int16
+---:(cwdm)
+---ro cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices

```

```

        /tet:connectivity-matrix/tet:path-properties
        /tet:path-route-objects/tet:path-route-object
        /tet:type/tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+---ro (grid-type)?
+---: (dwdm)
|   +---ro (single-or-super-channel)?
|   |   +---: (single)
|   |   |   +---ro dwdm-n?
|   |   |       layer0-types:dwdm-n
|   |   +---: (super)
|   |       +---ro subcarrier-dwdm-n*   int16
+---: (cwdm)
+---ro cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction:
+---rw grid-type?   identityref
+---rw priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction
        /tet:label-start/tet:te-label/tet:technology:
+---: (wson)
+---rw (grid-type)?
+---: (dwdm)
|   +---rw dwdm-n?   layer0-types:dwdm-n
+---: (cwdm)
+---rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction
        /tet:label-end/tet:te-label/tet:technology:
+---: (wson)
+---rw (grid-type)?
+---: (dwdm)
|   +---rw dwdm-n?   layer0-types:dwdm-n
+---: (cwdm)
+---rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction

```



```

        /tet:label-step/tet:technology:
+--: (wson)
  +--rw (layer0-grid-type)?
    +--: (dwdm)
      |   +--rw wson-dwdm?   identityref
    +--: (cwdm)
      |   +--rw wson-cwdm?   identityref
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities/tet:underlay
  /tet:primary-path/tet:path-element/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--: (wson)
  +--rw (grid-type)?
    +--: (dwdm)
      |   +--rw (single-or-super-channel)?
      |     +--: (single)
      |       |   +--rw dwdm-n?
      |       |           layer0-types:dwdm-n
      |     +--: (super)
      |       |   +--rw subcarrier-dwdm-n*   int16
    +--: (cwdm)
      |   +--rw cwdm-n?
      |           layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities/tet:underlay
  /tet:backup-path/tet:path-element/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--: (wson)
  +--rw (grid-type)?
    +--: (dwdm)
      |   +--rw (single-or-super-channel)?
      |     +--: (single)
      |       |   +--rw dwdm-n?
      |       |           layer0-types:dwdm-n
      |     +--: (super)
      |       |   +--rw subcarrier-dwdm-n*   int16
    +--: (cwdm)
      |   +--rw cwdm-n?
      |           layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric

```

```

    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      +--rw (single-or-super-channel)?
        +--:(single)
          +--rw dwdm-n?
            layer0-types:dwdm-n
        +--:(super)
          +--rw subcarrier-dwdm-n*   int16
    +--:(cwdm)
      +--rw cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-include-objects
  /tet:route-object-include-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      +--rw (single-or-super-channel)?
        +--:(single)
          +--rw dwdm-n?
            layer0-types:dwdm-n
        +--:(super)
          +--rw subcarrier-dwdm-n*   int16
    +--:(cwdm)
      +--rw cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:tunnel-termination-point
  /tet:local-link-connectivities
  /tet:path-properties/tet:path-route-objects
  /tet:path-route-object/tet:type/tet:label
  /tet:label-hop/tet:te-label/tet:technology:
+--:(wson)
  +--ro (grid-type)?
    +--:(dwdm)
      +--ro (single-or-super-channel)?
        +--:(single)

```

```

    |         |   +--ro dwdm-n?
    |         |       layer0-types:dwdm-n
    |         +---:(super)
    |         +--ro subcarrier-dwdm-n*   int16
+---:(cwdm)
    +--ro cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction:
+--rw grid-type?   identityref
+--rw priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(wson)
    +--rw (grid-type)?
        +---:(dwdm)
        |   +--rw dwdm-n?   layer0-types:dwdm-n
        +---:(cwdm)
            +--rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(wson)
    +--rw (grid-type)?
        +---:(dwdm)
        |   +--rw dwdm-n?   layer0-types:dwdm-n
        +---:(cwdm)
            +--rw cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(wson)
    +--rw (layer0-grid-type)?
        +---:(dwdm)
        |   +--rw wson-dwdm?   identityref

```

```

    +---:(cwdm)
        +---rw wson-cwdm?  identityref
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
    +---rw (grid-type)?
        +---:(dwdm)
            +---rw (single-or-super-channel)?
                +---:(single)
                    +---rw dwdm-n?
                        layer0-types:dwdm-n
                +---:(super)
                    +---rw subcarrier-dwdm-n*  int16
        +---:(cwdm)
            +---rw cwdm-n?
                layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
    +---rw (grid-type)?
        +---:(dwdm)
            +---rw (single-or-super-channel)?
                +---:(single)
                    +---rw dwdm-n?
                        layer0-types:dwdm-n
                +---:(super)
                    +---rw subcarrier-dwdm-n*  int16
        +---:(cwdm)
            +---rw cwdm-n?
                layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type

```

```

        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+---rw (grid-type)?
+---: (dwdm)
|   +---rw (single-or-super-channel)?
|   |   +---: (single)
|   |   |   +---rw dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---: (super)
|   |   +---rw subcarrier-dwdm-n*   int16
+---: (cwdm)
+---rw cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:local-link-connectivity/tet:optimizations
        /tet:algorithm/tet:metric
        /tet:optimization-metric
        /tet:explicit-route-include-objects
        /tet:route-object-include-object/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+---rw (grid-type)?
+---: (dwdm)
|   +---rw (single-or-super-channel)?
|   |   +---: (single)
|   |   |   +---rw dwdm-n?
|   |   |   |   layer0-types:dwdm-n
|   |   +---: (super)
|   |   +---rw subcarrier-dwdm-n*   int16
+---: (cwdm)
+---rw cwdm-n?
        layer0-types:cwdm-n
augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:local-link-connectivity/tet:path-properties
        /tet:path-route-objects/tet:path-route-object
        /tet:type/tet:label/tet:label-hop/tet:te-label
        /tet:technology:
+---: (wson)
+---ro (grid-type)?
+---: (dwdm)
|   +---ro (single-or-super-channel)?
|   |   +---: (single)

```

```

    |         |   +---ro dwdm-n?
    |         |       layer0-types:dwdm-n
    |         +---:(super)
    |         |   +---ro subcarrier-dwdm-n*   int16
+---:(cwdm)
    |         +---ro cwdm-n?
    |         |       layer0-types:cwdm-n
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
    +---rw (grid-type)?
    +---:(dwdm)
    |         +---rw (single-or-super-channel)?
    |         |   +---:(single)
    |         |   |   +---rw dwdm-n?
    |         |   |       layer0-types:dwdm-n
    |         |   +---:(super)
    |         |   |   +---rw subcarrier-dwdm-n*   int16
+---:(cwdm)
    |         +---rw cwdm-n?
    |         |       layer0-types:cwdm-n
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(wson)
    +---rw (grid-type)?
    +---:(dwdm)
    |         +---rw (single-or-super-channel)?
    |         |   +---:(single)
    |         |   |   +---rw dwdm-n?
    |         |   |       layer0-types:dwdm-n
    |         |   +---:(super)
    |         |   |   +---rw subcarrier-dwdm-n*   int16
+---:(cwdm)
    |         +---rw cwdm-n?
    |         |       layer0-types:cwdm-n
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions
    /tet:label-restriction:
    +---rw grid-type?   identityref
    +---rw priority?    uint8
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions

```

```

        /tet:label-restriction/tet:label-start
        /tet:te-label/tet:technology:
+---:(wson)
    +---rw (grid-type)?
        +---:(dwdm)
            | +---rw dwdm-n?    layer0-types:dwdm-n
        +---:(cwdm)
            +---rw cwdm-n?    layer0-types:cwdm-n
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions
    /tet:label-restriction/tet:label-end
    /tet:te-label/tet:technology:
+---:(wson)
    +---rw (grid-type)?
        +---:(dwdm)
            | +---rw dwdm-n?    layer0-types:dwdm-n
        +---:(cwdm)
            +---rw cwdm-n?    layer0-types:cwdm-n
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:label-restrictions
    /tet:label-restriction/tet:label-step
    /tet:technology:
+---:(wson)
    +---rw (layer0-grid-type)?
        +---:(dwdm)
            | +---rw wson-dwdm?    identityref
        +---:(cwdm)
            +---rw wson-cwdm?    identityref
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:label-restrictions/tet:label-restriction:
+---ro grid-type?    identityref
+---ro priority?    uint8
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(wson)
    +---ro (grid-type)?
        +---:(dwdm)
            | +---ro dwdm-n?    layer0-types:dwdm-n
        +---:(cwdm)
            +---ro cwdm-n?    layer0-types:cwdm-n
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(wson)

```

```

    +--ro (grid-type)?
      +--:(dwdm)
        |   +--ro dwdm-n?   layer0-types:dwdm-n
      +--:(cwdm)
        +--ro cwdm-n?   layer0-types:cwdm-n
augment /nw:networks/nw:network/nt:link/tet:te
  /tet:information-source-entry
  /tet:label-restrictions/tet:label-restriction
  /tet:label-step/tet:technology:
+--:(wson)
  +--ro (layer0-grid-type)?
    +--:(dwdm)
      |   +--ro wson-dwdm?   identityref
    +--:(cwdm)
      +--ro wson-cwdm?   identityref
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:underlay/tet:primary-path/tet:path-element
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      |   +--rw (single-or-super-channel)?
      |     +--:(single)
      |       |   +--rw dwdm-n?
      |       |           layer0-types:dwdm-n
      |     +--:(super)
      |       +--rw subcarrier-dwdm-n*   int16
    +--:(cwdm)
      +--rw cwdm-n?
          layer0-types:cwdm-n
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:underlay/tet:backup-path/tet:path-element
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(wson)
  +--rw (grid-type)?
    +--:(dwdm)
      |   +--rw (single-or-super-channel)?
      |     +--:(single)
      |       |   +--rw dwdm-n?
      |       |           layer0-types:dwdm-n
      |     +--:(super)
      |       +--rw subcarrier-dwdm-n*   int16
    +--:(cwdm)
      +--rw cwdm-n?

```



```

        layer0-types:cwdm-n
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction:
    +--rw grid-type?    identityref
    +--rw priority?     uint8
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
    +--:(wson)
        +--rw (grid-type)?
            +--:(dwdm)
                | +--rw dwdm-n?    layer0-types:dwdm-n
            +--:(cwdm)
                +--rw cwdm-n?    layer0-types:cwdm-n
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
    +--:(wson)
        +--rw (grid-type)?
            +--:(dwdm)
                | +--rw dwdm-n?    layer0-types:dwdm-n
            +--:(cwdm)
                +--rw cwdm-n?    layer0-types:cwdm-n
augment /nw:networks/tet:te/tet:templates
    /tet:link-template/tet:te-link-attributes
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
    +--:(wson)
        +--rw (layer0-grid-type)?
            +--:(dwdm)
                | +--rw wson-dwdm?    identityref
            +--:(cwdm)
                +--rw wson-cwdm?    identityref

```

3. The YANG Code for WSON topology

```

<CODE BEGINS> file "ietf-wson-topology@2019-11-04.yang"
module ietf-wson-topology {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-wson-topology";
  prefix "wson";

```

```
import ietf-network {
  prefix "nw";
  reference
    "RFC 8345: A YANG Data Model for Network Topologies";
}

import ietf-network-topology {
  prefix "nt";
  reference
    "RFC 8345: A YANG Data Model for Network Topologies";
}

import ietf-te-topology {
  prefix "tet";
  reference
    "RFC YYYY: YANG Data Model for
    Traffic Engineering (TE) Topologies";
}

/* Note: The RFC Editor will replace YYYY with the number assigned to
   the RFC once draft-ietf-teas-yang-te-topo becomes an RFC.*/

import ietf-layer0-types {
  prefix "layer0-types";
  reference
    "RFC XXXX: A YANG Data Model for WSON
    (Wavelength Switched Optical Networks)";
}

/* Note: The RFC Editor will replace XXXX with the number assigned to
   the RFC once draft-ietf-ccamp-layer0-types becomes an RFC.*/

organization
  "IETF CCAMP Working Group";

contact
  "Editor:  Haomian Zheng  <zhenghaomian@huawei.com>
   Editor:  Young Lee    <younglee.tx@gmail.com>
   Editor:  Aihua Guo    <aihuaguo.ietf@gmail.com>
   Editor:  Victor Lopez  <victor.lopezalvarez@telefonica.com>
   Editor:  Daniel King   <d.king@lancaster.ac.uk>";

description
  "This module provides a YANG data model for the routing and
   wavelength assignment (RWA) Traffic Engineering (TE)
   topology in wavelength switched optical networks (WSONs).
   The YANG model described in this document is a WSON
   technology-specific YANG model augmenting the generic TE
```

topology module (ietf-te-topology) based on the information model developed in RFC 7446 and the two encoding documents RFC 7581 and RFC 7579 that developed protocol independent encodings based on RFC 7446. The model fully conforms to the Network Management Datastore Architecture (NMDA).

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

```
revision 2019-11-04 {
  description
    "Initial Version";

  reference
    "RFC XXXX: A YANG Data Model for WSON (Wavelength Switched
    Optical Networks)";
}

/*
 * Groupings
 */
grouping wson-node-attributes {
  description "WSN node attributes";
  container wson-node {
    description "WSN node attributes";
    leaf node-type {
      type identityref {
        base layer0-types:layer0-node-type;
      }
      description "WSN node type";
    }
  }
}

grouping wson-link-attributes {
  description
    "Future WSON link attributes extensions";
}
```

```
grouping wson-tp-attributes {
  description "wson-tp-attributes";

  list supported-payload-types {
    key "index";
    description
      "Supported payload types of a TP (Termination Point).
       The payload type is defined as the generalized PIDs
       (Payload Identifiers) in GMPLS";
    leaf index {
      type uint16;
      description "payload type index";
    }
    leaf payload-type {
      type string;
      description "the payload type supported by this client TP";
      reference
        "http://www.iana.org/assignments/gmpls-sig-parameters
         /gmpls-sig-parameters.xhtml";
    }
  }
  leaf client-facing {
    type boolean;
    default 'false';
    description
      "Indicates if it is a client-facing TP";
  }
}

grouping wson-ttp-attributes {
  description
    "WSON tunnel termination point (e.g., tranponder) attributes";

  leaf-list supported-operational-modes {
    type layer0-types:operational-mode;
    description
      "List of all supported vendor-specific
       mode identifiers";
  }

  leaf configured-operational-modes {
    type layer0-types:operational-mode;
    description
      "Vendor-specific mode identifier configured
       on the TTP (TE-tunnel Termination Point)";
  }

  leaf-list supported-fec-types {
```

```
    type identityref {
      base layer0-types:fec-type;
    }
    description
      "List of all supported FEC (Forward Error Correction)
       types by this TTP";
  }

  leaf-list supported-termination-types {
    type identityref {
      base layer0-types:term-type;
    }
    description
      "List of all supported termination types by this TTP";
  }

  leaf supports-bit-stuffing {
    type boolean;
    description
      "Indicates whether bit stuffing is supported by this TTP";
  }

  leaf is-tunable {
    type boolean;
    description
      "Indicates if the TTP, or transponder, is tunable. Tunable
       transponders are assumed to be fully tunable to any of the
       96 channels within DWDM C-band";
  }

  leaf max-subcarrier-channel-num {
    type uint8 {
      range "1..max";
    }
    default 1;
    description
      "Indicates the maximum number of subcarrier channels for
       super-channel transponders. When the value equals 1 it
       represents regular single-channel transponder";
  }
}

/*
 * Data nodes
 */

augment "/nw:networks/nw:network/nw:network-types"
+ "/tet:te-topology" {
```

```
    description "wson-topology augmented";
    container wson-topology {
        presence "indicates a topology of WSON";
        description
            "Container to identify WSON topology type";
    }
}

augment "/nw:networks/nw:network/nt:link/tet:te"
+ "/tet:te-link-attributes" {
    when "/nw:networks/nw:network/nw:network-types"
    + "/tet:te-topology/wson:wson-topology" {
        description "This augment is only valid for WSON";
    }
    description "WSON Link augmentation.";
    uses wson-link-attributes;
}

augment "/nw:networks/nw:network/nw:node/nt:termination-point/"
+ "tet:te" {
    when "/nw:networks/nw:network/nw:network-types"
    + "/tet:te-topology/wson:wson-topology" {
        description "This augment is only valid for WSON";
    }
    description "WSON TP attributes";
    uses wson-tp-attributes;
}

augment "/nw:networks/nw:network/nw:node/tet:te"
+ "/tet:te-node-attributes" {
    when "/nw:networks/nw:network/nw:network-types"
    + "/tet:te-topology/wson:wson-topology" {
        description "This augment is only valid for WSON";
    }
    description "WSON Node augmentation";
    uses wson-node-attributes;
}

augment "/nw:networks/nw:network/nw:node/tet:te"
+ "/tet:tunnel-termination-point" {
    when "/nw:networks/nw:network/nw:network-types"
    + "/tet:te-topology/wson:wson-topology" {
        description "This augment is only valid for WSON";
    }
    description "WSON tunnel termination point augmentation";
    uses wson-ttp-attributes;
}
```

```

/*
 * Augment TE bandwidth
 */

augment "/nw:networks/nw:network/nw:node/nt:termination-point/"
  + "tet:te/"
  + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE bandwidth";
  }
  description
    "Augment maximum LSP WSON bandwidth of link termination point
    (LTP)";
  case wson {
    uses layer0-types:wson-path-bandwidth;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE bandwidth";
  }
  description
    "Augment WSON bandwidth path constraints of
    connectivity-matrices";
  case wson {
    uses layer0-types:wson-link-bandwidth;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE bandwidth";
  }
  description
    "Augment WSON bandwidth path constraints of
    connectivity-matrix";
  case wson {
    uses layer0-types:wson-link-bandwidth;
  }
}

```

```

    }
  }

  augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE bandwidth";
    }
    description
      "Augment WSON bandwidth path constraints of
      connectivity-matrices information-source";
    case wson {
      uses layer0-types:wson-link-bandwidth;
    }
  }

  augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE bandwidth";
    }
    description
      "Augment WSON bandwidth path constraints of
      connectivity-matrix information-source";
    case wson {
      uses layer0-types:wson-link-bandwidth;
    }
  }

  augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:client-layer-adaptation/tet:switching-capability/"
    + "tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE bandwidth";
    }
    description
      "Augment client WSON bandwidth of tunnel termination point
      (TTP)";
    case wson {
      uses layer0-types:wson-link-bandwidth;
    }
  }

```



```

}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/tet:path-constraints/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE bandwidth";
  }
  description
    "Augment WSON bandwidth path constraints of
    local-link-connectivities";
  case wson {
    uses layer0-types:wson-link-bandwidth;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/tet:path-constraints/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE bandwidth";
  }
  description
    "Augment WSON bandwidth path constraints of
    local-link-connectivity (LLC)";
  case wson {
    uses layer0-types:wson-link-bandwidth;
  }
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "WSON TE bandwidth";
  }
  description "Augment maximum LSP WSON bandwidth of TE link";
  case wson {
    uses layer0-types:wson-path-bandwidth;
  }
}

```

```
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "WSON TE bandwidth";
}
description
  "Augment maximum WSON bandwidth of TE link";
case wson {
  uses layer0-types:wson-link-bandwidth;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-resv-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "WSON TE bandwidth";
}
description
  "Augment maximum reservable WSON bandwidth of
  TE link";
case wson {
  uses layer0-types:wson-link-bandwidth;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:unreserved-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "WSON TE bandwidth";
}
description
  "Augment unreserved WSON bandwidth of TE Link";
case wson {
  uses layer0-types:wson-link-bandwidth;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
```

```

    + "tet:interface-switching-capability/"
    + "tet:max-lsp-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../.../.../.../.../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "WSON TE bandwidth";
}
description
    "Augment maximum LSP WSON bandwidth of TE link
    information-source";
case wson {
    uses layer0-types:wson-path-bandwidth;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:max-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../.../.../.../.../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "WSON TE bandwidth";
}
description
    "Augment maximum WSON bandwidth of TE link
    information-source";
case wson {
    uses layer0-types:wson-link-bandwidth;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:max-resv-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../.../.../.../.../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "WSON TE bandwidth";
}
description
    "Augment maximum reservable WSON bandwidth of TE link
    information-source";
case wson {
    uses layer0-types:wson-link-bandwidth;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"

```

```
    + "tet:information-source-entry/"
    + "tet:unreserved-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
when "../.../.../.../nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "WSON TE bandwidth";
}
description
    "Augment unreserved WSON bandwidth of TE link
    information-source";
case wson {
    uses layer0-types:wson-link-bandwidth;
}
}

augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:interface-switching-capability/"
    + "tet:max-lsp-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
description
    "Augment maximum WSON LSP bandwidth of TE link
    template";
case wson {
    uses layer0-types:wson-path-bandwidth;
}
}

augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:max-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
description
    "Augment maximum WSON bandwidth of TE link template";
case wson {
    uses layer0-types:wson-link-bandwidth;
}
}

augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:max-resv-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
description
    "Augment maximum reservable WSON bandwidth of TE link
    template";
case wson {
    uses layer0-types:wson-link-bandwidth;
}
```

```

    }
  }

  augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:unreserved-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
    description
      "Augment unreserved WSON bandwidth of TE link template";
    case wson {
      uses layer0-types:wson-link-bandwidth;
    }
  }

  /*
  * Augment TE label.
  */

  augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:label-restrictions/tet:label-restriction" {
    when "../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
    description
      "Augment WSON label restrictions of connectivity-matrices";
    uses layer0-types:layer0-label-restriction;
  }

  augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/"
    + "tet:te-label/tet:technology" {
    when "../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
    description
      "Augment WSON label restrictions start of
      connectivity-matrices";
    case wson {
      uses layer0-types:wson-link-label;
    }
  }

  augment "/nw:networks/nw:network/nw:node/tet:te/"

```

```

    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:label-restrictions/"
    + "tet:label-restriction/tet:label-end/"
    + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label restrictions end of
    connectivity-matrices";
case wson {
    uses layer0-types:wson-link-label;
}
}
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:label-restrictions/"
    + "tet:label-restriction/tet:label-step/"
    + "tet:technology" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label restrictions step of
    connectivity-matrices";
case wson {
    uses layer0-types:wson-label-step;
}
}
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:underlay/tet:primary-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label hop of underlay primary path of
    connectivity-matrices";
case wson {
    uses layer0-types:wson-path-label;
}
}

```

```

    }
  }

  augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:underlay/tet:backup-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment WSON label hop of underlay backup path of
    connectivity-matrices";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-exclude-objects/"
  + "tet:route-object-exclude-object/"
  + "tet:type/tet:label/tet:label-hop/"
  + "tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment WSON label hop of route-exclude of
    connectivity-matrices";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/"

```

```

    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label hop of route-include of
    connectivity-matrices";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:path-properties/tet:path-route-objects/"
    + "tet:path-route-object/tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology"{
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label hop of path-route of
    connectivity-matrices";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:from/"
    + "tet:label-restrictions/tet:label-restriction" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment ingress WSON label restrictions of
    connectivity-matrix";
    uses layer0-types:layer0-label-restriction;
}

```



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augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:from/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/"
  + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment ingress WSON label restrictions start of
  connectivity-matrix ";
case wson {
  uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:from/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/"
  + "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment ingress WSON label restrictions end of
  connectivity-matrix";
case wson {
  uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:from/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/"
  + "tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}

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    }
    description
      "Augment ingress WSON label restrictions step of
      connectivity-matrix";
    case wson {
      uses layer0-types:wson-label-step;
    }
  }

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment egress WSON label restrictions of
    connectivity-matrix";
  uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/"
  + "tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment egress WSON label restrictions start of
    connectivity-matrix";
  case wson {
    uses layer0-types:wson-link-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/"

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    + "tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
    description
    "Augment egress WSON label restrictions end of
    connectivity-matrix";
    case wson {
    uses layer0-types:wson-link-label;
    }
    }

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:to/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/"
    + "tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
    description
    "Augment egress WSON label restrictions step of
    connectivity-matrix";
    case wson {
    uses layer0-types:wson-label-step;
    }
    }

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:primary-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
    description
    "Augment WSON label hop of underlay primary path of
    connectivity-matrix";
    case wson {

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    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:underlay/tet:backup-path/tet:path-element/"
  + "tet:type/tet:label/tet:label-hop/"
  + "tet:te-label/tet:technology" {
  when "../../../../../../../../../../../../../../../"
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment WSON label hop of underlay backup path of
    connectivity-matrix";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:optimizations/"
  + "tet:algorithm/tet:metric/tet:optimization-metric/"
  + "tet:explicit-route-exclude-objects/"
  + "tet:route-object-exclude-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../../../../../../../../../../../../../../../"
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment WSON label hop of route-exclude of
    connectivity-matrix";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:optimizations/"
  + "tet:algorithm/tet:metric/tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"

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    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label hop of route-include of
    connectivity-matrix";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-properties/tet:path-route-objects/"
    + "tet:path-route-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label hop of path-route of
    connectivity-matrix";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/"
    + "tet:connectivity-matrices/tet:label-restrictions/"
    + "tet:label-restriction" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label restrictions of connectivity-matrices
    information-source";
    uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/nw:network/nw:node/tet:te/"

```

```

    + "tet:information-source-entry/"
    + "tet:connectivity-matrices/tet:label-restrictions/"
    + "tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions start of
  connectivity-matrices information-source";
case wson {
  uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/"
  + "tet:connectivity-matrices/tet:label-restrictions/"
  + "tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions end of
  connectivity-matrices information-source";
case wson {
  uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/"
  + "tet:connectivity-matrices/tet:label-restrictions/"
  + "tet:label-restriction/"
  + "tet:label-step/tet:technology" {
when "../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions step of
  connectivity-matrices information-source";

```

```

    case wson {
      uses layer0-types:wson-label-step;
    }
  }

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "...../"
      + "nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
        description "Augment WSON TE label";
      }
    description
      "Augment WSON label hop of underlay primary path of
      connectivity-matrices information-source";
    case wson {
      uses layer0-types:wson-path-label;
    }
  }

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "...../"
      + "nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
        description "Augment WSON TE label";
      }
    description
      "Augment label hop of underlay backup path of
      connectivity-matrices information-source";
    case wson {
      uses layer0-types:wson-path-label;
    }
  }

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-exclude-objects/"
  + "tet:route-object-exclude-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "...../"
      + "nw:network-types/tet:te-topology/"

```

```

    + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
  description
    "Augment WSON label hop of route-exclude of
     connectivity-matrices information-source";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
  description
    "Augment WSON label hop of route-include of
     connectivity-matrices information-source";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
  description
    "Augment WSON label hop of path-route of connectivity-matrices
     information-source";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

```



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augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/tet:label-restriction" {
when "../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment ingress WSON label restrictions of
  connectivity-matrix information-source";
uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/"
  + "tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment ingress WSON label restrictions start of
  connectivity-matrix information-source";
case wson {
  uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/"
  + "tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment ingress WSON label restrictions end of
  connectivity-matrix information-source";
case wson {

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    uses layer0-types:wson-link-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/"
  + "tet:label-restriction/"
  + "tet:label-step/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment ingress WSON label restrictions step of
    connectivity-matrix information-source";
  case wson {
    uses layer0-types:wson-label-step;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:to/tet:label-restrictions/tet:label-restriction" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment egress WSON label restrictions of connectivity-matrix
    information-source";
  uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:to/tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
}

```

```

    description
      "Augment egress WSON label restrictions start of
       connectivity-matrix information-source";
    case wson {
      uses layer0-types:wson-link-label;
    }
  }

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:to/tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment egress WSON label restrictions end of
     connectivity-matrix information-source";
  case wson {
    uses layer0-types:wson-link-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:to/tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment egress WSON label restrictions step of
     connectivity-matrix information-source";
  case wson {
    uses layer0-types:wson-label-step;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"

```

```

    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label hop of underlay primary path of
    connectivity-matrix information-source";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment WSON label hop of underlay backup path of
    connectivity-matrix information-source";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
    description "Augment WSON TE label";
    }
description
    "Augment label hop of route-exclude of connectivity-matrix
    information-source";

```

```

    case wson {
      uses layer0-types:wson-path-label;
    }
  }

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of route-include of
  connectivity-matrix information-source";
case wson {
  uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of path-route of connectivity-matrix
  information-source";
case wson {
  uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"

```

```
+ "tet:label-restrictions/tet:label-restriction" {
when "../../../nw:network-types/tet:te-topology/"
+ "wson:wson-topology" {
description "Augment WSON TE label";
}
description
"Augment WSON label restrictions of
local-link-connectivities";
uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:tunnel-termination-point/"
+ "tet:local-link-connectivities/"
+ "tet:label-restrictions/tet:label-restriction/"
+ "tet:label-start/"
+ "tet:te-label/tet:technology" {
when "../../../nw:network-types/tet:te-topology/"
+ "wson:wson-topology" {
description "Augment WSON TE label";
}
description
"Augment WSON label restrictions start of
local-link-connectivities";
case wson {
uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:tunnel-termination-point/"
+ "tet:local-link-connectivities/"
+ "tet:label-restrictions/tet:label-restriction/"
+ "tet:label-end/"
+ "tet:te-label/tet:technology"{
when "../../../nw:network-types/tet:te-topology/"
+ "wson:wson-topology" {
description "Augment WSON TE label";
}
description
"Augment WSON label restrictions end of
local-link-connectivities";
case wson {
uses layer0-types:wson-link-label;
}
}
```

```

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/"
  + "tet:technology" {
when "../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions step of
  local-link-connectivities";
case wson {
  uses layer0-types:wson-label-step;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of underlay primary path of
  local-link-connectivities";
case wson {
  uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description

```

```

    "Augment WSON label hop of underlay backup path of
      local-link-connectivities";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:tunnel-termination-point/"
+ "tet:local-link-connectivities/"
+ "tet:optimizations/tet:algorithm/tet:metric/"
+ "tet:optimization-metric/"
+ "tet:explicit-route-exclude-objects/"
+ "tet:route-object-exclude-object/tet:type/"
+ "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment WSON label hop of route-exclude of
      local-link-connectivities";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:tunnel-termination-point/"
+ "tet:local-link-connectivities/"
+ "tet:optimizations/tet:algorithm/tet:metric/"
+ "tet:optimization-metric/"
+ "tet:explicit-route-include-objects/"
+ "tet:route-object-include-object/tet:type/"
+ "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
    description "Augment WSON TE label";
  }
  description
    "Augment label hop of route-include of
      local-link-connectivities";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

```



```

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of path-route of
  local-link-connectivities";
case wson {
  uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:label-restrictions/tet:label-restriction" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions of
  local-link-connectivity (LLC)";
uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions start of
  local-link-connectivity (LLC)";

```

```

    case wson {
      uses layer0-types:wson-link-label;
    }
  }

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
  description
    "Augment WSON label restrictions end of
    local-link-connectivity (LLC)";
  case wson {
    uses layer0-types:wson-link-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
  when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
  description
    "Augment WSON label restrictions step of
    local-link-connectivity (LLC)";
  case wson {
    uses layer0-types:wson-label-step;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"

```

```

    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
description "Augment WSON TE label";
}
description
    "Augment WSON label hop of underlay primary path of
    local-link-connectivity (LLC)";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
description "Augment WSON TE label";
}
description
    "Augment WSON label hop of underlay backup path of
    local-link-connectivity (LLC)";
case wson {
    uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "wson:wson-topology" {
description "Augment WSON TE label";
}
description

```

```

    "Augment WSON label hop of route-exclude of
      local-link-connectivity (LLC)";
  case wson {
    uses layer0-types:wson-path-label;
  }
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:tunnel-termination-point/"
+ "tet:local-link-connectivities/"
+ "tet:local-link-connectivity/"
+ "tet:optimizations/tet:algorithm/tet:metric/"
+ "tet:optimization-metric/"
+ "tet:explicit-route-include-objects/"
+ "tet:route-object-include-object/tet:type/"
+ "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
+ "nw:network-types/tet:te-topology/"
+ "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of route-include of
    local-link-connectivity (LLC)";
case wson {
  uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:tunnel-termination-point/"
+ "tet:local-link-connectivities/"
+ "tet:local-link-connectivity/"
+ "tet:path-properties/tet:path-route-objects/"
+ "tet:path-route-object/tet:type/"
+ "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
+ "nw:network-types/tet:te-topology/"
+ "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of path-route of
    local-link-connectivity (LLC)";
case wson {
  uses layer0-types:wson-path-label;
}
}
}

```

```

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of underlay primary path of TE link";
case wson {
  uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label hop of underlay backup path of TE link";
case wson {
  uses layer0-types:wson-path-label;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction" {
when "../.../.../.../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions of TE link";
uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {

```

```
when "../../../../../../../nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions start of TE link";
case wson {
  uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
when "../../../../../../../nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions end of TE link";
case wson {
  uses layer0-types:wson-link-label;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
when "../../../../../../../nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
description
  "Augment WSON label restrictions step of TE link";
case wson {
  uses layer0-types:wson-label-step;
}
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:label-restrictions/tet:label-restriction" {
when "../../../../../../../nw:network-types/tet:te-topology/"
  + "wson:wson-topology" {
  description "Augment WSON TE label";
}
}
```

```

    description
      "Augment WSON label restrictions of TE link
       information-source";
    uses layer0-types:layer0-label-restriction;
  }

  augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
    when "../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
    description
      "Augment WSON label restrictions start of TE link
       information-source";
    case wson {
      uses layer0-types:wson-link-label;
    }
  }

  augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
    when "../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
    description
      "Augment WSON label restrictions end of TE link
       information-source";
    case wson {
      uses layer0-types:wson-link-label;
    }
  }

  augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
    when "../..../nw:network-types/tet:te-topology/"
      + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
    description
      "Augment WSON label restrictions step of TE link

```

```
        information-source";
    case wson {
        uses layer0-types:wson-label-step;
    }
}

augment "/nw:networks/tet:te/tet:templates/"
+ "tet:link-template/tet:te-link-attributes/"
+ "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
+ "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    description
        "Augment WSON label hop of underlay primary path of TE link
        template";
    case wson {
        uses layer0-types:wson-path-label;
    }
}

augment "/nw:networks/tet:te/tet:templates/"
+ "tet:link-template/tet:te-link-attributes/"
+ "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
+ "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    description
        "Augment WSON label hop of underlay backup path of TE link
        template";
    case wson {
        uses layer0-types:wson-path-label;
    }
}

augment "/nw:networks/tet:te/tet:templates/"
+ "tet:link-template/tet:te-link-attributes/"
+ "tet:label-restrictions/tet:label-restriction" {
    description
        "Augment WSON label restrictions of TE link template";
    uses layer0-types:layer0-label-restriction;
}

augment "/nw:networks/tet:te/tet:templates/"
+ "tet:link-template/tet:te-link-attributes/"
+ "tet:label-restrictions/tet:label-restriction/"
+ "tet:label-start/tet:te-label/tet:technology" {
    description
        "Augment WSON label restrictions start of TE link template";
    case wson {
        uses layer0-types:wson-link-label;
    }
}
```



```
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
  description
    "Augment WSON label restrictions end of TE link template";
  case wson {
    uses layer0-types:wson-link-label;
  }
}

augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
  description
    "Augment WSON label restrictions step of TE link template";
  case wson {
    uses layer0-types:wson-label-step;
  }
}
}

<CODE ENDS>
```

4. Security Considerations

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

The NETCONF Protocol over Secure Shell (SSH) [RFC6242] describes a method for invoking and running NETCONF within a Secure Shell (SSH) session as an SSH subsystem. The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative

effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

```
/nw:networks/nw:network/nw:network-types/tet:te-topology
/nw:networks/nw:network/nt:link/tet:te/tet:te-link-attributes
/nw:networks/nw:network/nw:node/nt:termination-point/tet:te
/nw:networks/nw:network/.../tet:te-bandwidth/tet:technology
/nw:networks/nw:network/nw:node/tet:te/.../tet:label-restriction
/nw:networks/nw:network/nw:node/.../tet:te-label/tet:technology
```

5. IANA Considerations

It is proposed that IANA should assign new URIs from the "IETF XML Registry" [RFC3688] as follows:

```
URI: urn:ietf:params:xml:ns:yang:ietf-wson-topology
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.
```

This document registers a YANG module in the YANG Module Names registry [RFC7950] and [RFC6020].

```
name:          ietf-wson-topology
namespace:     urn:ietf:params:xml:ns:yang:ietf-wson-topology
prefix:        wson
reference:      RFC XXXX
```

6. Contributors

Dhruv Dhody
Huawei Technologies
Email: dhruv.ietf@gmail.com

Bin Yeong Yoon
ETRI
Email: byyun@etri.re.kr

Ricard Vilalta
CTTC
Email: vricard.vilalta@cttc.es

Italo Busi
Huawei Technologies
Email: Italo.Busi@huawei.com

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Authors' Addresses

Haomian Zheng
Huawei Technologies
H1-1-A043S Huawei Industrial Base, Songshanhu
Dongguan, Guangdong 523808
China

Email: zhenghaomian@huawei.com

Young Lee
SKKU
Sung Kyun Kwan University
Seoul
South Korea

Email: younglee.tx@gmail.com

Aihua Guo
Individual

Email: aihuaguo.ietf@gmail.com

Victor Lopez
Telefonica

Email: victor.lopezalvarez@telefonica.com

Daniel King
University of Lancaster

Email: d.king@lancaster.ac.uk

Network Working Group
Internet Draft
Intended status: Informational

Y. Jiang
F. Yang
I. Busi
Huawei
J. Wang
Fiberhome

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Problem Statements of FlexE Interface Management
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Abstract

This document outlines the problem statements for FlexE interface management; it also gives an analysis of configuration requirements for Flex Ethernet (FlexE) interface management. Requirements on FlexE interface management are summarized in the end.

Status of this Memo

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

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Table of Contents

1.	Introduction	2
1.1.	Conventions used in this document	3
1.2.	Terminology	4
2.	Problem statements	4
2.1.	Overview of FlexE management	4
2.2.	Considerations on parameters in FlexE Overhead ...	5
2.2.1.	Static or configurable	6
2.2.2.	Negotiation enable or not	7
2.2.3.	Management of FlexE clients	7
2.3.	Considerations on bidirectional transport	8
3.	Requirements	9
4.	Security Considerations	10
5.	IANA Considerations	10
6.	References	10
6.1.	Normative References	10
6.2.	Informative References	10
7.	Acknowledgments	10

1. Introduction

The Flex Ethernet (FlexE) 2.0 Implementation Agreement [FLEXE] defined by the OIF provides the support of a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. This includes MAC rates that are both greater than (through bonding) and less than (through sub-rate and channelization) the Ethernet PHY rates used to carry FlexE.

Besides 100GBASE-R PHYs as supported in FlexE 1.0, FlexE 2.0 supports the bonding of 200GBASE-R PHYs or 400GBASE-R PHYs respectively. FlexE 2.1 further supports the bonding of 50GBASE-R PHYs.

According to [FLEXE], FlexE supports the following features:

- Bonding of multiple ETH PHYs (1~254)

- Sub-rates of ETH PHY (minimum of 5G to maximum capacity of bandwidth in a PHY)
- Channelization within a PHY or a group of bonded PHYs ($5G \sim k \cdot 5G$, combination of multiple slots, where each slot can be allocated from any PHY)

In the FlexE, multiple Ethernet PHYs (each PHY can further consist of one or more FlexE Instances) are bonded into a FlexE Group, and the total capacity of the FlexE Group is represented as a collection of slots (e.g., each slot has a granularity of 5Gbps or 25Gbps). Based on their bandwidth needs, FlexE Clients are each allocated with one or more slots in a FlexE group. The FlexE mechanism operates by using a calendar consisting of these slots.

This calendar is partitioned into sub-calendars for each PHY (earlier than FlexE 2.0) or sub-calendars for each FlexE instance (FlexE 2.0 and above). For example, the calendar for a FlexE Group composed of n 100G PHYs is partitioned into $20n$ slots (each slot representing 5Gbps of bandwidth when the slot granularity is 5Gbps).

Some FlexE use cases are introduced in details in [flexe-usecases].

This document describes the problem statements for FlexE interface management to support the transport of FlexE clients over a FlexE Group between two FlexE nodes. The equipment can be routers or optical transport products, which can support FlexE interfaces. Multiple hops of FlexE aware transport in OTN or MTN is out of the scope of this document.

1.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.2. Terminology

Terminologies used in this document are extracted from [FLEXE].

FlexE: Flex Ethernet.

FlexE Client: An Ethernet flow based on a MAC data rate that may or may not correspond to any Ethernet PHY rate, the format of the FlexE Client is simply a logically serial stream of 66B blocks at a given rate.

FlexE Group: A FlexE Group is composed of from 1 to n Ethernet PHYs.

FlexE Instance: A FlexE Instance is a unit of information consisting of 100G of capacity able to carry FlexE Client data, together with its associated overhead.

Ethernet PHY: an entity representing Ethernet Physical Coding Sublayer (PCS), Physical Media Attachment (PMA), and Physical Media Dependent (PMD) layers. Each PHY is consisted of one or more FlexE Instance (e.g., a 400GBASE-R PHY has four FlexE Instances).

FlexE Calendar: The total capacity of a FlexE Group is represented as a collection of slots. The calendar for a FlexE Group composed of n PHYs is represented in each PHY as an array of slots (e.g., each representing 5Gbps of bandwidth), i.e., calendar-slot-list.

CCA: Calendar Configuration A

CCB: Calendar Configuration B

2. Problem statements

2.1. Overview of FlexE management

Figure 1 depicts the overview diagram of FlexE management for a FlexE Group between PE1 and PE2, where PE1 and PE2 are network equipments such as routers or OTN products. SDN/NMS may control or manage the FlexE Group between PE1 and PE2 by interactions with PE1 and PE2 separately (by using Netconf or Restconf to connect with a management or control agent on each PE node).

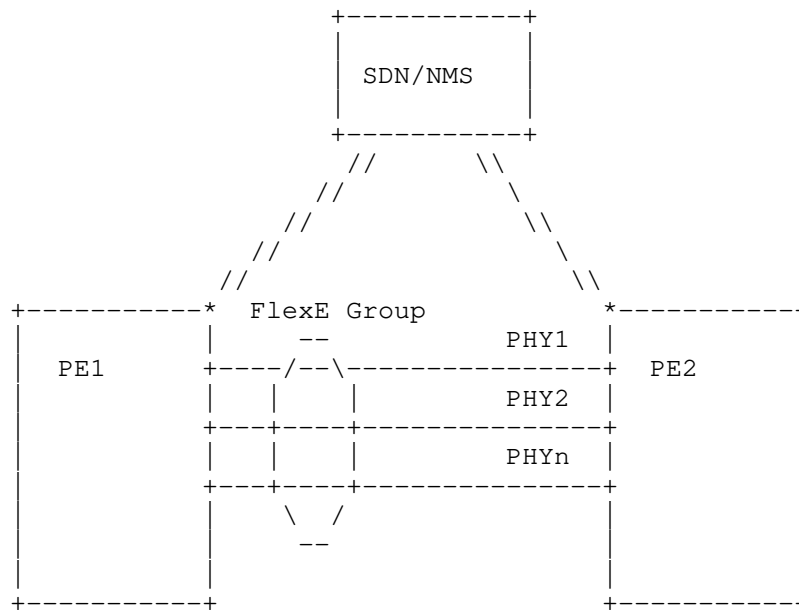


Figure 1: FlexE management overview

2.2. Considerations on parameters in FlexE Overhead

The OIF specifies how the configuration and verification of a FlexE Group can be realized in Section 7.3 of [FLEXE]. A FlexE Overhead Frame is defined in [FLEXE] to convey FlexE group specific information from PE1 to PE2, including configuration information (FlexE Group Number, FlexE Map, FlexE PHY/Instance Number, CCA and CCB), status information (RPF) and signaling information (CC, CR and CA).

The configuration information in the overhead frame is used by the receiving side to verify that both ends are properly configured with the same set of values in a FlexE Group. If PE2 finds out that the configuration

information in the overhead sent from PE1 does not match its own configuration, a mismatch alarm should be raised.

Note: Two calendar configurations are used in the FlexE data plane to facilitate reconfiguration, i.e., CCA and CCB. They are actually two lists (e.g., each list is 20*2Bytes for a PHY of 100GBASE-R; or 4*20*2Bytes for a PHY of 400GBASE-R) wherein each list item indicates the client number carried in a calendar slot. At any given time, only one of the calendar configurations is active and used for mapping the FlexE Clients into the FlexE Group and demapping the FlexE Clients from the FlexE Group. When a switch of calendar configurations adds/removes/resizes FlexE Clients in a FlexE Group, the switching does not affect existing clients whose size and calendar slot assignments are not changed.

Status information indicates status of the bonded PHYs, currently only RPF (Remote PHY Fault) is defined in [FLEXE], which informs the far-end of a locally detected failure of the PHY if set to one.

The signaling information can be used to coordinate the switching from the active calendar configuration (e.g., CCA) to the backup calendar configuration (e.g., CCB) between PE1 and PE2. As described in 7.3.4 of [FLEXE], CC, CR and CA are used to coordinate the switching of calendar A to calendar B or vice versa between the FlexE mux and FlexE demux (i.e., the source and the sink of a FlexE group). The protocol is optional to implement.

2.2.1. Static or configurable

If the FlexE is static, a FlexE Group is composed of a fixed number of FlexE PHYs, e.g., simple bonding for a single fixed client; fixed calendar configuration. That means, there is no need to configure a device or it is impossible to configure the device. Some simple implementations only support static configuration.

If the FlexE is configurable, the FlexE parameters can be controlled by a SDN controller or be configured by a network management system (NMS).

A FlexE static PE usually interconnect with another PE in FlexE static (it is required that both PEs implement a FlexE group with exact the same set of fixed parameter

values). However, sometimes there is a need to interconnect one FlexE static PE with another PE in FlexE configurable if the latter is properly configured with the same set of fixed parameter values.

2.2.2. Negotiation enable or not

[FLEXE] uses two calendar configurations (i.e., CCA and CCB) to facilitate client reconfiguration. Furthermore, Section 7.3 of [FLEXE] specifies a dynamic negotiation protocol (by signaling in the FlexE overhead) for the automatic switching of calendars in a FlexE Group. If this negotiation protocol is enabled (if one PE enables negotiation, the other PE MUST enable negotiation too), a receiving PE (i.e., slave) can further extract the configuration information (particularly CCA and CCB) from the FlexE overhead and multi-frame sent from a sending PE (i.e., master).

It seems that the slave does not need to configure any FlexE parameters if negotiation protocol is enabled. However, from the viewpoint of bidirectional transport, a receiving PE in one direction is also acting as a sending PE in the other direction. Furthermore, FlexE group and its bonding PHYs must be configured firstly so that FlexE overhead channel can be set up for the signaling protocol to work properly. Therefore, FlexE configuration is needed on both side of PEs even if negotiation is enabled.

Since the dynamic signaling of CC, CR and CA is done automatically in the data plane (especially, CR and CA are request and acknowledgement exchanged dynamically over the FlexE overhead, CC decides whether CCA or CCB is active), the mechanism works on the FlexE data plane independent from the management plane. Exposing all these signaling information to the management plane is not only unnecessary, but also greatly complicates the operations of FlexE. Thus, it is not needed to configure or retrieve these ephemeral signaling states.

2.2.3. Management of FlexE clients

The following management of FlexE clients needs to be supported:

- Add a client or clients

- Delete a client or clients
- resize a client or clients
- adjust slot locations for a client or clients

If the negotiation protocol is not enabled, management of FlexE clients (add/delete/resize/adjust) usually is a sequential action to the current calendar of each FlexE PE, and retrieval of the calendar configuration values is also based on the active calendar. Thus, synchronous switching from the active calendar configuration to the backup calendar configuration is not needed. However, some client traffic may be lost during the reconfiguration.

If the negotiation protocol is enabled, management of FlexE clients (add/delete/resize/adjust) usually is a sequential action to the backup calendar of each FlexE PE. Then dynamic negotiation as described in Section 2.2.2 controls peer PEs to switch the backup calendar configuration into the active calendar configuration synchronously. The switching is hitless since the client traffic is not lost during the reconfiguration, thus it is recommended to be the default working mode. Moreover, retrieval of the calendar configuration values SHOULD be based on the new active calendar after protocol convergence (the convergence time is expected to be around 10ms calculated according to [FLEXE]).

In either cases, the management plane only needs to deal with a single calendar, and there is no need to monitor whether the calendar is CCA or CCB from the SDN/NMS point of view.

2.3. Considerations on bidirectional transport

OIF only discusses the configuration of a unidirectional client.

In fact, the overhead signaling of CR and CA relies on a bidirectional channel in the same FlexE Group.

Furthermore, the FlexE links (including each of the bonding PHYs) are always bidirectional, and FlexE clients

are usually reserved with the same number of slots (or bandwidth) in both directions over the same FlexE link. For a FlexE client, the expected value of FlexE parameters to be received will be the same as the values of those parameters configured in the transmit direction on the same PE, thus the expected parameters are not needed to be configured explicitly. If the received parameters are not the same values as those parameters configured locally, a PE should report the mismatch to the SDN controller/NMS. Examples of mismatch may include: FlexE group number mismatch, FlexE PHY number mismatch, Calendar configuration Mismatch, and etc.).

3. Requirements

This section summarizes the management requirements of FlexE interfaces.

- a). Support of a flexible FlexE group bonding with one to 254 Ethernet PHYs, the Ethernet PHY types may include 50 GBASE-R, 100GBASE-R, 200GBASE-R and 400GBASE-R.
- b). Support add/remove Ethernet PHYs to/from a FlexE group, the range of FlexE PHY number still follows a).
- c). Support of flexible FlexE client management in a FlexE group, and the total clients number can be in a range of from 0 to a value equal to the maximum number of slots in the FlexE group (that is, each client is allocated a single slot).
- d). Support add/delete/resize FlexE clients in a FlexE group without impacts on the traffic of any existing FlexE clients in the same FlexE group, the range of FlexE client number still follows c).
- e). Support FlexE static or FlexE configurable operations.
- f). Support coordination of calendar updates and switchover by enabling FlexE negotiation between peer FlexE PEs.
- g). Support a client with bidirectional slot allocation while its bandwidth can be inferred from the allocated slot number and slot granularity.

h). Support retrieval status of a FlexE group, a FlexE PHY, or a FlexE client.

i). Management shall be compatible as much as possible with all OIF FlexE versions, including 1.0, 1.1, 2.0 and 2.1.

4. Security Considerations

This document gives the problem statements for FlexE management, and summarizes the requirements. As no solution is discussed in this document, no security concerns are raised.

5. IANA Considerations

There are no IANA actions required by this document.

6. References

6.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, May 2017

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Authors' Addresses

Yuanlong Jiang
Huawei Technologies Co., Ltd.
Bantian, Longgang district
Shenzhen 518129, China
Email: jiangyuanlong@huawei.com

Fan Yang
Huawei Technologies Co., Ltd.
Huawei Campus, No. 156 Beiqing Rd.
Beijing 100095
Email: shirley.yangfan@huawei.com

Italo Busi
Huawei Technologies Co., Ltd.
HUAWEI TECHNOLOGIES ITALIA Srl Centro Direzionale Milano 2
Milan, Milan 20090, Italy
Email: Italo.Busi@huawei.com

Junfang Wang
Fiberhome
Email: wjf@fiberhome.com

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Y. Jiang
X. He
Huawei
W. Cheng
China Mobile
J. Wang
Y. Han
Fiberhome

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YANG Data Model for FlexE Interface Management
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Abstract

This document defines YANG data models for the configuration of Flex Ethernet (FlexE) interfaces, including a FlexE group and its FlexE clients. The YANG modules in this document conforms to the Network Management Datastore Architecture (NMDA).

Status of this Memo

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Table of Contents

1.	Introduction	2
1.1.	Conventions used in this document	3
1.2.	Terminology	3
2.	YANG model hierarchy for FlexE interfaces	4
3.	YANG Module for FlexE group interface	7
4.	YANG Module for FlexE client interface	14
5.	Security Considerations	16
6.	IANA Considerations	18
7.	References	18
7.1.	Normative References	18
7.2.	Informative References	19
8.	Acknowledgments	20

1. Introduction

The Flex Ethernet (FlexE) 2.0 Implementation Agreement [FLEXE] defined by the OIF provides the support of a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. This includes MAC rates that are both greater than (through bonding) and less than (through sub-rate and channelization) the Ethernet PHY rates used to carry FlexE. Besides 100GBASE-R PHYs, FlexE 2.0 further supports the bonding of 200GBASE-R PHYs or 400GBASE-R PHYs respectively.

In the FlexE, multiple Ethernet PHYs (each PHY can further consist of one or more FlexE Instances) are bonded into a FlexE Group, and the total capacity of the FlexE Group is represented as a collection of slots (e.g., each slot has a granularity of 5Gbps or 25Gbps). Based on their bandwidth needs, FlexE Clients are each mapped into one or more slots in a FlexE group. The FlexE mechanism operates using a calendar consisting of these slots.

This calendar is partitioned into sub-calendars for each PHY (earlier than FlexE 2.0) or sub-calendars for each FlexE instance (FlexE 2.0 and above). For example, the calendar for a FlexE Group composed of n 100G PHYs is partitioned into 20n slots (each slot representing 5Gbps of bandwidth when the slot granularity is 5Gbps).

[FLEXE-PS] discusses the problem statements and requirements for FlexE interface management.

This document defines a YANG data model for the configuration of a Flex Ethernet interface (i.e., FlexE Group). The data model is augmented based on the generic interfaces data model as defined in [RFC8343], the FlexE attributes are based on the FlexE 2.0 Implementation Agreement as specified in [FLEXE]. With the help of this YANG data module, the FlexE Groups can be managed conveniently as ordinary network interfaces on a network device (e.g., a router or bridge).

This document also defines a YANG data model for the configuration of a Flex Ethernet client interface (i.e., FlexE Client). The data model is augmented based on the generic interfaces data model as defined in [RFC8343], currently it only includes mac-address and group-number attributes for a FlexE client.

The YANG modules in this document conforms to the Network Management Datastore Architecture (NMDA) [RFC8342].

1.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.2. Terminology

Most terminologies used in this document are extracted from [FLEXE].

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FlexE Group: A FlexE Group is composed of from 1 to n Ethernet PHYs.

FlexE Instance: A FlexE Instance is a unit of information consisting of 100G of capacity able to carry FlexE Client data, together with its associated overhead.

Ethernet PHY: an entity representing Ethernet Physical Coding Sublayer (PCS), Physical Media Attachment (PMA), and Physical Media

Dependent (PMD) layers. Each PHY is consisted of one or more FlexE Instance (e.g., a 400GBASE-R PHY has four FlexE Instances).

FlexE Calendar: The total capacity of a FlexE Group is represented as a collection of slots. The calendar for a FlexE Group composed of n PHYs is represented in each PHY as an array of slots (e.g., each representing 5Gbps of bandwidth), i.e., calendar-slot-list.

2. YANG model hierarchy for FlexE

This section describes the hierarchy of the YANG modules for the FlexE interface management and the FlexE client interface.

Configuration and status of FlexE group interface information include:

- flexe-group specifies a management interface for configuration of a FlexE group.
- flexe-phy-list specifies a list of PHYs in a Flex Group.
- flexe-client-list specifies a list of FlexE client, each client is mapped to some slots in this FlexE group. flexe-client-if references to a FlexE client interface. flexe-client-status indicates whether there is any fault in local or remote for this client.

Configuration and status of FlexE client interface information include:

- flexe-group specifies the FlexE Group number of the FlexE group to which this FlexE client belongs.
- mac-address specifies the MAC address for a FlexE client.

A flag calendar-protocol-enable is added to indicate that whether FlexE calendar negotiation protocol as described in Section 7.3 of [FLEXE] is enabled or not.

The readers are assumed to be familiar with FlexE 2.0, as all FlexE terminologies are described in details in [FLEXE].

In order to simplify the YANG module of the FlexE interface and to follow the YANG style of terminology, the full calendar in FlexE is not modelled explicitly. However, a calendar-slot-list per PHY is modeled which represents all the slots in a PHY (i.e., slots in all sub-calendars of the FlexE instances in this PHY), and the calendar

is actually a conglomerate of all the slots in calendar-slot-lists for all FlexE PHYs of this FlexE Group.

From FlexE 2.0 on, concept of "FlexE Instance" is introduced, which is equivalent to 100GBASE-R PHY, and slots for each instance is used and carried in the overhead. However, we decide not to model the instance, for the following reasons:

- instance numbers can be inferred from the FlexE PHY, and any slot in an instance is corresponding to a slot in a PHY;
- instance is an internal logical construct, there is no benefit in exposing it for management;
- instance is only introduced after FlexE 2.0, its construct will not be compatible with the early versions of FlexE. A simplified YANG tree diagram [RFC8340] representing the data model is typically used by YANG modules. This document uses the same tree diagram syntax as described in [RFC8340].

A tree diagram of the module for FlexE group interface is depicted as the following:

```
module: ietf-flexe
  augment /if:interfaces/if:interface:
    +--rw flexe-group
      +--rw group-number?          uint32
      +--rw slot-granularity?      slot-granularity-enumeration
      +--rw flexe-phy-type?        flexe-phy-enumeration
      +--rw calendar-protocol-enable? boolean
      +--rw flexe-phy-list* [flexe-phy-if]
        +--rw flexe-phy-if?        if:interface-ref
        +--rw phy-number           uint8
        +--ro flexe-phy-status?     phy-status-enumeration
        +--rw calendar-slot-list* [slot-id]
          +--rw slot-id            uint8
          +--rw flexe-slot-status?  slot-status-enumeration
      +--rw flexe-client-list* [client-id]
        +--rw client-id            uint16
        +--rw flexe-client-if?     if:interface-ref
        +--rw client-slot-list* [client-slot-id]
          +--rw client-slot-id      uint8
          +--rw mapped-phy-if?      if:interface-ref
          +--rw mapped-slot-id      uint8
          +--ro flexe-client-status? client-status-enumeration
      +--ro flexe-group-status?    uint8
```

A tree diagram of the module for FlexE client interface is depicted as the following:

```
module: ietf-interfaces-flexec-client
  augment /if:interfaces/if:interface:
    +--rw flexec-client
      +--ro mac-address
      +--rw group-number?          uint32
```


3. YANG Module for FlexE group interface

The following YANG data module augments the interface container defined in RFC 8343 for a FlexE group interface. It imports iana-if-type [RFC7224] and ietf-interfaces [RFC8343].

```
<CODE BEGINS> file "ietf-flexex@2019-10-30.yang"
module ietf-flexex {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-flexex";
  prefix "flexex";

  import iana-if-type {
    prefix ianaift;
  }
  import ietf-interfaces {
    prefix if;
    reference
      "RFC8343: A YANG Data Model for Interface Management";
  }

  organization "IETF CCAMP Working Group";
  contact
    "WG Web:  http://tools.ietf.org/wg/ccamp/
    WG List:  <mailto:ccamp@ietf.org>
    Author:   Yuanlong Jiang
              <mailto:jiangyuanlong@huawei.com>
    Author:   Xiang He
              <mailto:hexiang@huawei.com>
    Author:   Weiqiang Cheng
              <mailto:chengweiqiang@chinamobile.com>
    Author:   Junfang Wang
              <mailto:wjf@fiberhome.com>
    Author:   Yalei Han
              <mailto:ylhan@fiberhome.com>";

  description
    "This YANG module defines a data model for the configuration
    of FlexE interface.";

  revision "2019-10-30" {
    description "Initial version";
    reference
      "draft-jiang-ccamp-flexex-yang-02: YANG Data Model for FlexE
      Interface Management ";
  }
}
```

```
identity flexEthernet {
  base ianaift:iana-interface-type;
  description
    "Flex Ethernet.";
}

typedef slot-granularity-enumeration {
  type enumeration {
    enum slot-5g {
      value 1;
      description
        "5Gbps per slot.";
    }
    enum slot-25g {
      value 2;
      description
        "25Gbps per slot.";
    }
    enum slot-others {
      value 254;
      description
        "Other type of granularities per slot.";
    }
  }
  description
    "The bandwidth granularity of a slot. Options for this
    enumeration are specified by the OIF standard, currently only
    5G and 25G are defined.";
  reference
    "OIF Flex 2.0: Section 6.7";
}

typedef slot-status-enumeration {
  type enumeration {
    enum unavailable {
      value 1;
      description
        "slot is unavailable for a FlexE client.";
    }
    enum unused {
      value 2;
      description
        "slot is unused.";
    }
    enum used {
      value 3;
      description

```

```
        "slot is used.";
    }
}
description
    "The status of a slot in a PHY. Options for this enumeration
    are specified by the OIF standard, 'used' is implicit.";
reference
    "OIF Flex 2.0: Section 7.3.4 and Section 7.6";
}

typedef flexe-phy-enumeration {
    type enumeration {
        enum 'PHY-100GBASE-R' {
            value 1;
            description
                "100GBASE-R PHY, as defined in FlexE 1.0.";
        }
        enum 'PHY-200GBASE-R' {
            value 2;
            description
                "200GBASE-R PHY, as defined in FlexE 2.0.";
        }
        enum 'PHY-400GBASE-R' {
            value 3;
            description
                "400GBASE-R PHY, as defined in FlexE 2.0.";
        }
        enum 'PHY-50GBASE-R' {
            value 4;
            description
                "50GBASE-R PHY, as defined in FlexE 2.1.";
        }
    }
}

description
    "The current type of PHYs bonded in a FlexE Group. Values for
    this enumeration are specified by the OIF standard.";
reference
    "OIF Flex 2.0 and 2.1: Section 5.2.1.5";
}

typedef phy-status-enumeration {
    type enumeration {
        enum phy-status-OK {
            value 0;
            description
                "The FlexE PHY status is ok";
        }
    }
}
```

```
    }
    enum phy-status-LOF {
        value 1;
        description
            "The FlexE PHY status is Loss of Frame";
    }
    enum phy-status-RPF {
        value 2;
        description
            "The FlexE PHY status is Remote PHY Fault";
    }
    enum phy-status-LPF {
        value 3;
        description
            "The FlexE PHY status is Local PHY Fault";
    }
}
description
    "The current PHY status. RPF, LPF, LOF and OK are defined.";
reference
    "OIF Flex 2.0: Section 7.3.8";
}
```

```
typedef client-status-enumeration {
    type enumeration {
        enum flexe-client-status-OK {
            value 0;
            description
                "The FlexE client status is OK";
        }
        enum flexe-client-status-LF {
            value 1;
            description
                "The FlexE client status is Local Fault";
        }
        enum flexe-client-status-RF {
            value 2;
            description
                "The FlexE client status is Remote Fault";
        }
    }
}
description
    "The client status. RPF, LPF and OK are defined.";
reference
    "OIF Flex 2.0: Section 7.3.8";
```

```
}

augment "/if:interfaces/if:interface" {

    when "if:type = 'ianaif:flexEthernet'" {
        description "Applies to Flex bonded Ethernet interfaces";
    }

    description
        "Augment interface model with OIF Flex Ethernet interface
        specific configuration nodes. Each flexEthernet interface
        represents a FlexE Group configured in a device.";

    container flexe-group {
        description
            "The struct containing all FlexE related configuration
            (see OIF FlexE 2.0 Section 6.1).
            Note that max number of FlexE groups in a network is 63.";

        leaf group-number {
            type uint32 {
                range "1..1048574";
            }
            description
                "FlexE Group Number as defined in Section 7.3.6 of FlexE
                2.0.";
        }

        leaf slot-granularity {
            type slot-granularity-enum;
            default "slot-5g";
            description
                "The granularity of a slot in a FlexE group.";
        }

        leaf flexe-phy-type {
            type flexe-phy-enum;
            default "PHY-100GBASE-R";
            description
                "The type of PHYs bonded in a FlexE Group.";
        }

        leaf calendar-protocol-enable {
            type boolean;
            default true;
            description
                "Whether calendar negotiation protocol is enabled or
```

```
        not.";
        reference
        "OIF Flex 2.0: Section 7.3.4";
    }

    list flexe-phy-list {

        key "flexe-phy-if";
        description
            "List of PHYs bonded in a FlexE group.";

        leaf flexe-phy-if {
            type if:interface-ref;
            description
                "Reference to a Flexe PHY interface.";
        }

        leaf phy-number {
            type uint8 {
                range "1 .. 254";
            }
            description
                "PHY number of a FlexE PHY.
                If PHY type is 100GBASE-R, phy-number is [1,254].
                If PHY type is 200GBASE-R, phy-number is [1,126].
                If PHY type is 400GBASE-R, phy-number is [1, 62].";
        }

        leaf flexe-phy-status {
            type phy-status-enum;
            default "phy-status-OK";
            config false;
            description
                "The FlexE PHY status.";
        }

        list calendar-slot-list {
            key "slot-id";
            leaf slot-id {
                type uint8;
                description
                    "slot id of a slot in a PHY.";
            }
            description
                "List of slots in a FlexE PHY. Max elements of
```

slot-list for a FlexE PHY is dependent on the PHY bandwidth (X)G and the slot granularity (Y)G, i.e., X/Y. For example, for a 400GBASE-R PHY:
If slot-granularity=slot-5g, max-elements is 80.
If slot-granularity=slot-25g, max-elements is 16.";

```
leaf flexe-slot-status {
  type slot-status-enumeration;
  default unused;
  config false;
  description
    "Slot status of a FlexE slot.";
}
} //calendar-slot-list
} //flexe-phy-list

list flexe-client-list {

  key "client-id";
  description
    "List of FlexE clients in a FlexE Group.";
  leaf client-id {
    type uint16 {
      range "1..65534";
    }
    description
      "FlexE Client field as defined in FlexE 2.0 Section
        7.3.4.";
  }

  leaf flexe-client-if {
    type if:interface-ref;
    description
      "The type of a flexe client interface must be
        'flexeClient'.";
  }

  list client-slot-list {
    key "client-slot-id";
    min-elements 1;
    description
      "List of slots for a FlexE client.";
    leaf client-slot-id {
      type uint8;
      description
        "Client slot id of a client slot in sequence for a
          client.";
```

```
    }

    leaf mapped-phy-if {
      type if:interface-ref;
      description
        "Mapped PHY interface of a client slot.";
    }
    leaf mapped-slot-id {
      type uint8;
      description
        "Mapped Slot id of a client slot in the mapped PHY.
        If a slot [i] is mapped, flexe-slot-status[i] in the
        Mapped PHY MUST be set to 'used' ";
    }
  } // client-slot-list

  leaf flexe-client-status {
    type client-status-enumeration;
    default flexe-client-status-OK;
    config false;
    description
      "The FlexE client status.";
  }

} //flexe-client-list

leaf flexe-group-status {
  type uint8;
  config false;
  description
    "Status for a FlexE Group. If any PHY is in fault,
    or any FlexE configuration is mismatched, the FlexE
    Group status is indicated in fault. Status includes:
    OK, Local Fault, Remote Fault, mismatch and etc.";
}
} //flexe-group
} //augment
}
```

<CODE ENDS>

4. YANG Module for FlexE client interface

The following YANG data module augments the interface container defined in RFC 8343 for a FlexE client interface.

<CODE BEGINS> file "ietf-interfaces-flexe-client@2019-10-30.yang"


```
module ietf-interfaces-flexex-client {
  yang-version 1.1;

  namespace
    "urn:ietf:params:xml:ns:yang:ietf-interfaces-flexex-client";

  prefix flexcl;

  import ietf-interfaces {
    prefix if;
  }

  import ietf-yang-types {
    prefix yang;
  }

  import iana-if-type {
    prefix ianaift;
  }

  organization "IETF CCAMP Working Group";
  contact
    "WG Web:  http://tools.ietf.org/wg/ccamp/
    WG List:  <mailto:ccamp@ietf.org>
    Author:   Yuanlong Jiang
              <mailto:jiangyuanlong@huawei.com>
    Author:   Xiang He
              <mailto:hexiang@huawei.com>
    Author:   Weiqiang Cheng
              <mailto:chengweiqiang@chinamobile.com>
    Author:   Junfang Wang
              <mailto:wjf@fiberhome.com>
    Author:   Yalei Han
              <mailto:ylhan@fiberhome.com>";

  description
    "This module contains YANG definitions for configuration of
    'FlexE client' interfaces.  FlexE Client is defined in
    OIF Flexible Ethernet 2.0 Implementation Agreement.";

  revision 2019-10-30 {
    description "Initial revision";

    reference
      "Internet draft: draft-jiang-ccamp-flexex-yang-02";
  }
}
```

```
identity flexeClient {
  base ianaift:iana-interface-type;
  description
    "FlexE Client.";
}

/*
 * Configuration parameters for FlexE client interfaces.
 */
augment "/if:interfaces/if:interface" {
  when "derived-from-or-self(if:type, 'ianaift:flexeClient')" {
    description "Applies to FlexE client interfaces";
  }
  description
    "Augment the interface model with parameters for
    FlexE client interfaces";

  container flexe-client {
    description
      "Contains parameters for FlexE client interfaces
      which expose an Ethernet MAC layer.";
    leaf mac-address {
      type yang:mac-address;
      config false;
      description
        "The MAC address of the FlexE client.";
    }
    leaf group-number {
      type uint32 {
        range "1..1048574";
      }
      description
        "FlexE Group Number of the FlexE group to which this
        Client belongs.";
    }
    // statistics can further be defined for the MAC layer
  }
}
}
<CODE ENDS>
```

5. Security Considerations

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

RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in the YANG data modules in this document are writable, and the involved subtrees that are sensitive include:

/flexe/flexe-group/flexe-phy-list specifies a list of FlexE PHYs.

/flexe/flexe-group/flexe-client-list specifies a list of FlexE Client, and each client is mapped to some slots in a FlexE PHY.

/flexcl/mac-address specifies a MAC address for a FlexE client.

/flexcl/group-number specifies the group number of a FlexE Group to which a FlexE client belongs.

Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. Specifically, an inappropriate configuration of them may cause an interrupt of a FlexE client flow, drop of all Ethernet frames of a FlexE client, or even break down of a whole FlexE group interface.

6. IANA Considerations

It is proposed that IANA register the following URI in the "IETF XML registry" [RFC3688]:

URI: urn:ietf:params:xml:ns:yang:ietf-flex

Registrant Contact: The IESG

XML: N/A; the requested URI is an XML namespace

It is proposed that IANA register the following URI in the "IETF XML registry" [RFC3688]:

URI: urn:ietf:params:xml:ns:yang:ietf-interfaces-flex-client

Registrant Contact: The IESG

XML: N/A; the requested URI is an XML namespace

It is proposed that IANA register the following YANG module in the "YANG Module Names" registry:

Name: ietf-flex

Namespace: urn:ietf:params:xml:ns:yang:ietf-flex

Prefix: flex

Reference: this document

It is proposed that IANA register the following YANG module in the "YANG Module Names" registry:

Name: ietf-interfaces-flex-client

Namespace: urn:ietf:params:xml:ns:yang:ietf-interfaces-flex-client

Prefix: flexcl

Reference: this document

It is proposed that IANA register a new IANAifType TBD for the interface type of Flex Ethernet group in the "IANA Interface Type YANG Module" [RFC7224].

It is proposed that IANA register a new IANAifType TBD for the interface type of Flex Ethernet client in the "IANA Interface TypeYANG Module" [RFC7224].

7. References

7.1. Normative References

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7.2. Informative References

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Authors' Addresses

Yuanlong Jiang
Huawei Technologies Co., Ltd.
Bantian, Longgang district
Shenzhen 518129, China
Email: jiangyuanlong@huawei.com

Xiang He
Huawei Technologies Co., Ltd.
Huawei Campus, No. 156 Beiqing Rd.
Beijing 100095
Email: hexiang9@huawei.com

Weiqiang Cheng
China Mobile
No.32 Xuanwumen West Street
Beijing 100053, China
Email: chengweiqiang@chinamobile.com

Junfang Wang
Fiberhome
Email: wjf@fiberhome.com

Yalei Han
Fiberhome
Email: ylhan@fiberhome.com

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Yi Lin
Huawei Technologies
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RSVP-TE Extensions in Support of Proactive Protection
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Abstract

This document describes protocol-specific procedures and extensions for Generalized Multi-Protocol Label Switching (GMPLS) Resource ReSerVation Protocol - Traffic Engineering (RSVP-TE) signaling to support Label Switched Path (LSP) Proactive Protection, which create the protection LSP after a failure is predicted and before it becomes a real failure.

Table of Contents

1. Introduction	2
2. Conventions used in this document	3
3. Overview of Predicted Failure and Related Recovery Methods	3
3.1. Predicted Failure	3
3.2. Proactive Protection	4
4. Modified PROTECTION Object Format	5
5. Extension to ERROR_SPEC Object	6
5.1. New Error Code / Sub-code	6
5.2. New TLV in ERROR_SPEC Object	6
6. End-to-end Proactive Protection	7
6.1. Creation of the Protected LSP	7
6.2. Notification of Predicted Failure Event	7
6.3. Tearing Down of the Protection LSP	8
7. Proactive Segment Protection	8
7.1. Creation of the Protected LSP	8
7.2. Notification of Predicted Failure Event	9
7.3. Tearing Down of the Segment Recovery LSP	9
7.4. Priority and Resource Pre-emption	10
8. Consideration of Backward Compatibility	11
9. Security Considerations	11
10. IANA Considerations	11
11. References	12
11.1. Normative References	12
11.2. Informative References	12
12. Authors' Addresses	12

1. Introduction

[RFC4872] and [RFC4873] describe protocol-specific procedures and extensions for GMPLS RSVP-TE signaling to support end-to-end LSP

recovery (including protection and restoration) and segment LSP recovery, respectively.

Traditional protection solution (e.g., 1+1 or 1:1 protection) could have very fast protection switch after failure happens, but takes twice of resource in the network during the whole lifetime of the LSP. On the other hand, the traditional restoration solution has much higher resource use, but the recovery of the LSP is much slower, due to the additional signaling time to create the restoration LSP.

In order to reduce the recovery resource while keeping the very fast protection switch, an approach is to use the failure prediction technologies and to create 1+1 or 1:1 protection only when a potential failure is predicted. This approach refers to "Proactive Protection" in this document.

This document extends the RSVP-TE protocol to support the control of the Proactive Protection.

2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. Overview of Predicted Failure and Related Recovery Methods

3.1. Predicted Failure

In most cases, there will be some indications before a physical failure happens in a network. For example, abnormal fluctuation of noise of a lightpath, BER (Bit Error Rate) (before error correction) rising, temperature rising of a transponder.

Therefore, by monitoring on certain physical parameters and analyzing the change tendency using, for example, Machine Learning (ML) or other technologies, a node is possible to predict whether failure will happen in an upcoming period of time.

Note that a predicted failure is different from a Signal Degrade in that:

- When Signal Degrade happens to a connection, the connection is still available but the quality of the signal carried by this

connection has declined and is lower than the predetermined threshold. For example, the BER of a connection rises and is out of tolerance.

- When a predicted failure of a connection is inferred, no failure nor degradation happens at present, but there is a trend that after a period of time, failure will probably happen, which will cause Signal Fail or Signal Degrade.

The methods to predict failures are outside the scope of this document.

3.2. Proactive Protection

The "Proactive Protection" refers to an LSP protection approach which create the protection LSP after a failure is predicted and before it becomes a real failure. Both end-to-end protection (defined in [RFC4872]) and segment protection (defined in [RFC4873]) are applicable for the Proactive Protection.

The main procedure of Proactive Protection is shown in Figure 1:

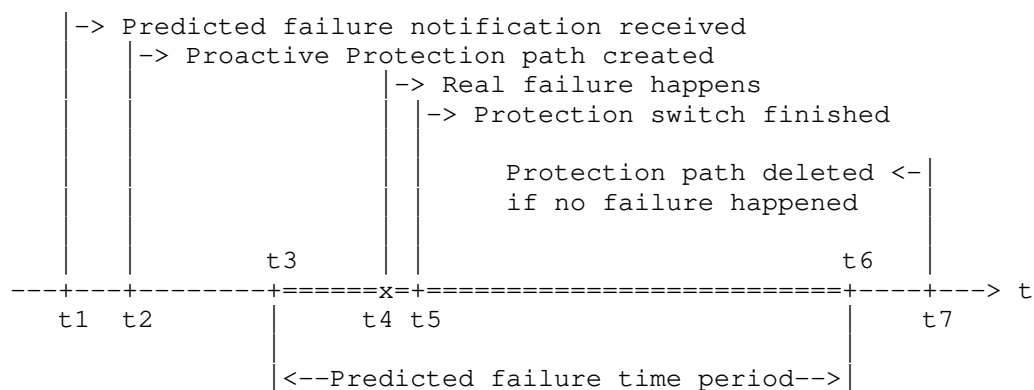


Figure 1: Overview of Proactive Protection

- t1: The protection source node of an LSP is notified that a failure will probably happen during t3~t6, so it starts to create 1+1 or 1:1 protection of the connection. Here the protection source node can be the source node of the LSP (for end-to-end protection case), or a branch node located between the source node and the predicted failure point of the LSP (for segment protection case).

t2: The 1+1 or 1:1 protecting path is created between the protection source node and the protection destination node. Here the protection destination node can be the destination node of the LSP (for end-to-end protection case), or a merge node located between the predicted failure point and the destination node of the LSP (for segment protection case).

- t4: If real failure happens as predicted, the 1+1 or 1:1 protection switch will be triggered.
- t5: Protection switch finished and the service in the connection is recovered.
- t7: If in fact the predicted failure didn't happen, and no further predicted failure notification received, the protection source node MAY tear down the protecting path after t6, in order to save the network resource.

4. Modified PROTECTION Object Format

This document modifies the PROTECTION object (C-Type=2) by adding two new bits T and A in reserved fields, as shown in Figure 2 below:

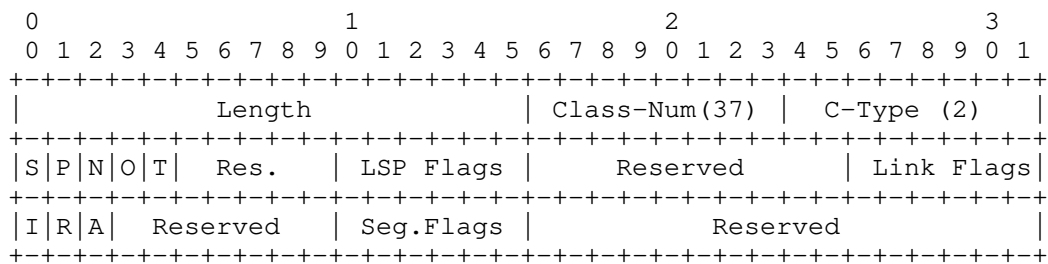


Figure 2: The modified PROTECTION object (C-Type=2)

- T (Triggered End-to-end Proactive Protection): 1 bit, when set (1), it indicates that the end-to-end Proactive Protection are required.

Note that if T bit is set (1), the LSP Flags SHOULD be one of:

0x04 1:N Protection with Extra-Traffic

0x08 1+1 Unidirectional Protection

```
0x10      1+1 Bidirectional Protection
```

- A (proActive Segment Protection): 1 bit, when set (1), it indicates that the Proactive Segment Protection are required.

Note that If A bit is set (1), the Seg. Flags SHOULD be one of:

```

0x04    1:N Protection with Extra-Traffic
0x08    1+1 Unidirectional Protection
0x10    1+1 Bidirectional Protection

```

See [RFC4872] and [RFC4873] for the definition of other fields.

5. Extension to ERROR_SPEC Object

5.1. New Error Code / Sub-code

A new Error Sub-code under Error Code "25 - Notify Error" is defined in this document, which is used to notify the event of a predicted failure:

Error Code = 25: "Notify Error" (see [RFC3209])

Error Sub-code = TBA: "Notify Error/LSP Local Predicted Failure"

5.2. New TLV in ERROR_SPEC Object

When predicting a failure, a certain time before which the failure may happen may also be predicted. This time information is useful for the source node to know how long it should wait for the predicted failure to become a real failure, and to decide when it's safe to tear down the protection LSP if the predicted failure didn't happen.

A new TLV in IPv4/IPv6 IF_ID ERROR_SPEC Object is defined in this document, which is used to indicate the time before which the predicted failure will probably become real failure. The format of this new TLV is shown in Figure 3 below:

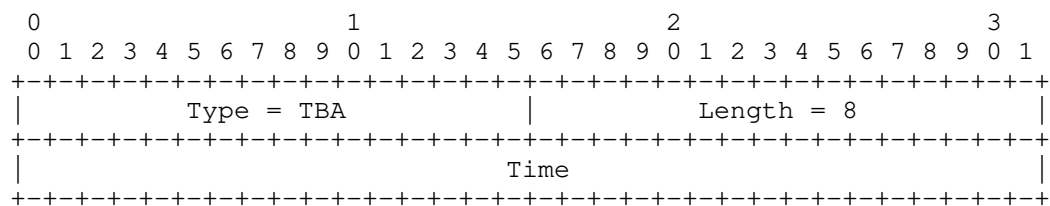


Figure 3: New TLV (type=TBA) in ERROR_SPEC Object

- Type: TBA
- Length: 8

- Time: A relative time measured in second, which indicates within how many seconds (from the current time) the predicted failure will probably become real failure.

6. End-to-end Proactive Protection

6.1. Creation of the Protected LSP

To create an LSP with recovery type of "End-to-end Proactive Protection", the source node of the LSP generates a Path message with a PROTECTION object included. The T bit in the PROTECTION object MUST be set to 1 (End-to-end Proactive Protection), so that all other nodes along the LSP can start the failure prediction function on related links/nodes.

Note that the N bit in the PROTECTION object is used to indicate whether the control plane message exchange is only used for notification or for protection-switching purpose after real failure happens, see [RFC4872]. In other words, the N bit have nothing to do with the notification of a predicted failure before real failure happens.

To allow the notification of predicted failure event to the source node by the Notify message, the NOTIFY REQUEST object MUST also be included in the Path message (see [RFC3473]), where the "Notify Node Address" SHOULD be the address of the source node of the LSP.

6.2. Notification of Predicted Failure Event

When an intermediate node on an LSP infers that a failure will happen and will affect the LSP, a Notify message will be sent to the source node of the LSP, to inform such predicted failure event. A new error code/sub-code "Notify Error/LSP Local Predicted Failure" is used in the ERROR_SPEC object or IF_ID_ERROR_SPEC object in the Notify message.

The Notify message MAY also include a TLV (type = TBA) in the IPv4 or IPv6 IF_ID_ERROR_SPEC object, to indicate the time before which the predicted failure will probably become real failure.

On receiving the Notify message with error code/sub-code "Notify Error/LSP Local Predicted Failure", the source node of the LSP SHOULD trigger the procedure to create the protection LSP, according to the protection type indicated in the "LSP Flags" field of the PROTECTION object in the Path message for the protected LSP. The procedures of creating the protection LSP and the protection switching after real failure happens are described in [RFC4872].

6.3. Tearing Down of the Protection LSP

After the protected LSP is created, the source node MAY start a timer `T_wait` and wait for the predicted failure to become a real failure. If no real failure happens and no more notification of predicted failure is received till `T_wait`, the source node MAY trigger the procedure to tear down the protection LSP, according to local policy. See [RFC4872] about the process of tearing down a protection LSP.

Implementations SHOULD allow this policy to be configured to provide a default across all LSPs on a node, but SHOULD also allow it to be configured per LSP.

Note that the `T_wait` MUST longer than the time indicated in the TLV (type=TBA) in the `ERROR_SPEC` object in the Notify message, if the TLV exists.

Note also that the value of `T_wait` is a local matter of the source node, and is outside the scope of this document.

7. Proactive Segment Protection

7.1. Creation of the Protected LSP

To create an LSP with recovery type of "Proactive Segment Protection", the source node of the LSP generates a Path message, where:

- A `PROTECTION` object is included, where the `A` bit MUST be set to 1 (Proactive Segment Protection), so that all nodes along the protected LSP can start the failure prediction function on related links/nodes if supported. The "Seg. Flags" are used to indicate the protection type of the Proactive Segment Protection.
- One or more `SERO` objects MAY included (i.e., explicit Proactive Segment Protection), indicating the branch node and the merge node of each segment recovery LSP. If no `SERO` object is included, it indicates that the dynamic Proactive Segment Protection method is used.
- A `NOTIFY REQUEST` object is included, where the `Notify Node Address` SHOULD be the address of the source node of the LSP.

For explicit Proactive Segment Protection, when a branch node receives a Path message with `A` bit set to 1 in the `PROTECTION` object, the branch node follows [RFC4873] to process the Path

message, except that the Path message for the recovery LSP will not be generated and be sent at this stage. Also, one more NOTIFY REQUEST object SHOULD be added to the Path message of the protected LSP, which carries the address of this branch node.

For dynamic Proactive Segment Protection, when an intermediate node receives a Path message with A bit set to 1 in the PROTECTION object, the node will determine if it has the ability to be a branch node, as described in Section 6.2 of [RFC4873]. If yes, it follows the same procedure as what a branch node does in the case of explicit Proactive Segment Protection, as described above. If not, the node only follows the standard procedure to create the protected LSP.

7.2. Notification of Predicted Failure Event

When an intermediate node between a pair of branch and merge nodes on an LSP infers that a failure will happen and will affect the LSP, a Notify message will be sent to the nearest branch node on the upstream direction of the LSP, to inform such predicted failure event. The error code/sub-code "Notify Error/LSP Local Predicted Failure" is used in the ERROR_SPEC object or IF_ID_ERROR_SPEC object in the Notify message.

Similar to End-to-end Proactive Protection, the time before which the predicted failure may occur MAY also be included in the Notify message.

On receiving the Notify message with error code/sub-code "Notify Error/LSP Local Predicted Failure", the branch node on the protected LSP SHOULD generate a new Path message, and send this new Path message along the recovery LSP between the branch and the merge nodes. The procedures of generating new Path message and creating the recovery LSP are the same as what is described in [RFC4873], except that the A bit in the PROTECTION object of this new Path message MUST set to 1.

7.3. Tearing Down of the Segment Recovery LSP

After the segment recovery LSP is created, the branch node MAY start a timer T_wait and wait for the predicted failure to become a real failure. If no real failure happen and no more notification of predicted failure is received till T_wait, the branch node MAY trigger the procedure to tear down the segment recovery LSP, according to local policy. See [RFC4873] about the process of tearing down a segment recovery LSP.

Implementations SHOULD allow this policy to be configured to provide a default across all LSPs on a node, but SHOULD also allow it to be configured per LSP.

Note that the T_wait MUST longer than the time indicated in the TLV (type=TBA) in the ERROR_SPEC object in the Notify message, if the TLV exists.

Note also that the value of T_wait is a local matter of the branch node, and is outside the scope of this document.

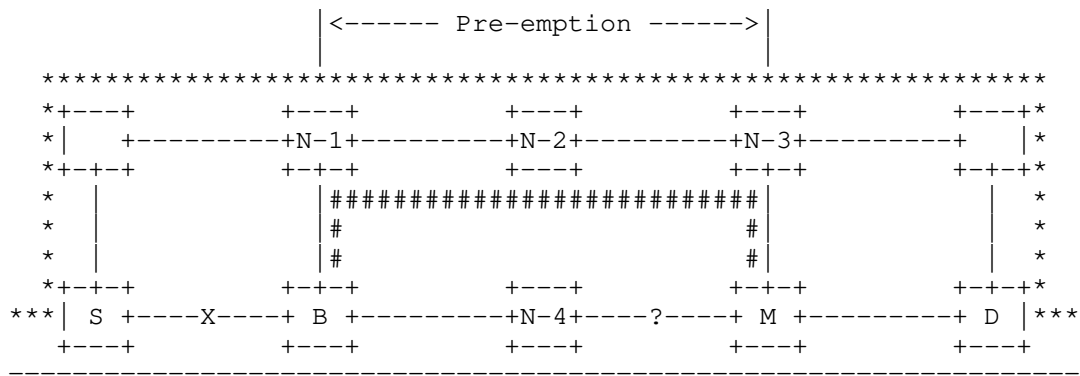
7.4. Priority and Resource Pre-emption

It's possible that after recovery LSP is created and before the predicted failure becomes a real failure, another real failure happens on the LSP outside the protected segment. In this case, the source node (or an intermediate node in the upstream direction of the real failure) may start a restoration procedure to recover the LSP. For the same protected LSP, since recovering from a real failure always has higher priority than protecting against a predicted failure which still hasn't happened, the restoration LSP can pre-empt the resource of the segment recovery LSP.

As shown in Figure 4, assume that node B (branch node) was notified of a predicted failure event between N-4 and M (merge node), and has created the segment recovery LSP along B, N-1, N-2, N-3 and M. If another failure between S (source node) and B happens before the predicted failure becomes a real failure, node S will try to create the restoration LSP. Since that resource is limited, the restoration LSP can pre-empt the resource of the segment recovery LSP between N-1 and N-3.

The nodes along the segment recovery LSP has enough information to determine whether pre-emption is allowed. This is because these nodes know that:

- The current segment recovery LSP is used for Proactive Segment Protection through the A bit in the PROTECTION object;
- The segment recovery LSP and the restoration LSP are protecting the same LSP through the association relationship.



S: Source node D: Destination node
 B: Branch node M: Merge node
 X: Real failure ?: Predicted failure (haven't happened yet)

=====: Protected LSP
 #####: Segment Recovery LSP
 *****: Restoration LSP

Figure 4: Resource pre-emption by restoration LSP

8. Consideration of Backward Compatibility

TBD.

[Editor's note]: will add some description about interwork with legacy nodes which do not support the function of failure prediction and reporting.

9. Security Considerations

TBD.

10. IANA Considerations

IANA assigns values to RSVP protocol parameters. Within the current document, a new Error code/sub-code value is defined:

Error Code = 25: "Notify Error" (see [RFC3209])

- o "Notify Error/LSP Local Predicted Failure" (TBA)

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12. Authors' Addresses

Yi Lin
Huawei Technologies
F3 R&D Center, Huawei Industrial Base,
Bantian, Longgang District,
Shenzhen 518129 P.R.China
Email: yi.lin@huawei.com

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Q. Wang, Ed.
X. Niu, Ed.
ZTE Corporation
Y. Xu
CAICT
November 4, 2019

Analysis for FlexE control
draft-wang-ccamp-flexe-control-analysis-03

Abstract

This document gives some analysis about the control of FlexE.

Status of This Memo

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

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Table of Contents

1. Introduction	2
2. Terminology	3
2.1. Requirements Language	3
3. Analysis	3
3.1. General Introduction of FlexE	3
3.1.1. FlexE Group	3
3.1.2. FlexE Client	4
3.1.3. Encapsulation of FlexE Client into FlexE Group	4
3.1.4. MAC Frame	5
3.1.5. Encapsulation of MAC frames into FlexE Client	5
3.2. General requirements	5
3.2.1. Configuration Mode for FlexE client	6
3.2.2. Configuration of FlexE group	6
3.2.3. Allocate Resources for FlexE Client	7
3.3. Control Requirements Derived	8
4. Summary	8
5. Acknowledgements	9
6. IANA Considerations	9
7. Security Considerations	9
8. References	9
8.1. Normative References	9
8.2. Informative References	9
Authors' Addresses	10

1. Introduction

OIF published the first version of FlexE Implementation Agreement in March 2016, aiming to provide a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. ITU-T SG15 has endorsed the OIF FlexE data plane as parts of [ITU-T G.872], [ITU-T G.709], [ITU-T G.798] and [ITU-T G.8023]. The Recommendations depend on or are based on the FlexE data plane.

This draft is intended to trigger discussion of the FlexE control requirements. What kind of models should we use when configuring FlexE capable equipment, how to configure the FlexE group and FlexE client, and what kind of parameters do we need to take into consideration when configuring FlexE group and FlexE client. The analysis is based on the description in section 7 and 8 of [ITU-T G.8023] and FlexE IA 2.0.

2. Terminology

2.1. 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].

3. Analysis

3.1. General Introduction of FlexE

The FlexE shim is built into the Ethernet PCS (physical coding sublayer). If a FlexE group is configured, a corresponding $n \times 100\text{G}$ (or $n \times 50\text{G}$, $n \times 200\text{G}$, $n \times 400\text{G}$) PCS module which may support multiple FlexE clients is created as well.

The difference between the FlexE and the traditional Ethernet is that the traditional Ethernet PCS has a 1:1 relationship with the client MAC flow, while with FlexE one bonded huge PCS module can be used to transport more than one FlexE client i.e., the relationship is 1:n.

3.1.1. FlexE Group

A FlexE Group is consisted of from 1 to n 100G FlexE instances, which are carried over from 1 to m 100G, 200G or 400G Ethernet PHYs. A FlexE group can also consisted of from 1 to n 50G FlexE instances, which are carried over from 1 to m 50G Ethernet PHYs. All PHYs in the group must operate at the same rate.

A FlexE Instance is a unit of information consisting of 50G or 100G of capacity, which is able to carry FlexE Client data, together with its associated overhead. Section monitoring overhead is added/extracted as one 66B block at the FlexE group source and destination (i.e., trail termination) to determine the status of the FlexE group. Currently, only RPF (Remote PHY Fault) indication is used to report the status of one FlexE group.

The set of FlexE Instances in the FlexE Group (not necessarily consecutive FlexE Instance numbers) are indicated in the "FlexE Map" field of the FlexE overhead. The full FlexE map is sent on all FlexE Instances of the FlexE Group so that it is possible for the FlexE demux to verify that the same FlexE Instance numbers are configured at the FlexE mux as at the FlexE demux, and can tell whether all expected FlexE Instances are being received.

3.1.2. FlexE Client

A FlexE Client is an Ethernet flow based on a MAC data rate that may or may not correspond to any Ethernet PHY rate. The FlexE Client MAC rates supported by a FlexE Groups could be 10Gb/s, 40Gb/s, or $m \times 25\text{Gb/s}$. The FlexE Client MAC rates supported by FlexE Groups may support all, or only a subset of these FlexE Client rates. Each FlexE Client is presented to the FlexE Shim as a 64B/66B encoded bit stream according to clause 82 of [IEEE 802.3]. The FlexE client has the semantics of an Ethernet PHY and there is no new layer network defined for FlexE client, as both FlexE group and FlexE client are processed in Ethernet PHY layer. From the network management point of view, the FlexE client can be created accordingly and the corresponding calendar slots of one FlexE group are allocated to one FlexE client. The FlexE client could be generated internally within a system, or created from a traditional Ethernet PHY. What kind of FlexE clients will be created depends on the operator's needs.

According to the description in clause 8.1 of [ITU-T G.8023], there is no overhead defined for monitoring a FlexE client, so the concept of network connection for FlexE client in the equipment does not exist. It is not correct to treat FlexE client as a network layer.

One FlexE client can be generated internally within one system, it can also be formed by converting from the standard Ethernet signal, e.g, a 10GBASE-R signal could be converted to a 10G FlexE Client format by performing idle insertion/deletion. FlexE Clients do not need to be produced or received in the same manner at both ends of the connection.

3.1.3. Encapsulation of FlexE Client into FlexE Group

In order to distribute the FlexE client over PHYs of one FlexE group, a number of management information command should be sent to the processing function which performs the encapsulation of FlexE client over FlexE group.

[ITU-T G.8023] specifies the equipment function blocks for Flex Ethernet interface, which are between equipment management function and atomic function within one network element. According to the description in clause 7.2 of [ITU-T G.8023], the management information commands sent to the source adaptation function from equipment management function are listed below:

TxCC, TxCCA, TxCCB, TxCR, TxCA

TxGID, TxPHYMAP

The TxCC, TxCCA and TxCCB are used to configure the calendar for use, which could be type A or type B calendar configuration, slots allocated for a specific FlexE client and FlexE client number.

TxCR and TxCA are used to coordinate the switch of calendar configuration between the FlexE source and destination node.

The TxGID is used to configure the FlexE group identifier. The TxPHYMAP is used to configure the set of PHYs in the FlexE group. If 200G and 400G are used, the 100G FlexE instance should be used in the case of PHYMAP.

The built-in function multiplexer performs the action of assigning the individual FlexE Client to specific calendar slots of the FlexE group according to the input management information.

At the destination side, the Demultiplexer function could use activate the FlexE Client and assigns the calendar slots of the FlexE group payload area to the individual FlexE client according to external configuration or the client calendar information carried in the overhead. Expected group ID, PHYMAP and calendar allocation information are needed sometimes to help verify the correctness of FlexE configuration.

However, not all of the management information listed in [ITU-T G.8023] need to be exposed to the external management system, as some of them may be inferred, e.g., Calendar configuration(CC), which could be inferred by comparing the original and new configuration.

3.1.4. MAC Frame

Defined in IEEE.

3.1.5. Encapsulation of MAC frames into FlexE Client

The external management information commands used as input to the encapsulation/adaptation function are defined by [IEEE 802.3], according to the description in [ITU-T G.8023]. The [IEEE 802.3] process mainly includes the 64B/66B encoding, as well as MAC frame check sequence generation and frame counting. The FlexE client stream is generated at the determined FlexE Client MAC rate and 64B/66B encoded.

3.2. General requirements

It can be derived from section 2.1.2 and section 2.1.5 that process involved when producing the FlexE Client from MAC frames is 64b/66b encoding, and this encoding has already been defined by [IEEE 802.3].

as no extra overhead is added during this process. Therefore, configuration for mapping MAC frames into FlexE client from external management system is not needed. In addition to the above analysis, this draft also consider other aspects of requirements for FlexE control/management.

Configuration mode for FlexE

Configuration of FlexE group

Creation of FlexE client and allocation of one or more FlexE group calendar slot resources to a FlexE client.

3.2.1. Configuration Mode for FlexE client

There are two different configuration modes for bring one FlexE client into service. The first one is static model, which is to use external management system to configure the FlexE client and resources allocated for the FlexE client at source and destination FlexE shims. In this case, the CR/CA mechanism does not work. Verification of configuration consistency at FlexE source and destination site by comparing the in-band FlexE overhead with the configuration at FlexE destination are needed; The other one is MASTER/SLAVE mode, which is to use the FlexE overhead to coordinate the resource configuration between FlexE source and destination, the external resource configuration information is only sent the source node.

3.2.2. Configuration of FlexE group

It can be concluded from the above analysis that external configuration tools should be involved to bring one FlexE group into service. The initial configuration commands could be from external management system, SDN controller etc.

A FlexE group must be configured first before any client signals are carried over it. When a new FlexE Group is brought into service, the initial configuration must be provisioned for both ends, and the initial configuration must be the same for both direction. The group is configured to be consist of from 1 to n 100G FlexE Instances carried over from 1 to m PHYs of the same rate (100GBASE-R, 200GBASE-R, or 400GBASE-R). The group could also be configured to be consist of from 1 to n 50G FlexE Instances carried over from 1 to m PHYs of the same rate (50GBASE-R). A PHY number may correspond to the physical port ordering on equipment, but the FlexE Shim at each end of the group must identify each PHY in the group using the same PHY number, and each FlexE Instance with the same FlexE Instance number. In certain cases, it may be desirable not to populate all 100G FlexE

instances on a 200G or 400G PHY, and these so-called unequipped FlexE instance should also be configured. Unequipped instances must always be the highest numbered instance(s) on a PHY of the FlexE Group, and there must always be at least one equipped 100G FlexE Instance on every PHY.

If aware case is needed to be considered, unavailable slot information should be configured at FlexE aware node to discard unavailable slot first, so as to put the rest of available slots onto the lower rate physical port. Unavailable slots are placed at the end of each relevant sub-calendar (the highest numbered slots).

3.2.3. Allocate Resources for FlexE Client

The FlexE client MAC flows are encapsulated in one or more FlexE calendar slots.

According to the analysis in section 3.2.1, there are two different configuration modes. For the first one, static mode, after the FlexE group is configured, the FlexE client resource allocation information are sent both to FlexE source and destination to help create the FlexE client. A number of expected configuration parameters are sent to FlexE destination to help verify the correctness of configuration at both sides. Information sent can be found in [draft-xiaobn-ccamp-flexe-yang-mod]. For the Master/slave mode, the FlexE client resource allocation information are only sent to the FlexE source site. The FlexE source site first create the FlexE clients, and then the built-in multiplexer at the FlexE source site allocates the calendar slots to a specific FlexE client according to the input from external management system, and insert these configuration information into the FlexE overhead. When these overheads arrives at the destination site, the demultiplexer function at the destination site extracts FlexE overhead first and get the information of calendar slot allocation information. Based on these information, the FlexE destination site finish the configuration of FlexE clients. In order to verify the correctness of the resource configuration, the expected FlexE group ID, PHY number and instance number information, FlexE client number and slot allocation information for a specific FlexE client should also be configured to FlexE destination site.

The FlexE client port is an internal port which only perform the function of encapsulating upper layer packets into MAC frames, 64b/66b encoding. The bandwidth capability of these internal ports should be known by external management/control tools in order to be used by the upper layer (e.g., MPLS-TP) flow correctly.

3.3. Control Requirements Derived

- a. Using external control/management system to configure FlexE group, which may include the configuration of group number, PHY number and instance number, as well as correlation between logical PHY number and physical port number. A number of expected configuration parameters are also needed to help verify the consistency between FlexE source and destination.
- b. Using external control/management system to create the FlexE client, which include the FlexE client number, FlexE client type and slots allocation information. Different configuration mode for FlexE client are needed.
- c. External control command could be provide to trigger the switch of calendar slots.
- d. Interworking between 5G slot granularity capable node and 25G slot granularity node.
- e. Configuration of unequipped instance, unavailable slots, which include the number of unequipped instance and number of unavailable slots on each instances
- f. An interface needs to be defined for a FlexE client in the case that an Ethernet PHY signal (e.g., 40GBASE-R) is directed towards a FlexE client interface or delivered from one FlexE shim to another in the case of equipment which terminates the FlexE group. This interface is used to indicate the conversion of Ethernet PHY signal to FlexE client signal, as only idle insertion/deletion is performed during this process in the former case, while in the latter case, this interface is used to indicate the "switch" of FlexE client.
- g. Different kinds of alarms should be taken into consideration when modelling FlexE technology, which may include PHY failed, skew exceed threshold, inconsistent configuration between two ends.

4. Summary

According to the analysis in section 2, the main control/management requirement for FlexE technology is to configure the FlexE group and FlexE client. Once a FlexE group is configured and the FlexE client ports is created, slots allocation is configured, use of the FlexE technology is the same as that in traditional Ethernet.

5. Acknowledgements

6. IANA Considerations

This memo includes no request to IANA.

7. Security Considerations

None.

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Authors' Addresses

Qilei Wang (editor)
ZTE Corporation
Nanjing
CN

Email: wang.qilei@zte.com.cn

Xiaobing Niu (editor)
ZTE Corporation
Beijing
CN

Email: niu.xiaobing@zte.com.cn

Yunbin Xu
CAICT
Beijing
CN

Email: xuyunbin@caict.ac.cn

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X. Niu, Ed.
Q. Wang, Ed.
ZTE
Y. Xu
CAICT
S. Munagapati
Cisco
November 3, 2019

A YANG Data Model for Flex Ethernet (FlexE)
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Abstract

Flex Ethernet (FlexE) implementation agreement have been published by OIF. FlexE provides a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate.

This document describes a YANG data model for FlexE. It can be used to manage and control devices supporting FlexE functions.

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Table of Contents

1. Introduction	2
2. Terminology	3
2.1. Requirements Language	3
2.2. FlexE terminology used in this document	3
3. FlexE Reference Configuration Model	4
4. Requirements	4
4.1. Requirements	4
5. YANG Data Model for FlexE (Tree Structure)	5
6. FlexE types Module	7
7. FlexE YANG Module	10
8. Acknowledgements	19
9. Authors (Full List)	19
10. Contributors	20
11. IANA Considerations	20
12. Security Considerations	20
13. References	21
13.1. Normative References	21
13.2. Informative References	22
Authors' Addresses	23

1. Introduction

Flex Ethernet (FlexE) implementation agreement version 1.1 [OIFFLEXE1] , 2.0 [OIFFLEXE2] and 2.1[OIFFLEXE2.1] have been published by OIF. FlexE provides a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. This includes MAC rates that are both greater than (through bonding) and less than (through sub-rate and channelization) the Ethernet PHY rates used to carry FlexE.

This document defines a data model of FlexE, using YANG[RFC7950]. This model mainly deals with the data model of the FlexE Group and the FlexE client. It can be used by an application to configure and modify the parameters of the FlexE Group and the FlexE client, and to receive notifications, e.g. mismatch errors, from devices supporting FlexE functions.

Requirements for the FlexE YANG model are considered. And FlexE YANG tree and YANG files are given.

2. Terminology

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in the YANG data tree presented later in this document is defined in [RFC8340]. They are provided below for reference.

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write) and "ro" state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.
- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- o Ellipsis ("...") stands for contents of subtrees that are not shown.
- o Some of the key terms used in this document are listed as follow.

The terminology for describing YANG data models is found in [RFC7950].

2.1. 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].

2.2. FlexE terminology used in this document

- a. CSG: Calendar Slot Granularity. It can be 5G or 25G.
- b. FlexE Calendar: In FlexE IA v1.1, the total capacity of a FlexE Group is represented as a collection of slots which have a granularity of 5G. The calendar for a FlexE Group composed of n 100G PHYs is represented as an array of 20n slots (each representing 5G of bandwidth). This calendar is partitioned into sub-calendars, with 20 slots per 100G PHY. Each FlexE client is mapped into one or more calendar slots (based on the bandwidth the FlexE client flow will need). In FlexE IA v2.0 [OIFFLEXE2], the total capacity of a FlexE Group is represented as a collection of slots which may have a granularity of 5G or 25G. The calendar for a FlexE Group composed of n 100G FlexE instances from m 100G/200G/400G PHYs is represented as an array of 20n

slots (each representing 5G of bandwidth) or 4n slots (25G granularity).

- c. FlexE Client: An Ethernet flow based on a MAC data rate that may or may not correspond to any Ethernet PHY rate.
- d. FlexE Group: A FlexE Group is composed of from 1 to n 50G or 100G FlexE Instances that are carried by a group of from 1 to m bonded Ethernet PHYs.
- e. FlexE instance: A 100G FlexE Instance is a unit of information consisting of 100G of capacity able to carry FlexE Client data, together with its associated overhead. In FlexE IA v2.1[OIFFLEXE2.1], 50G FlexE Instance is defined.

Detailed description of these terms can be found in [OIFFLEXE1] and [OIFFLEXE2] .

3. FlexE Reference Configuration Model

FlexE can be implemented between the FlexE mux and demux in two end devices connected directly by the FlexE links. In this case, FlexE is just a link connection technology.

FlexE can also be transported by transport networks. There are three kinds of transport network mapping mechanisms for FlexE signals, that is, FlexE unaware transport, FlexE termination in the transport network and FlexE aware transport.

How to configure the ingress or egress of transport network about FlexE mapping relationship may be application specific. In this document, the part of YANG data model for the transport network mapping for FlexE is not included at present.

4. Requirements

4.1. Requirements

This section summarizes the management requirements for the FlexE Group and the FlexE Client.

Req-1 The model SHALL support the management of the FlexE Group, consisting of one or more 100G FlexE instances which carried by one or more 100GE, 200GE, 400GE Ethernet PHY(s). The model SHALL support the management of the FlexE Group, consisting of one or more 50G FlexE instances which carried by one or more 50GE Ethernet PHY(s).

The detailed management covers the CRUD functions (create, update, read and delete), and lock/unlock.

Req-2 The model SHOULD be able to verify that the collection of Ethernet PHY(s) included in a FlexE Group have the same characteristics (e.g. number of PHYs, rate of PHYs, etc.) at the local FlexE shims. If inconsistency exists, notifications (e.g. errors) SHOULD be invoked.

Req-3 The model SHOULD be able to verify that the collection of FlexE instances included in a FlexE Group have the same characteristics (e.g. calendar slot granularity, unequipped slots, etc.) at the local FlexE shims. If inconsistency exists, notifications (e.g. errors) SHOULD be invoked.

Req-4 The model SHALL allow the addition (or removal) of one or more FlexE clients on a FlexE Group. The addition (or removal) of a FlexE client flow SHALL NOT affect the services for the other FlexE client signals whose size and calendar slot assignments are not changed.

Req-5 The model SHALL allow FlexE client signals to flexibly span the set of FlexE instances which comprise the FlexE Group.

Req-6 The model SHALL support a FlexE client flow resizing without affecting any existing FlexE clients within the same FlexE Group.

Req-7 The model SHALL support the switching of a calendar configuration. There are two calendar configurations, A and B.

5. YANG Data Model for FlexE (Tree Structure)

```

module: ietf-flex-e-yang
  +--rw flex-e-configuration
    +--rw flex-e-groups
      +--rw flex-e-group* [group-number]
        +--rw group-number          uint32
        +--rw group-attributes
          +--rw flex-e-gp-avb-bw?    rt-types:bandwidth-ieee-float32
          +--rw cal-slot-gran?       flex-e-tp:cal-slot-gran
          +--rw flex-e-phy-type?     flex-e-tp:flex-e-phy-type
          +--rw bonded-phys
            +--rw flex-e-phys* [phy-number-in-group]
              +--rw phy-number-in-group  uint8
              +--rw local-phy-interface?  if:interface-ref
              +--rw remote-phy-interface? if:interface-ref
          +--rw flex-e-instances
            +--rw flex-e-instance* [flex-e-inst-num]

```

```

|--rw flexe-inst-num          uint8
    +--rw unavb-sub-cal-slot-list* [sub-cal-slot-id]
        +--rw sub-cal-slot-id    uint8
    +--rw uneq-flexe-instance* [flexe-inst-num]
        +--rw flexe-inst-num      uint8
+--rw expected-group-number?   uint32
+--rw expected-phy-map?       string
+--rw expected-cal-cfg?       flexe-tp:calendar-AorB
+--rw tx-calendar?            flexe-tp:calendar-AorB
+--rw rx-calendar?            flexe-tp:calendar-AorB
+--rw tx-calendar-neg?        enumeration
+--rw reply-ca-mode?          enumeration
+--rw flexe-clients
    +--rw flexe-client* [client-number]
        +--rw client-number      uint16
        +--rw bandwidth
            +--rw signal-type?    flexe-client-signal-rate
            +--rw mac-rate?       rt-types:bandwidth-ieee-float32
+--rw flexe-group-number?     uint32
+--rw alloc-slots
    +--rw tx-alloc-A-slots
        +--rw instance-slots* [flexe-inst-num slot-id]
            +--rw flexe-inst-num  uint8
            +--rw slot-id         uint8
    +--rw tx-alloc-B-slots
        +--rw instance-slots* [flexe-inst-num slot-id]
            +--rw flexe-inst-num  uint8
            +--rw slot-id         uint8
+--rw (tx-calendar-neg)?
    +--:(STATIC-MODE)
        +--rw rx-alloc-slots
            +--rw instance-slots* [flexe-inst-num slot-id]
                +--rw flexe-inst-num  uint8
                +--rw slot-id         uint8
        +--rw rx-expected-A-slots
            +--rw instance-slots* [flexe-inst-num slot-id]
                +--rw flexe-inst-num  uint8
                +--rw slot-id         uint8
        +--rw rx-expected-B-slots
            +--rw instance-slots* [flexe-inst-num slot-id]
                +--rw flexe-inst-num  uint8
                +--rw slot-id         uint8
    +--:(MASTER-SLAVE)
+--rw client-interface?       if:interface-ref

```

Figure 1

6. FlexE types Module

```
<CODE BEGINS> file "ietf-flexex-types@2019-11-04.yang"
module ietf-flexex-types {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-flexex-types";
  prefix "flexex-tp";
  import ietf-routing-types {
    prefix rt-types;
    description "Import ietf-routing-types module.";
  }
  organization
    "Internet Engineering Task Force (IETF) CCAMP WG";
  contact
    "WG List: <mailto:ccamp@ietf.org>
    Editor: Xiaobing Niu (niu.xiaobing@zte.com.cn);
    Editor: Qilei Wang (wang.qilei@zte.com.cn); ";
  description
    "This module defines a YANG data types used in FlexE YANG modules.

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    Relating to IETF Documents(http://trustee.ietf.org/license-info).

    This version of this YANG module is part of RFC TBD; see
    the RFC itself for full legal notices.";
  revision 2019-11-04{
    description
      "Version 02.";
    reference
      "draft-xiaobn-ccamp-flexex-yang-mod-03.txt";
  }
  revision 2019-06-06{
    description
      "Version 01.";
    reference
      "draft-xiaobn-ccamp-flexex-yang-mod-02.txt";
  }
  revision 2019-03-11{
    description
      "Initial version.";
    reference
      "draft-xiaobn-ccamp-flexex-yang-mod-00.txt";
```

```

}

/* typedefs */
typedef cal-slot-gran {
  type enumeration {
    enum csg-5G {
      value 1;
      description "Calendar slot with a 5G granularity";
    }
    enum csg-25G {
      value 2;
      description "Calendar slot with a 25G granularity";
    }
  }
  description
    "Defines a type representing the granularity of a calendar slot.";
}

typedef flexe-client-signal-rate {
  type enumeration {
    enum flexe-client-signal-10Gbps{
      value 1;
      description
        "FlexE Client signal rate of 10Gbps";
    }
    enum flexe-client-signal-40Gbps{
      value 2;
      description
        "FlexE Client signal rate of 40Gbps";
    }
    enum flexe-client-signal-25mGbps{
      value 3;
      description
        "FlexE Client signal rate of m*25Gbps";
    }
  }
  description
    "Defines FlexE Client signal rate, including 10, 40, m*25Gbps.";
}

typedef flexe-phy-type {
  type enumeration {
    enum flexe-phy-100GBASE-R {
      value 1;
      description "100GBASE-R PHY";
    }
    enum flexe-phy-200GBASE-R {
      value 2;
      description "200GBASE-R PHY";
    }
  }
}
```

```
    }
    enum flexe-phy-400GBASE-R {
        value 3;
        description "400GBASE-R PHY";
    }
    enum flexe-phy-50GBASE-R {
        value 4;
        description "50GBASE-R PHY";
    }
}
description
    "Defines types of PHYs in a FlexE group";
}
typedef calendar-AorB {
    type enumeration {
        enum calendar-A {
            value 0 ;
            description
                "Set the A calendar configuration.";
        }
        enum calendar-B {
            value 1 ;
            description
                "Set the B calendar configuration.";
        }
    }
}
description
    "Calendar configuration A or B";
}
/* interface states: OK, SF, SD */
typedef intf-state {
    type enumeration {
        enum ok {
            value 0 ;
            description
                "The interface state of the FlexE Group is OK.";
        }
        enum sf {
            value 1 ;
            description
                "The interface state of the FlexE Group is SF.";
        }
        enum sd {
            value 2 ;
            description
                "The interface state of the FlexE Group is SD.";
        }
    }
}
```



```
        description
            "Interface state of port group.";
    }
    /* grouping */
    grouping flexe-client-bandwidth{
        leaf signal-type{
            type flexe-client-signal-rate;
            description
                "Client signal types: 10, 40, m*25 Gbps.";
        }
        leaf mac-rate {
            type rt-types:bandwidth-ieee-float32;
            description
                "Bandwidth of clients.";
        }
        description
            "The bandwidth of a FlexE client.";
    }
}
```

<CODE ENDS>

7. FlexE YANG Module

```
<CODE BEGINS> file "ietf-flex-e-yang@2019-11-04.yang"
module ietf-flex-e-yang {
    yang-version 1.1;
    namespace "urn:ietf:params:xml:ns:yang:ietf-flex-e-yang";
    prefix "flex-e";
    import ietf-routing-types {
        prefix rt-types;
        description "Import ietf-routing-types module.";
        reference "RFC8294";
    }
    import ietf-interfaces {
        prefix if;
        description "Import ietf-interfaces module.";
        reference "RFC7223";
    }
    import ietf-flex-e-types {
        prefix flex-e-tp;
        description "Import ietf-flex-e-types module.";
    }
    organization
        "Internet Engineering Task Force (IETF) CCAMP WG";
    contact
        "WG List: <mailto:ccamp@ietf.org>
        Editor: Xiaobing Niu (niu.xiaobing@zte.com.cn);
```

```
Editor: Qilei Wang (wang.qilei@zte.com.cn);
Editor: Sivakumar Munagapati (smunagap@cisco.com)";
description
  "This module defines a YANG data model for FlexE.

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  Relating to IETF Documents(http://trustee.ietf.org/license-info).

  This version of this YANG module is part of RFC TBD; see the RFC
  itself for full legal notices.";
revision 2019-11-04 {
  description
    "Version 03.";
  reference
    "draft-xiaobn-ccamp-flex-e-yang-mod-03.txt";
}
revision 2019-06-06 {
  description
    "Version 02.";
  reference
    "draft-xiaobn-ccamp-flex-e-yang-mod-02.txt";
}
revision 2019-05-17 {
  description
    "Version 01.";
  reference
    "draft-xiaobn-ccamp-flex-e-yang-mod-01.txt";
}
revision 2019-03-11 {
  description
    "Initial version.";
  reference
    "draft-xiaobn-ccamp-flex-e-yang-mod-00.txt";
}

grouping slot-list
{
  description
    "Calendar slots in FlexE instances.";
  list instance-slots{
    key "flex-e-inst-num slot-id";
    description
```

```
    "List of slots for the FlexE client.";
leaf flexe-inst-num{
    type uint8 ;
    description
        "It refers to the FlexE instance of a calendar slot.
        Clause 6.1 FlexE Group in FlexE IA 2.1";
}
leaf slot-id {
    type uint8;
    description
        "Id number of a sub-calendar slot in a FlexE instance.
        In a 100G FlexE instance,
        for 5G granularity, the range of slot-id is [0,19];
        for 25G granularity, the range of slot-id is [0,3];
        In a 50G FlexE instance,
        for 5G granularity, the range of slot-id is [0,9];
        for 25G granularity, the range of slot-id is [0,1];
        Refer to clause 6.8 in FlexE IA 2.1. ";
}
}
}

/* Configuration of FlexE */
container flexe-configuration{
    description
        "FlexE configuration, including configurations of FlexE groups
        and FlexE clients.";
    container flexe-groups {
        description
            "Container for the FlexE Group";
        list flexe-group {
            key group-number;
            description
                "List of FlexE Group";
            leaf group-number {
                type uint32 {
                    range 1..1048574 ;
                }
            }
            description
                "The FlexE Group number is selected from the range 1~0xFFFFFE.
                The value of 0x00000 and 0xFFFFF may not be used to
                designate a FlexE Group.";
        }
        container group-attributes {
            description
                "The attributes of a FlexE Group";
            leaf flexe-gp-avb-bw{
                type rt-types:bandwidth-ieee-float32;
            }
        }
    }
}
```

```
description
  "Availbale bandwidth allocated in the FlexE Group.
  Considering the FlexE Client MAC rates supported by FlexE
  Groups are 10, 40, m*25 Gbps, or a subset of these rates,
  it's recommended to confine the bandwidth allocated for a
  FlexE group into a integer compound from litimited types
  of MAC rateds."
}
leaf cal-slot-gran{
  type flexe-tp:cal-slot-gran;
  description
    "The granularity of calendar slot is 5G or 25G";
  reference
    "OIF FlexE IA 2.1";
}
leaf flexe-phy-type{
  type flexe-tp:flexe-phy-type;
  description
    "Types of PHYs, such as 50/100/200/400GBASE-R";
  reference
    "OIF FlexE IA 2.1";
}
container bonded-phys {
  description
    "PHYs bonded to form a FlexE Group";
  list flexe-phys {
    key phy-number-in-group;
    description
      "One of bonded PHYs in a FlexE Group";
    leaf phy-number-in-group{
      type uint8{
        range "1 .. 254";
      }
      description
        "Refer to the clause 6.1 in FlexE IA 2.0.
        For 100GBASE-R, the FlxeE PHY num and the 100G
        FlexE instance num are the same and in the range
        [1-254]; For 200GBASE-R, each PHY num is in the
        range [1-126]. For 400GBASE-R, each PHY num is
        in the range [1-62]. For 50GBASE-R, each PHY num is
        in the range [1-126].";
    }
  }
  leaf local-phy-interface{
    type if:interface-ref;
    description
      "Local PHY interface related to the current PHY in a
      FlexE group."
  }
}
```

```
    leaf remote-phy-interface{
        type if:interface-ref;
        description
            "Remote PHY interface related to the current PHY in
            a FlexE group.";
    }
}

container flexe-instances {
    description
        "FlexE instances in a FlexE Group";
    list flexe-instance {
        key flexe-inst-num;
        description
            "List of a FlexE instance in a FlexE Group. Not including
            those unequipped instances in the bonded PHYs.";
        leaf flexe-inst-num{
            type uint8 ;
            description
                "Logical FlexE instance number";
            reference
                "Clause 6.1 FlexE Group in FlexE IA 2.1.
                For 50G and 100G, instance num=PHY num;
                For 200G, 8-bit instance num consists of the PHY num
                in the upper seven bits, and 0 or 1 in the lower order
                bit.
                For 400G, 8-bit instance num consists of the PHY num
                in the upper six bits, and 0,1,2, or 3 in the two
                lower order bits. ";
        }
    }
    list unavb-sub-cal-slot-list {
        key sub-cal-slot-id;
        description
            "List of sub-calendar slots unavailable in a FlexE
            Instance.";
        leaf sub-cal-slot-id {
            type uint8;
            description
                "Id number of a sub-calendar slot in a FlexE instance.
                In a 100G FlexE instance,
                for 5G granularity, the range of slot-id is [0,19];
                for 25G granularity, the range of slot-id is [0,3];
                In a 50G FlexE instance,
                for 5G granularity, the range of slot-id is [0,9];
                for 25G granularity, the range of slot-id is [0,1];
                Refer to clause 6.8 in FlexE IA 2.1. ";
        }
    }
}
```

```

    }
  }
  list uneq-flexe-instance {
    key flexe-inst-num;
    description
      "Unequipped FlexE instances in the bonded PHYs.
      Strictly speaking, a unequipped instance does not belong
      to any FlexE Group, because in the overhead frame, the
      FlexE Group number is set to 0x00000.
      Refer to Clause 6.6 Unequipped 100G FlexE Instances in
      FlexE IA 2.1.";
    leaf flexe-inst-num{
      type uint8 ;
      description
        "Clause 6.1 FlexE Group in FlexE IA 2.1";
    }
  }
}
leaf expected-group-number {
  type uint32 {
    range 1..1048574 ;
  }
  description
    "The expected FlexE group number is configured at the FlexE
    demux. Its value is in the range 1~0xFFFFE.
    Refer to ExGID in G.8023.";
}
leaf expected-phy-map {
  type string {
    length "256";
    pattern "[0-1]*";
  }
  description
    "The expected FlexE PHY MAP is configured at the FlexE
    demux. The length of PHY MAP is 8*32=256. If a FlexE PHY
    ( for FlexE IA V1.1) or FlexE instance( for FlexE IA V2.0)
    is configured in the FlexE Group, the corresponding bit is
    set to 1.
    Refer to ExPHYMAP in G.8023.";
}
leaf expected-cal-cfg {
  type flexe-tp:calendar-AorB;
  description
    "The expected calendar configuration( ExCC in ITU-T G.8023)
    is configured on FlexE demux.
    Refer to ExCC in G.8023.";
}
leaf tx-calendar {

```

```
    type flexe-tp:calendar-AorB;
    description
        "Calendar configuration in the transmit direction.
        Refer to TxCC in G.8023. ";
}
leaf rx-calendar {
    type flexe-tp:calendar-AorB;
    description
        "Calendar configuration in the receive direction";
}
leaf tx-calendar-neg {
    type enumeration {
        enum STATIC-MODE {
            value 1 ;
            description
                "STATIC mode. In this mode, calendar slots on mux and
                demux need to be configured";
        }
        enum MASTER-SLAVE {
            value 2 ;
            description
                "MASTER-SLAVE mode. In this mode, calendar slots only
                need to be configured on mux";
        }
    }
    description
        "TX calendar negotiation methods";
}
leaf reply-ca-mode {
    type enumeration {
        enum never {
            value 1 ;
            description
                "never reply CA (Configuration Ack)";
        }
        enum immediately {
            value 2 ;
            description
                "immediately reply CA (Configuration Ack)";
        }
        enum ask-controller {
            value 3 ;
            description
                "Ask controller for more control";
        }
    }
    description
        "Reply CA mode";
}
```

```

    }
  }
}
container flexe-clients {
  description
    "FlexE clients information";
  list flexe-client {
    key client-number ;
    description
      "Attributes of FlexE client" ;
    leaf client-number {
      type uint16 {
        range 1..65534 ;
      }
      description
        "Client number in the range of 1~0xFFFE.
        The value 0x0000 indicates a calendar slot which is unused
        (but available).
        The value 0xFFFF (all ones) indicates a calendar slot that
        is unavailable.
        Refer to Clause 7.3.4 in FlexE IA 2.1.";
      reference
        "FlexE IA 2.1.";
    }
  }
  container bandwidth {
    description "Client bandwidth";
    uses flexe-tp:flexe-client-bandwidth;
  }
  leaf flexe-group-number {
    type uint32 {
      range 1..1048574 ;
    }
    description
      "The FlexE Group is used to transport the FlexE client.";
  }
  container alloc-slots{
    description
      "Slots are allocated on the mux(Transmit-direction).";
    container tx-alloc-A-slots{
      uses slot-list;
      description
        "Slots in A calendar are allocated on the mux.
        Refer to TxCCA in G.8023.";
    }
    container tx-alloc-B-slots{
      uses slot-list;
      description

```



```

        "Slots in B calendar are allocated on the mux.
        Refer to TxCCB in G.8023.";
    }
    choice tx-calendar-neg{
        description
            "According to the mode, to determine what should be
            configured.";
        case STATIC-MODE{
            container rx-alloc-slots{
                uses slot-list;
                description
                    "Slots for a specific FlexE client allocated on the
                    demux(Receive-direction).";
            }
            container rx-expected-A-slots{
                uses slot-list;
                description
                    "The expected received slots for a specific FlexE
                    client in A calendar are configured on the demux.
                    Refer to ExCCA in G.8023.";
                reference
                    "ITU-T G.8023";
            }
            container rx-expected-B-slots{
                uses slot-list;
                description
                    "The expected received slots for a specific FlexE
                    client in B calendar are configured on the demux.
                    Refer to ExCCB in G.8023.";
                reference
                    "ITU-T G.8023";
            }
        }
        case MASTER-SLAVE{
        }
    }
}

leaf client-interface {
    type if:interface-ref;
    description
        "A FlexE Client is used as an interface.
        The attributes of the interface can be configured.";
}
}
}
}

```

}

<CODE ENDS>

8. Acknowledgements

9. Authors (Full List)

Xiaobing NIU (editor)

ZTE

Beijing, China

Email: niu.xiaobing@zte.com.cn

Qilei Wang (editor)

ZTE

Nanjing, China

Email: wang.qilei@zte.com.cn

Yunbin Xu

CAICT

Beijing, China

Email: xuyunbin@caict.ac.cn

Sivakumar Munagapati

Cisco

USA

Email: smunagap@cisco.com

10. Contributors

11. IANA Considerations

This document registers the following namespace URIs in the IETF XML registry[RFC3688]:

URI: urn:ietf:params:xml:ns:yang:ietf-flexex-yang

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

This document registers the following namespace URIs in the IETF XML registry[RFC3688]:

URI: urn:ietf:params:xml:ns:yang:ietf-flexex-types

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

This document registers the following YANG modules in the YANG Module Names registry[RFC6020] :

name: ietf-flexex-yang

namespace: urn:ietf:params:xml:ns:yang:ietf-flexex-yang

prefix: flexex

reference: RFC XXXX (TDB)

name: ietf-flexex-types

namespace: urn:ietf:params:xml:ns:yang:ietf-flexex-types

prefix: flexex-tp

reference: RFC XXXX (TDB)

12. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF[RFC6241] or RESTCONF[RFC8040]. The lowest NETCONF layer

is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable. These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations.

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Authors' Addresses

Xiaobing Niu (editor)
ZTE
Beijing
CN

Email: niu.xiaobing@zte.com.cn

Qilei Wang (editor)
ZTE
Nanjing
CN

Email: wang.qilei@zte.com.cn

Yunbin Xu
CAICT
Beijing
CN

Email: xuyunbin@caict.ac.cn

Sivakumar Munagapati
Cisco
USA

Email: smunagap@cisco.com

CCAMP Working Group
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H. Zheng
I. Busi
Huawei Technologies
Y. Zheng
China Unicom
November 4, 2019

A YANG Data Model for Client Signal Performance Monitoring
draft-zheng-ccamp-client-pm-yang-00

Abstract

A transport network is a server-layer network to provide connectivity services to its client. Given the client signal is configured, the followup function for performance monitoring, such as latency and bit error rate, would be needed for network operation.

This document describes the data model to support the performance monitoring functionalities. The module carefully maps to relevant performance monitoring standards.

Status of This Memo

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Table of Contents

1. Introduction	2
2. Terminology and Notations	3
3. Model Relationship	3
4. Consideration on Monitoring Parameters	4
5. YANG Model for Client Signal Performance Monitoring	4
5.1. YANG Tree for Ethernet Performance Monitoring	4
5.2. YANG Tree for Transparent Client Signal Performance Monitoring	4
6. YANG Code for Performance Monitoring	5
6.1. The ETH Service Performance Monitoring YANG Code	5
6.2. The Transparent Client Signals Performance Monitoring YANG Code	8
7. IANA Considerations	11
8. Manageability Considerations	11
9. Security Considerations	12
10. Contributors	12
11. References	12
11.1. Normative References	12
11.2. Informative References	13
Authors' Addresses	13

1. Introduction

Client-layer network and server-layer network have been respectively modeled to allow the tunnels carrying the client traffic. Server-layers are modeled as tunnels with various switching technologies, such as [I-D.ietf-ccamp-otn-tunnel-model] and [I-D.ietf-ccamp-wson-tunnel-model]. Client-layers are modeled as client signals according to the client-signal identities specified in [I-D.ietf-ccamp-layer1-types].

In the network operation, the operator is interested in monitoring for their instantiated client signal over tunnels. The objective for such monitoring is to complete timely adjustment once there is abnormal statistic which may result in failure of the client signal. The parameters specified in the performance monitoring model can be collected for the operation need.

2. Terminology and Notations

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in the YANG data tree presented later in this document is defined in [RFC8340]. They are provided below for reference.

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write) and "ro" state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.
- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- o Ellipsis ("...") stands for contents of subtrees that are not shown.

3. Model Relationship

[I-D.ietf-ccamp-client-signal-yang] has specified the two models for the client signal configuration, module ietf-trans-client-service for transparent client service and module ietf-eth-tran-service for Ethernet service. A common types module, ietf-eth-tran-types, has also been defined for the common use for service configuration. Basically the client signal types in this document is consistent with ietf-eth-tran-types, and focus on different functionality. On the perspective of operator, the modules in [I-D.ietf-ccamp-client-signal-yang] can be used to configure the service given any underlay tunnels, while the operation about monitoring the performance on given service can be achieved by using the model in this document.

Consideration on Key Performance Information (KPI) monitoring for Virtual Network (VN) and tunnels has been specified in [I-D.ietf-teas-actn-pm-telemetry-autonomics]. Usually the monitoring on the tunnels are the VNs should be separately deployed for the network operation, but it is possible to have common parameters that are both needed for the VN/TE and the configured services. Common types are imported in both modules.

VPN-level parameters and their monitoring have been defined in [I-D.www-bess-yang-vpn-service-pm]. This module focus on the performance on the topology at different layer or the overlay topology between VPN sites. On the other hand, this document is

focusing on the performance of the service configured between Customer Ends (CE), as described in [I-D.ietf-ccamp-client-signal-yang].

4. Consideration on Monitoring Parameters

There can be multiple groups of parameters for monitoring, such as latency, bit error rate (BER). Some of these parameters are layer-dependent, for example, packet loss is only applicable in packet networks and won't be needed for layer 1 OTN and layer 0 WSON.

This document starts with the specification of the latency measurement for both Ethernet service and client signal service. In the future version additional parameters would be added into the data model in the same approach as the latency in the current version. A candidate list of parameters to be monitored include: Latency, Packet Loss, Bit Error Rate (BER), Jitter, Bandwidth, Byte/Packet number and so on.

5. YANG Model for Client Signal Performance Monitoring

5.1. YANG Tree for Ethernet Performance Monitoring

```
module: ietf-eth-service-pm
  +--rw performance-monitoring
    +--rw service-pm* [service-name]
      +--rw service-name          leafref
      +--rw pm-enable?            boolean
      +--rw latency-monitoring
        | +--rw latency-measure-enable?  boolean
      +--ro service-pm-state
        +--ro start-time?          yang:date-and-time
        +--ro last-update-time?    yang:date-and-time
        +--ro latency?             uint32
        +--ro error-message?       string
        +--ro service-oper-status? identityref
```

5.2. YANG Tree for Transparent Client Signal Performance Monitoring

```
module: ietf-trans-client-svc-pm
  +--rw performance-monitoring
    +--rw service-pm* [service-name]
      +--rw service-name          leafref
      +--rw pm-enable?            boolean
      +--rw latency-monitoring
        | +--rw latency-measure-enable?  boolean
      +--ro service-pm-state
        +--ro start-time?          yang:date-and-time
        +--ro last-update-time?    yang:date-and-time
        +--ro latency?             uint32
        +--ro error-message?       string
        +--ro service-oper-status?  identityref
```

6. YANG Code for Performance Monitoring

6.1. The ETH Service Performance Monitoring YANG Code

```
<CODE BEGINS> file "ietf-eth-service-pm@2019-11-04.yang"
module ietf-eth-service-pm {
  /* TODO: FIXME */
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-eth-service-pm";
  prefix "ethsvc-pm";

  import ietf-eth-tran-service {
    prefix "ethtsvc";
  }

  import ietf-eth-tran-types {
    prefix "eth-t-types";
  }

  import ietf-yang-types {
    prefix "yang";
  }

  import ietf-te-types {
    prefix "te-types";
  }

  organization
    "Internet Engineering Task Force (IETF) CCAMP WG";
```

contact

```
"
  WG List: <mailto:ccamp@ietf.org>

  ID-draft editor:
    Haomian Zheng (zhenghaomian@huawei.com);
    Italo Busi (italo.busi@huawei.com);
    Yanlei Zheng (zhengyanlei@chinaunicom.cn);
";
```

description

"This module defines the performance monitoring for Ethernet services. The model fully conforms to the Network Management Datastore Architecture (NMDA).

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```
revision 2019-11-04 {
  description
    "Initial version";
  reference
    "ADD REFERENCE HERE";
}
```

```
container performance-monitoring {
  description
    "This part is for performance monitoring. ";
  list service-pm {
    key "service-name";
    description
      "The list of service to be monitored.";
    leaf service-name {
      type leafref {
        path "/ethtsvc:etht-svc/ethtsvc:etht-svc-instances/ethtsvc:etht-svc-na
me";
      }
      description "The name of service.";
    }
  }
}
```

```
leaf pm-enable {
  type boolean;
  description
    "Indicate whether the performance monitoring
    is enable or not.";
}

container latency-monitoring {
  description
    "To monitor the latency of service.";
  leaf latency-measure-enable {
    type boolean;
    description
      "Indicate whether the latency measurement
      is enable or not.";
  }
}

container service-pm-state {
  config false;
  description
    "The state of service performance monitoring.";
  leaf start-time {
    type yang:date-and-time;
    description
      "The time stamp when the service is started.";
  }

  leaf last-update-time {
    type yang:date-and-time;
    description
      "The time stamp when the service is last updated.";
  }

  leaf latency {
    type uint32;
    units microsecond;
    description
      "The latency of service.";
  }

  leaf error-message {
    type string;
    description
      "The message of error.";
  }

  leaf service-oper-status {
```

```
        type identityref {
            base te-types:tunnel-state-type;
        }
        description
            "The operational status of the services.";
    }
}
}
```

<CODE ENDS>

6.2. The Transparent Client Signals Performance Monitoring YANG Code

```
<CODE BEGINS> file "ietf-trans-client-svc-pm@2019-11-04.yang"
module ietf-trans-client-svc-pm {
    /* TODO: FIXME */
    yang-version 1.1;
    namespace "urn:ietf:params:xml:ns:yang:ietf-trans-client-svc-pm";
    prefix "clntsvc-pm";

    import ietf-trans-client-service {
        prefix "clntsvc";
    }

    import ietf-yang-types {
        prefix "yang";
    }

    import ietf-te-types {
        prefix "te-types";
    }

    organization
        "Internet Engineering Task Force (IETF) CCAMP WG";
    contact
        "
            WG List: <mailto:ccamp@ietf.org>

            ID-draft editor:
                Haomian Zheng (zhenghaomian@huawei.com);
                Italo Busi (italo.busi@huawei.com);
                Yanlei Zheng (zhengyanlei@chinaunicom.cn);
        ";
```

description

"This module defines the performance monitoring for transparent client signals. The model fully conforms to the Network Management Datastore Architecture (NMDA).

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revision 2019-11-04 {

description

"Initial version";

reference

"ADD REFERENCE HERE";

}

container performance-monitoring {

description

"This part is for performance monitoring. ";

list service-pm {

key "service-name";

description

"The list of service to be monitored.";

leaf service-name {

type leafref {

path "/clntsvc:client-svc/clntsvc:client-svc-instances/clntsvc:client-svc-name";

}

description "The name of service.";

}

leaf pm-enable {

type boolean;

description

"Indicate whether the performance monitoring is enable or not.";

}

container latency-monitoring {

description

"To monitor the latency of service.";

```
    leaf latency-measure-enable {
      type boolean;
      description
        "Indicate whether the latency measurement
         is enable or not.";
    }
  }

  container service-pm-state {
    config false;
    description
      "The state of service performance monitoring.";

    leaf start-time {
      type yang:date-and-time;
      description
        "The time stamp when the service is started.";
    }

    leaf last-update-time {
      type yang:date-and-time;
      description
        "The time stamp when the service is last updated.";
    }

    leaf latency {
      type uint32;
      units microsecond;
      description
        "The latency of service.";
    }

    leaf error-message {
      type string;
      description
        "The message of error.";
    }

    leaf service-oper-status {
      type identityref {
        base te-types:tunnel-state-type;
      }
      description
        "The operational status of the services.";
    }
  }
```



```
    }  
  }  
}
```

<CODE ENDS>

7. IANA Considerations

It is proposed that IANA should assign new URIs from the "IETF XML Registry" [RFC3688] as follows:

URI: urn:ietf:params:xml:ns:yang:ietf-eth-service-pm
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-trans-client-svc-pm
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

This document registers following YANG modules in the YANG Module Names registry [RFC7950].

name:	ietf-eth-service-pm
namespace:	urn:ietf:params:xml:ns:yang:ietf-eth-service-pm
prefix:	ethsvc-pm
reference:	RFC XXXX (This document)

name:	ietf-trans-client-svc-pm
namespace:	urn:ietf:params:xml:ns:yang:ietf-trans-client-svc-pm
prefix:	clntsvc-pm
reference:	RFC XXXX (This document)

8. Manageability Considerations

TBD.

9. Security Considerations

The data following the model defined in this document is exchanged via, for example, the interface between an orchestrator and a transport network controller. The security concerns mentioned in [I-D.ietf-ccamp-client-signal-yang] also applies to this document.

The YANG module defined in this document can be accessed via the RESTCONF protocol defined in [RFC8040], or maybe via the NETCONF protocol [RFC6241].

10. Contributors

Chaode YU
Huawei Technologies,
Email: yuchaode@huawei.com

11. References

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Authors' Addresses

Haomian Zheng
Huawei Technologies
H1-1-A043S Huawei Industrial Base, Songshanhu
Dongguan, Guangdong 523808
China

Email: zhenghaomian@huawei.com

Italo Busi
Huawei Technologies

Email: Italo.Busi@huawei.com

Yanlei Zheng
China Unicom

Email: zhengyanlei@chinaunicom.cn

CCAMP Working Group
Internet-Draft
Intended status: Standards Track
Expires: May 7, 2020

H. Zheng
Huawei Technologies
A. Guo
Individual
I. Busi
Huawei Technologies
Y. Xu
CAICT
Y. Zhao
China Mobile
X. Liu
Volta Networks
November 4, 2019

A YANG Data Model for Ethernet TE Topology
draft-zheng-ccamp-client-topo-yang-07

Abstract

A transport network is a server-layer network to provide connectivity services to its client. In this draft the topology of Ethernet with TE is described with YANG data model.

Status of This Memo

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

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Table of Contents

1. Introduction	2
2. Terminology and Notations	3
3. YANG Model for Topology of Client Layer	3
3.1. YANG Tree for Ethernet Topology	3
4. YANG Code for Topology Client Layer	21
4.1. The ETH Topology YANG Code	21
5. Considerations and Open Issue	63
6. IANA Considerations	63
7. Manageability Considerations	63
8. Security Considerations	63
9. Acknowledgements	64
10. Contributors	64
11. References	65
11.1. Normative References	65
11.2. Informative References	65
Authors' Addresses	66

1. Introduction

A transport network is a server-layer network designed to provide connectivity services for a client-layer network to carry the client traffic transparently across the server-layer network resources. The topology model in Traffic-Engineered network has been defined in both generic way and technology-specific way. The generic model, which is the base TE YANG model, can be found at [I-D.ietf-teas-yang-te-topo]. Technology-specific models, such as OTN/WSON topology model, have also been defined in [I-D.ietf-ccamp-otn-topo-yang] and [I-D.ietf-ccamp-wson-yang] respectively. Corresponding topology on client-layer is also required, to have a complete topology view from the perspective of network controllers.

This document defines a data model of all client-layer Topology, using YANG language defined in [RFC7950]. The model is augmenting the generic TE topology model, and can be used by either applications exposing to a network controller or among controllers. Furthermore, it can be used by an application for topology description in client-layer network.

2. Terminology and Notations

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in the YANG data tree presented later in this document is defined in [RFC8340]. They are provided below for reference.

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write) and "ro" state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.
- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- o Ellipsis ("...") stands for contents of subtrees that are not shown.

3. YANG Model for Topology of Client Layer

3.1. YANG Tree for Ethernet Topology

```

module: ietf-eth-te-topology
  augment /nw:networks/nw:network/nw:network-types
    /tet:te-topology:
      +--rw eth-tran-topology!
  augment /nw:networks/nw:network/nw:node
    /nt:termination-point:
      +--rw ltp-mac-address?
      |   yang:mac-address
      +--rw port-vlan-id?
      |   etht-types:vlanid
      +--rw maximum-frame-size?                               uint16
      +--rw (direction)?
      |   +--:(symmetrical)
      |   |   +--rw ingress-egress-bandwidth-profile
      |   |   |   +--rw bandwidth-profile-type?
      |   |   |   |   etht-types:bandwidth-profile-type
      |   |   |   +--rw CIR?                               uint64
      |   |   |   +--rw CBS?                               uint64
      |   |   |   +--rw EIR?                               uint64
      |   |   |   +--rw EBS?                               uint64
      |   |   |   +--rw color-aware?                       boolean
      |   |   |   +--rw coupling-flag?                     boolean

```

```

+---:(asymmetrical)
  +---rw ingress-bandwidth-profile
    |   +---rw bandwidth-profile-type?
    |   |       etht-types:bandwidth-profile-type
    |   +---rw CIR?                               uint64
    |   +---rw CBS?                               uint64
    |   +---rw EIR?                               uint64
    |   +---rw EBS?                               uint64
    |   +---rw color-aware?                       boolean
    |   +---rw coupling-flag?                     boolean
  +---rw egress-bandwidth-profile
    |   +---rw bandwidth-profile-type?
    |   |       etht-types:bandwidth-profile-type
    |   +---rw CIR?                               uint64
    |   +---rw CBS?                               uint64
    |   +---rw EIR?                               uint64
    |   +---rw EBS?                               uint64
    |   +---rw color-aware?                       boolean
    |   +---rw coupling-flag?                     boolean
+---rw eth-svc!
  +---rw client-facing?                          boolean
  +---rw supported-classification
    |   +---rw port-classification?              boolean
    |   +---rw vlan-classification
    |   |   +---rw vlan-tag-classification?      boolean
    |   |   +---rw outer-tag
    |   |   |   +---rw supported-tag-types*
    |   |   |   |       etht-types:eth-tag-classify
    |   |   |   +---rw vlan-bundling?            boolean
    |   |   |   +---rw vlan-range?
    |   |   |   |       etht-types:vid-range-type
    |   |   +---rw second-tag
    |   |   |   +---rw second-tag-classification? boolean
    |   |   |   +---rw supported-tag-types*
    |   |   |   |       etht-types:eth-tag-classify
    |   |   |   +---rw vlan-bundling?            boolean
    |   |   |   +---rw vlan-range?
    |   |   |   |       etht-types:vid-range-type
  +---rw supported-vlan-operations
    |   +---rw asymmetrical-operations?          boolean
    |   +---rw transparent-vlan-operations?      boolean
    |   +---rw vlan-pop
    |   |   +---rw vlan-pop-operations?          boolean
    |   |   +---rw max-pop-tags?                  uint8
  +---rw vlan-push
    |   +---rw vlan-push-operation?              boolean
    |   +---rw outer-tag
    |   |   +---rw supported-tag-types*

```



```

    |
    |         etht-types:eth-tag-type
    +---rw vlan-range?
    |         etht-types:vid-range-type
+---rw second-tag
    +---rw push-second-tag?          boolean
    +---rw supported-tag-types*
    |         etht-types:eth-tag-type
    +---rw vlan-range?
    |         etht-types:vid-range-type
augment /nw:networks/nw:network/nw:node
    /nt:termination-point/tet:te
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+---:(eth)
    +---rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+---:(eth)
    +---rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+---:(eth)
    +---rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+---:(eth)
    +---ro eth-bandwidth?    uint64
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:path-constraints
    /tet:te-bandwidth/tet:technology:
+---:(eth)
    +---ro eth-bandwidth?    uint64
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:client-layer-adaptation
    /tet:switching-capability/tet:te-bandwidth
    /tet:technology:
+---:(eth)

```

```
    +--rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:path-constraints/tet:te-bandwidth
    /tet:technology:
+--:(eth)
    +--rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:path-constraints/tet:te-bandwidth
    /tet:technology:
+--:(eth)
    +--rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+--:(eth)
    +--rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:max-link-bandwidth
    /tet:te-bandwidth/tet:technology:
+--:(eth)
    +--rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes
    /tet:max-resv-link-bandwidth/tet:te-bandwidth
    /tet:technology:
+--:(eth)
    +--rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:te-link-attributes/tet:unreserved-bandwidth
    /tet:te-bandwidth/tet:technology:
+--:(eth)
    +--rw eth-bandwidth?    uint64
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
    /tet:interface-switching-capability
    /tet:max-lsp-bandwidth/tet:te-bandwidth
    /tet:technology:
+--:(eth)
    +--ro eth-bandwidth?    uint64
augment /nw:networks/nw:network/nt:link/tet:te
    /tet:information-source-entry
```

```

        /tet:max-link-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(eth)
        +--ro eth-bandwidth?   uint64
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:information-source-entry
        /tet:max-resv-link-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(eth)
        +--ro eth-bandwidth?   uint64
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:information-source-entry
        /tet:unreserved-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(eth)
        +--ro eth-bandwidth?   uint64
    augment /nw:networks/tet:te/tet:templates
        /tet:link-template/tet:te-link-attributes
        /tet:interface-switching-capability
        /tet:max-lsp-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(eth)
        +--rw eth-bandwidth?   uint64
    augment /nw:networks/tet:te/tet:templates
        /tet:link-template/tet:te-link-attributes
        /tet:max-link-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(eth)
        +--rw eth-bandwidth?   uint64
    augment /nw:networks/tet:te/tet:templates
        /tet:link-template/tet:te-link-attributes
        /tet:max-resv-link-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(eth)
        +--rw eth-bandwidth?   uint64
    augment /nw:networks/tet:te/tet:templates
        /tet:link-template/tet:te-link-attributes
        /tet:unreserved-bandwidth/tet:te-bandwidth
        /tet:technology:
    +--:(eth)
        +--rw eth-bandwidth?   uint64
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:te-node-attributes
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction:
    +--rw tag-type?   eth-types:eth-tag-type
    +--rw priority?   uint8
    augment /nw:networks/nw:network/nw:node/tet:te

```

```

        /tet:te-node-attributes
        /tet:connectivity-matrices
        /tet:label-restrictions/tet:label-restriction
        /tet:label-start/tet:te-label/tet:technology:
+---:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(eth)
    +--rw eth-step?   uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te

```

```

    /tet:te-node-attributes
    /tet:connectivity-matrices/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(eth)
  +--rw vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices/tet:path-properties
  /tet:path-route-objects/tet:path-route-object
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(eth)
  +--ro vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction:
+--rw tag-type?   etht-types:eth-tag-type
+--rw priority?   uint8
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+--:(eth)
  +--rw vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+--:(eth)
  +--rw vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:from
  /tet:label-restrictions/tet:label-restriction
  /tet:label-step/tet:technology:
+--:(eth)
```

```
    +--rw eth-step?    uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction:
    +--rw tag-type?    etht-types:eth-tag-type
    +--rw priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
    +--:(eth)
        +--rw eth-step?    uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:te-node-attributes
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
```

```

    +---:(eth)
      +---rw vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-exclude-objects
  /tet:route-object-exclude-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(eth)
  +---rw vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-include-objects
  /tet:route-object-include-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(eth)
  +---rw vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:te-node-attributes
  /tet:connectivity-matrices
  /tet:connectivity-matrix/tet:path-properties
  /tet:path-route-objects/tet:path-route-object
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+---:(eth)
  +---ro vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:label-restrictions/tet:label-restriction:
+---ro tag-type?   etht-types:eth-tag-type
+---ro priority?   uint8
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+---:(eth)
  +---ro vlanid?   etht-types:vlanid
```

```
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+--:(eth)
  +--ro vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices
  /tet:label-restrictions/tet:label-restriction
  /tet:label-step/tet:technology:
+--:(eth)
  +--ro eth-step?  uint16
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices/tet:underlay
  /tet:primary-path/tet:path-element/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(eth)
  +--ro vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices/tet:underlay
  /tet:backup-path/tet:path-element/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(eth)
  +--ro vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-exclude-objects
  /tet:route-object-exclude-object/tet:type
  /tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(eth)
  +--ro vlanid?   etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
  /tet:information-source-entry
  /tet:connectivity-matrices/tet:optimizations
  /tet:algorithm/tet:metric
  /tet:optimization-metric
  /tet:explicit-route-include-objects
  /tet:route-object-include-object/tet:type
```



```

        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +--:(eth)
        +--ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices/tet:path-properties
        /tet:path-route-objects/tet:path-route-object
        /tet:type/tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +--:(eth)
        +--ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:from
        /tet:label-restrictions/tet:label-restriction:
    +--ro tag-type?    etht-types:eth-tag-type
    +--ro priority?    uint8
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:from
        /tet:label-restrictions/tet:label-restriction
        /tet:label-start/tet:te-label/tet:technology:
    +--:(eth)
        +--ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:from
        /tet:label-restrictions/tet:label-restriction
        /tet:label-end/tet:te-label/tet:technology:
    +--:(eth)
        +--ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:from
        /tet:label-restrictions/tet:label-restriction
        /tet:label-step/tet:technology:
    +--:(eth)
        +--ro eth-step?    uint16
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:to
        /tet:label-restrictions/tet:label-restriction:

```

```
    +---ro tag-type?    etht-types:eth-tag-type
    +---ro priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
+---:(eth)
    +---ro vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
+---:(eth)
    +---ro vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:to
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+---:(eth)
    +---ro eth-step?    uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(eth)
    +---ro vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+---:(eth)
    +---ro vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:information-source-entry
    /tet:connectivity-matrices
    /tet:connectivity-matrix/tet:optimizations
```

```

        /tet:algorithm/tet:metric
        /tet:optimization-metric
        /tet:explicit-route-exclude-objects
        /tet:route-object-exclude-object/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +---ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:optimizations
        /tet:algorithm/tet:metric
        /tet:optimization-metric
        /tet:explicit-route-include-objects
        /tet:route-object-include-object/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +---ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:information-source-entry
        /tet:connectivity-matrices
        /tet:connectivity-matrix/tet:path-properties
        /tet:path-route-objects/tet:path-route-object
        /tet:type/tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +---ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction:
    +---rw tag-type?    etht-types:eth-tag-type
    +---rw priority?    uint8
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction
        /tet:label-start/tet:te-label/tet:technology:
    +---:(eth)
        +---rw vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:label-restrictions/tet:label-restriction
        /tet:label-end/tet:te-label/tet:technology:
    +---:(eth)

```

```

    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
+--:(eth)
    +--rw eth-step?  uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities/tet:underlay
    /tet:backup-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-exclude-objects
    /tet:route-object-exclude-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities/tet:optimizations
    /tet:algorithm/tet:metric
    /tet:optimization-metric
    /tet:explicit-route-include-objects
    /tet:route-object-include-object/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
+--:(eth)
    +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point

```

```

        /tet:local-link-connectivities
        /tet:path-properties/tet:path-route-objects
        /tet:path-route-object/tet:type/tet:label
        /tet:label-hop/tet:te-label/tet:technology:
    +--:(eth)
        +--ro vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction:
    +--rw tag-type?    etht-types:eth-tag-type
    +--rw priority?    uint8
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction
    /tet:label-start/tet:te-label/tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction
    /tet:label-end/tet:te-label/tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity
    /tet:label-restrictions/tet:label-restriction
    /tet:label-step/tet:technology:
    +--:(eth)
        +--rw eth-step?    uint16
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point
    /tet:local-link-connectivities
    /tet:local-link-connectivity/tet:underlay
    /tet:primary-path/tet:path-element/tet:type
    /tet:label/tet:label-hop/tet:te-label
    /tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
augment /nw:networks/nw:network/nw:node/tet:te
    /tet:tunnel-termination-point

```

```

        /tet:local-link-connectivities
        /tet:local-link-connectivity/tet:underlay
        /tet:backup-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +--rw vlanid?   etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:local-link-connectivity/tet:optimizations
        /tet:algorithm/tet:metric
        /tet:optimization-metric
        /tet:explicit-route-exclude-objects
        /tet:route-object-exclude-object/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +--rw vlanid?   etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:local-link-connectivity/tet:optimizations
        /tet:algorithm/tet:metric
        /tet:optimization-metric
        /tet:explicit-route-include-objects
        /tet:route-object-include-object/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +--rw vlanid?   etht-types:vlanid
    augment /nw:networks/nw:network/nw:node/tet:te
        /tet:tunnel-termination-point
        /tet:local-link-connectivities
        /tet:local-link-connectivity/tet:path-properties
        /tet:path-route-objects/tet:path-route-object
        /tet:type/tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +--ro vlanid?   etht-types:vlanid
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes/tet:underlay
        /tet:primary-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +---:(eth)
        +--rw vlanid?   etht-types:vlanid
    augment /nw:networks/nw:network/nt:link/tet:te

```

```

        /tet:te-link-attributes/tet:underlay
        /tet:backup-path/tet:path-element/tet:type
        /tet:label/tet:label-hop/tet:te-label
        /tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes/tet:label-restrictions
        /tet:label-restriction:
        +--rw tag-type?    etht-types:eth-tag-type
        +--rw priority?    uint8
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes/tet:label-restrictions
        /tet:label-restriction/tet:label-start
        /tet:te-label/tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes/tet:label-restrictions
        /tet:label-restriction/tet:label-end
        /tet:te-label/tet:technology:
    +--:(eth)
        +--rw vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:te-link-attributes/tet:label-restrictions
        /tet:label-restriction/tet:label-step
        /tet:technology:
    +--:(eth)
        +--rw eth-step?    uint16
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:information-source-entry
        /tet:label-restrictions/tet:label-restriction:
        +--ro tag-type?    etht-types:eth-tag-type
        +--ro priority?    uint8
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:information-source-entry
        /tet:label-restrictions/tet:label-restriction
        /tet:label-start/tet:te-label/tet:technology:
    +--:(eth)
        +--ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:information-source-entry
        /tet:label-restrictions/tet:label-restriction
        /tet:label-end/tet:te-label/tet:technology:
    +--:(eth)
        +--ro vlanid?    etht-types:vlanid
    augment /nw:networks/nw:network/nt:link/tet:te
        /tet:information-source-entry

```

```
        /tet:label-restrictions/tet:label-restriction
        /tet:label-step/tet:technology:
+--:(eth)
  +--ro eth-step?   uint16
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:underlay/tet:primary-path/tet:path-element
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(eth)
  +--rw vlanid?    etht-types:vlanid
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:underlay/tet:backup-path/tet:path-element
  /tet:type/tet:label/tet:label-hop/tet:te-label
  /tet:technology:
+--:(eth)
  +--rw vlanid?    etht-types:vlanid
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:label-restrictions/tet:label-restriction:
+--rw tag-type?    etht-types:eth-tag-type
+--rw priority?    uint8
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:label-restrictions/tet:label-restriction
  /tet:label-start/tet:te-label/tet:technology:
+--:(eth)
  +--rw vlanid?    etht-types:vlanid
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:label-restrictions/tet:label-restriction
  /tet:label-end/tet:te-label/tet:technology:
+--:(eth)
  +--rw vlanid?    etht-types:vlanid
augment /nw:networks/tet:te/tet:templates
  /tet:link-template/tet:te-link-attributes
  /tet:label-restrictions/tet:label-restriction
  /tet:label-step/tet:technology:
+--:(eth)
  +--rw eth-step?   uint16
```


4. YANG Code for Topology Client Layer

4.1. The ETH Topology YANG Code

```
<CODE BEGINS> file "ietf-eth-te-topology@2019-11-04.yang"
module ietf-eth-te-topology {

    namespace "urn:ietf:params:xml:ns:yang:ietf-eth-te-topology";

    prefix "ethtetopo";

    import ietf-network {
        prefix "nw";
    }

    import ietf-network-topology {
        prefix "nt";
    }

    import ietf-te-topology {
        prefix "tet";
    }

    import ietf-yang-types {
        prefix "yang";
    }

    import ietf-eth-tran-types {
        prefix "etht-types";
    }

    organization
        "Internet Engineering Task Force (IETF) CCAMP WG";
    contact
        "
            WG List: <mailto:ccamp@ietf.org>

            ID-draft editor:
            Haomian Zheng (zhenghaomian@huawei.com);
            Italo Busi (italo.busi@huawei.com);
            Aihua Guo (aihuaguo.ietf@gmail.com);
            Yunbin Xu (xuyunbin@caict.ac.cn);
            Yang Zhao (zhaoyangyjy@chinamobile.com);
            Xufeng Liu (xufeng.liu.ietf@gmail.com);
        ";

    description
```

"This module defines a YANG data model for describing layer-2 Ethernet transport topologies. The model fully conforms to the Network Management Datastore Architecture (NMDA).

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```
revision 2019-11-04 {
  description
    "Initial Revision";
  reference
    "RFC XXXX: A YANG Data Model for Client-layer Topology";
  // RFC Ed.: replace XXXX with actual RFC number, update date
  // information and remove this note
}

/*
 * Groupings
 */

grouping eth-tran-topology-type {
  description
    "Identifies the Ethernet Transport topology type";

  container eth-tran-topology {
    presence "indicates a topology type of
      Ethernet Transport Network.";
    description "Eth transport topology type";
  }
}

grouping ltp-bandwidth-profiles {
  description
    "A grouping which represents the bandwidth profile(s)
    for the ETH LTP.";

  choice direction {
    description
```

```
    "Whether the bandwidth profiles are symmetrical or
    asymmetrical";
  case symmetrical {
    description
      "The same bandwidth profile is used to describe the ingress
      and the egress bandwidth profile.";

    container ingress-egress-bandwidth-profile {
      description
        "The bandwidth profile used in the ingress and egress
        direction.";
      uses etht-types:etht-bandwidth-profiles;
    }
  }
  case asymmetrical {
    description
      "Different ingress and egress bandwidth profiles
      can be specified.";
    container ingress-bandwidth-profile {
      description
        "The bandwidth profile used in the ingress direction.";
      uses etht-types:etht-bandwidth-profiles;
    }
    container egress-bandwidth-profile {
      description
        "The bandwidth profile used in the egress direction.";
      uses etht-types:etht-bandwidth-profiles;
    }
  }
}

grouping eth-ltp-attributes {
  description
    "Ethernet transport link termination point attributes";

  /*
   * Open Issue: should we remove this attribute
   * (duplicates with I2RS L2 attributes)?
   */
  leaf ltp-mac-address {
    type yang:mac-address;
    description "the MAC address of the LTP.";
  }
  /*
   * Open Issue: should we remove this attribute
   * (duplicates with I2RS L2 attributes)?
   */
}
```

```
leaf port-vlan-id {
  type etht-types:vlanid;
  description "the port VLAN ID of the LTP.";
}
/*
 * Open Issue: should we remove this attribute
 * (duplicates with I2RS L2 attributes)?
 */
leaf maximum-frame-size {
  type uint16 {
    range "64 .. 65535";
  }
  description
    "Maximum frame size";
}
uses ltp-bandwidth-profiles;
}

grouping svc-vlan-classification {
  description
    "Grouping defining the capabilities for VLAN classification.";

  leaf-list supported-tag-types {
    type etht-types:eth-tag-classify;
    description
      "List of VLAN tag types that can be used for the VLAN
      classification. In case VLAN classification is not
      supported, the list is empty.";
  }
  leaf vlan-bundling {
    type boolean;
    description
      "In case VLAN classification is supported, indicates whether
      VLAN bundling classification is also supported.";
  }
  leaf vlan-range {
    type etht-types:vid-range-type;
    description
      "In case VLAN classification is supported, indicates the
      of available VLAN ID values.";
  }
}

grouping svc-vlan-push {
  description
    "Grouping defining the capabilities for VLAN push or swap
    operations.";
```

```
leaf-list supported-tag-types {
  type etht-types:eth-tag-type;
  description
    "List of VLAN tag types that can be used to push or swap a
    VLAN tag. In case VLAN push/swap is not supported, the list
    is empty.";
}
leaf vlan-range {
  type etht-types:vid-range-type;
  description
    "In case VLAN push/swap operation is supported, the range
    of available VLAN ID values.";
}
}

grouping eth-ltp-svc-attributes {
  description
    "Ethernet link termination point (LTP) service attributes.";

  container supported-classification {
    description
      "Service classification capability supported by the ETH LTP.";

    leaf port-classification {
      type boolean;
      description
        "Indicates that the ETH LTP support port-based service
        classification.";
    }

    container vlan-classification {
      description
        "Service classification capabilities based on the VLAN
        tag(s) supported by the ETH LTP.";

      leaf vlan-tag-classification {
        type boolean;
        description
          "Indicates that the ETH LTP supports VLAN service
          classification.";
      }
    }

    container outer-tag {
      description
        "Service classification capabilities based on the outer
        VLAN tag, supported by the ETH LTP.";
      uses svc-vlan-classification;
    }

    container second-tag {
      description

```

```
        "Service classification capabilities based on the second
        VLAN tag, supported by the ETH LTP.";
    /*
    * Open issue: indicates that second-tag-classification
    * can be True only if outer-tag-classification is also True.
    */
    leaf second-tag-classification {
        type boolean;
        description
            "Indicates that the ETH LTP support VLAN service
            classification based on the second VLAN tag.";
    }
    uses svc-vlan-classification;
}
}

container supported-vlan-operations {
    description
        "Reports the VLAN operations supported by the ETH LTP.";

    leaf asymmetrical-operations {
        type boolean;
        description
            "Indicates whether the ETH LTP supports also asymmetrical
            VLAN operations. It is assumed that symmetrical VLAN
            operations are always supported.";
    }
    leaf transparent-vlan-operations {
        type boolean;
        description
            "Indicates that the ETH LTP supports transparent
            operations.";
    }
}

container vlan-pop {
    description
        "Indicates VLAN pop or swap operations capabilities.";

    leaf vlan-pop-operations {
        type boolean;
        description
            "Indicates that the ETH LTP supports VLAN pop or
            swap operations.";
    }
}

leaf max-pop-tags {
    type uint8 {
        range "1..2";
    }
}
```

```
        description
            "Indicates the maximum number of tags that can be
             popped/swapped.";
    }
}
container vlan-push {
    description
        "Indicates VLAN push or swap operations capabilities.";

    leaf vlan-push-operation {
        type boolean;
        description
            "Indicates that the ETH LTP supports VLAN push or
             swap operations.";
    }
    container outer-tag {
        description
            "Indicates the supported VLAN operation capabilities
             on the outer VLAN tag.";
        uses svc-vlan-push;
    }
    container second-tag {
        description
            "Indicates the supported VLAN operation capabilities
             on the second VLAN tag.";
        leaf push-second-tag {
            type boolean;
            description
                "Indicates that the ETH LTP supports VLAN push or swap
                 operations for the second VLAN tag.";
        }
        uses svc-vlan-push;
    }
}
}
}

/*
 * Data nodes
 */

augment "/nw:networks/nw:network/nw:network-types/tet:te-topology" {
    description
        "Augment network types to include ETH transport newtork";

    uses eth-tran-topology-type;
}
```

```

augment "/nw:networks/nw:network/nw:node/nt:termination-point" {
  when "../..//nw:network-types/tet:te-topology/eth-tran-topology" {
    description
      "Augment only for ETH transport network";
  }
  description
    "Augment ETH LTP attributes";

  uses eth-ltp-attributes;

  container eth-svc {
    presence "client-facing LTP.";
    description
      "ETH LTP Service attributes.";

    leaf client-facing {
      type boolean;
      default "false";
      description
        "Indicates whether this LTP is a client-facing LTP.";
    }
    uses eth-ltp-svc-attributes;
  }
}

/*
 * Augment TE bandwidth
 */

/* Augment maximum LSP bandwidth of link terminationpoint (LTP) */
augment "/nw:networks/nw:network/nw:node/nt:termination-point/"
  + "tet:te/"
  + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..//..//..//..//nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment bandwidth path constraints of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
  when "../..//..//..//..//nw:network-types/tet:te-topology/"

```



```

        + "ethtetopo:eth-tran-topology" {
            description "Ethernet TE bandwidth";
        }
        description "Ethernet bandwidth.";
        case eth {
            uses etht-types:eth-bandwidth;
        }
    }

/* Augment bandwidth path constraints of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..//..//..//..//..//nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
            description "Ethernet TE bandwidth";
        }
    description "Ethernet bandwidth.";
    case eth {
        uses etht-types:eth-bandwidth;
    }
}

/* Augment bandwidth path constraints of connectivity-matrices
 * information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..//..//..//..//..//nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
            description "Ethernet TE bandwidth";
        }
    description "Ethernet bandwidth.";
    case eth {
        uses etht-types:eth-bandwidth;
    }
}

/* Augment bandwidth path constraints of connectivity-matrix
 * information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..//..//..//..//..//nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
            description "Ethernet TE bandwidth";
        }
}

```

```

    }
    description "Ethernet bandwidth.";
    case eth {
        uses etht-types:eth-bandwidth;
    }
}

/* Augment client bandwidth of tunnel termination point (TTP) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:client-layer-adaptation/tet:switching-capability/"
    + "tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE bandwidth";
    }
    description "Ethernet bandwidth.";
    case eth {
        uses etht-types:eth-bandwidth;
    }
}

/* Augment bandwidth path constraints of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/tet:path-constraints/"
    + "tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE bandwidth";
    }
    description "Ethernet bandwidth.";
    case eth {
        uses etht-types:eth-bandwidth;
    }
}

/* Augment bandwidth path constraints of local-link-connectivity */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/tet:path-constraints/"
    + "tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE bandwidth";
    }
    description "Ethernet bandwidth.";
}

```

```
    case eth {
      uses etht-types:eth-bandwidth;
    }
  }

/* Augment maximum LSP bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment maximum bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment maximum reservable bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-resv-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}
```

```
}

/* Augment unreserved bandwidth of TE Link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:unreserved-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment maximum LSP bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:interface-switching-capability/"
  + "tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment maximum bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:max-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment maximum reservable bandwidth of TE link
```

```

    * information-source */
    augment "/nw:networks/nw:network/nt:link/tet:te/"
      + "tet:information-source-entry/"
      + "tet:max-resv-link-bandwidth/"
      + "tet:te-bandwidth/tet:technology" {
    when "../..../nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE bandwidth";
    }
    description "Ethernet bandwidth.";
    case eth {
      uses etht-types:eth-bandwidth;
    }
  }

/* Augment unreserved bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:unreserved-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment maximum LSP bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:interface-switching-capability/"
  + "tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
/*
  when "../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
*/
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

```

```

/* Augment maximum bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:max-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
/*
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
*/
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment maximum reservable bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:max-resv-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
/*
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
*/
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

/* Augment unreserved bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:unreserved-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
/*
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE bandwidth";
  }
*/
  description "Ethernet bandwidth.";
  case eth {
    uses etht-types:eth-bandwidth;
  }
}

```

```
    }
  }

/*
 * Augment TE label.
 */

/* Augment label restrictions of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:label-restrictions/tet:label-restriction" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label restriction.";
  uses etht-types:eth-label-restriction;
}

/* Augment label restrictions start of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-start/"
  + "tet:te-label/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions end of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-end/"
  + "tet:te-label/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}
```

```

/* Augment label restrictions step of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-step/"
  + "tet:technology" {
  when "../.../.../.../.../.../.../.../.../.../.../.../.../.../.../.../..."
  + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label-step;
  }
}

/* Augment label hop of underlay primary path of
 * connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:underlay/tet:primary-path/tet:path-element/"
  + "tet:type/tet:label/tet:label-hop/"
  + "tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label hop of underlay backup path of
 * connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:underlay/tet:backup-path/tet:path-element/"
  + "tet:type/tet:label/tet:label-hop/"
  + "tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

```



```

}

/* Augment label hop of route-exclude of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:te-node-attributes/tet:connectivity-matrices/"
+ "tet:optimizations/tet:algorithm/tet:metric/"
+ "tet:optimization-metric/"
+ "tet:explicit-route-exclude-objects/"
+ "tet:route-object-exclude-object/"
+ "tet:type/tet:label/tet:label-hop/"
+ "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
+ "nw:network-types/tet:te-topology/"
+ "ethrtetopo:eth-tran-topology" {
description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
uses ethrtypes:eth-label;
}
}

/* Augment label hop of route-include of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:te-node-attributes/tet:connectivity-matrices/"
+ "tet:optimizations/tet:algorithm/tet:metric/"
+ "tet:optimization-metric/"
+ "tet:explicit-route-include-objects/"
+ "tet:route-object-include-object/"
+ "tet:type/tet:label/tet:label-hop/"
+ "tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
+ "nw:network-types/tet:te-topology/"
+ "ethrtetopo:eth-tran-topology" {
description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
uses ethrtypes:eth-label;
}
}

/* Augment label hop of path-route of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
+ "tet:te-node-attributes/tet:connectivity-matrices/"
+ "tet:path-properties/tet:path-route-objects/"
+ "tet:path-route-object/tet:type/tet:label/tet:label-hop/"
+ "tet:te-label/tet:technology" {

```

```

    when "../../../../../../../../../../../"
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label;
    }
  }

/* Augment ingress label restrictions of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:from/"
  + "tet:label-restrictions/tet:label-restriction" {
    when "../../../../../../../../../../../nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    uses etht-types:eth-label-restriction;
  }

/* Augment ingress label restrictions start of
 * connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:from/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-start/"
  + "tet:te-label/tet:technology" {
    when "../../../../../../../../../../../"
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label;
    }
  }

/* Augment ingress label restrictions end of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:from/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-end/"
  + "tet:te-label/tet:technology" {

```

```

    when "../../../../../../.."
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label;
    }
  }

/* Augment ingress label restrictions step of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:from/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-step/"
  + "tet:technology" {
    when "../../../../../../.."
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label-step;
    }
  }

/* Augment egress label restrictions of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction" {
    when "../../../../../../../nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    uses etht-types:eth-label-restriction;
  }

/* Augment egress label restrictions start of
 * connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-start/"
  + "tet:te-label/tet:technology" {

```

```

    when "../../../../../../"
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label;
    }
  }

/* Augment egress label restrictions end of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-end/"
  + "tet:te-label/tet:technology" {
    when "../../../"
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label;
    }
  }

/* Augment egress label restrictions step of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/tet:to/"
  + "tet:label-restrictions/tet:label-restriction/tet:label-step/"
  + "tet:technology" {
    when "../../../"
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label-step;
    }
  }

/* Augment label hop of underlay primary path of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:te-node-attributes/tet:connectivity-matrices/"

```

```

    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:primary-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label hop of underlay backup path of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:backup-path/tet:path-element/"
    + "tet:type/tet:label/tet:label-hop/"
    + "tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label hop of route-exclude of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:optimizations/"
    + "tet:algorithm/tet:metric/tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
}
description "Ethernet label.";
case eth {

```

```

    uses etht-types:eth-label;
}

/* Augment label hop of route-include of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/tet:optimizations/"
    + "tet:algorithm/tet:metric/tet:optimization-metric/"
    + "tet:explicit-route-include-objects/"
    + "tet:route-object-include-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of path-route of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-properties/tet:path-route-objects/"
    + "tet:path-route-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label restrictions of connectivity-matrices
 * information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/"
    + "tet:connectivity-matrices/tet:label-restrictions/"
    + "tet:label-restriction" {
    when "../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"

```

```
    + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE label";
    }
    description "Ethernet label.";
    uses etht-types:eth-label-restriction;
  }

/* Augment label restrictions start of connectivity-matrices
* information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/"
  + "tet:connectivity-matrices/tet:label-restrictions/"
  + "tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
  when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE label";
    }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions end of connectivity-matrices
* information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/"
  + "tet:connectivity-matrices/tet:label-restrictions/"
  + "tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
  when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE label";
    }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions step of connectivity-matrices
* information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/"
  + "tet:connectivity-matrices/tet:label-restrictions/"
```

```

        + "tet:label-restriction/"
        + "tet:label-step/tet:technology" {
when "../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label-step;
    }
}

/* Augment label hop of underlay primary path of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of underlay backup path of
 * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of route-exclude of

```



```

    * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label hop of route-include of
    * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-include-objects/"
    + "tet:route-object-include-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label hop of path-route of
    * connectivity-matrices information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:path-properties/tet:path-route-objects/"
    + "tet:path-route-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"

```

```

        + "ethtetopo:eth-tran-topology" {
          description "Ethernet TE label";
        }
      description "Ethernet label.";
      case eth {
        uses etht-types:eth-label;
      }
    }

/* Augment ingress label restrictions of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/tet:label-restriction" {
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  uses etht-types:eth-label-restriction;
}

/* Augment ingress label restrictions start of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment ingress label restrictions end of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {

```

```

    when "../../../../../../../../../../../"
      + "nw:network-types/tet:te-topology/"
      + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
      }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label;
    }
  }

/* Augment ingress label restrictions step of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:from/tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
  when "../../../../../../../../../../../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE label";
    }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label-step;
  }
}

/* Augment egress label restrictions of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:to/tet:label-restrictions/tet:label-restriction" {
  when "../../../../../../../../../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  uses etht-types:eth-label-restriction;
}

/* Augment egress label restrictions start of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"

```

```

        + "tet:to/tet:label-restrictions/tet:label-restriction/"
        + "tet:label-start/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment egress label restrictions end of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:to/tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment egress label restrictions step of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:to/tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label-step;
    }
}

```

```

/* Augment label hop of underlay primary path of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../../../../../../../../../../../../../../../"
        + "nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
            description "Ethernet TE label";
        }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of underlay backup path of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../../../../../../../../../../../../../../../"
        + "nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
            description "Ethernet TE label";
        }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of route-exclude of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-exclude-objects/"
    + "tet:route-object-exclude-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../../../../../../../../../../../../../../../"
        + "nw:network-types/tet:te-topology/"

```

```

    + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
      uses etht-types:eth-label;
    }
  }

/* Augment label hop of route-include of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE label";
    }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label hop of path-route of
 * connectivity-matrix information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
      description "Ethernet TE label";
    }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

```

```

/* Augment label restrictions of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:label-restrictions/tet:label-restriction" {
  when "../..//../..//../..//nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  uses etht-types:eth-label-restriction;
}

/* Augment label restrictions start of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
  when "../..//../..//../..//nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions end of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
  when "../..//../..//../..//nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions step of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"

```

```

    + "tet:local-link-connectivities/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology"{
when "../../../../../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
    uses etht-types:eth-label-step;
}
}

/* Augment label hop of underlay primary path of
 * local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../../../../../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label hop of underlay backup path of
 * local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../../../../../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

```



```

/* Augment label hop of route-exclude of
 * local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-exclude-objects/"
  + "tet:route-object-exclude-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
  uses etht-types:eth-label;
}
}

/* Augment label hop of route-include of
 * local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-include-objects/"
  + "tet:route-object-include-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
  + "nw:network-types/tet:te-topology/"
  + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
}
description "Ethernet label.";
case eth {
  uses etht-types:eth-label;
}
}

/* Augment label hop of path-route of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:path-properties/tet:path-route-objects/"
  + "tet:path-route-object/tet:type/"

```

```

    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
    }
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label restrictions of local-link-connectivity */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:label-restrictions/tet:label-restriction" {
when "../..../..../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
    }
description "Ethernet label.";
uses etht-types:eth-label-restriction;
}

/* Augment label restrictions start of local-link-connectivity */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
when "../..../..../..../..../..../..../"
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
description "Ethernet TE label";
    }
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label restrictions end of local-link-connectivity */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"

```

```

    + "tet:local-link-connectivity/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
    }
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

/* Augment label restrictions step of local-link-connectivity */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
    }
description "Ethernet label.";
case eth {
    uses etht-types:eth-label-step;
}
}

/* Augment label hop of underlay primary path of
 * local-link-connectivity */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
    }
description "Ethernet label.";
case eth {
    uses etht-types:eth-label;
}
}

```

```

}
}

/* Augment label hop of underlay backup path of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label hop of route-exclude of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/"
  + "tet:optimizations/tet:algorithm/tet:metric/"
  + "tet:optimization-metric/"
  + "tet:explicit-route-exclude-objects/"
  + "tet:route-object-exclude-object/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
  when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label hop of route-include of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"

```

```

    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:optimizations/tet:algorithm/tet:metric/"
    + "tet:optimization-metric/"
    + "tet:explicit-route-include-objects/"
    + "tet:route-object-include-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of path-route of
 * local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:tunnel-termination-point/"
    + "tet:local-link-connectivities/"
    + "tet:local-link-connectivity/"
    + "tet:path-properties/tet:path-route-objects/"
    + "tet:path-route-object/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of underlay primary path of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:te-link-attributes/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
when "../.../.../.../.../.../.../.../..."
    + "nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
}

```

```

    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label hop of underlay backup path of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:te-link-attributes/"
    + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label restrictions of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:te-link-attributes/"
    + "tet:label-restrictions/tet:label-restriction" {
    when "../.../.../.../.../.../.../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    uses etht-types:eth-label-restriction;
}

/* Augment label restrictions start of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:te-link-attributes/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-start/tet:te-label/tet:technology" {
    when "../.../.../.../.../.../.../.../.../.../.../.../.../.../.../.../..."
        + "nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

```

```
/* Augment label restrictions end of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions step of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label-step;
  }
}

/* Augment label restrictions of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:label-restrictions/tet:label-restriction" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
  description "Ethernet label.";
  uses etht-types:eth-label-restriction;
}

/* Augment label restrictions start of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
  when "../..../..../..../nw:network-types/tet:te-topology/"
```

```

        + "ethtetopo:eth-tran-topology" {
            description "Ethernet TE label";
        }
        description "Ethernet label.";
        case eth {
            uses etht-types:eth-label;
        }
    }
}

/* Augment label restrictions end of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-end/tet:te-label/tet:technology" {
    when "../..//../..//../..//../nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label;
    }
}

/* Augment label restrictions step of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
    + "tet:information-source-entry/"
    + "tet:label-restrictions/tet:label-restriction/"
    + "tet:label-step/tet:technology" {
    when "../..//../..//../..//../nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";
    }
    description "Ethernet label.";
    case eth {
        uses etht-types:eth-label-step;
    }
}

/* Augment label hop of underlay primary path of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
    + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
/*
    when "../..//../..//../..//../..//../nw:network-types/tet:te-topology/"
        + "ethtetopo:eth-tran-topology" {
        description "Ethernet TE label";

```



```

    }
  */
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label hop of underlay backup path of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
  + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
/*
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
*/
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction" {
/*
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
*/
  description "Ethernet label.";
  uses etht-types:eth-label-restriction;
}

/* Augment label restrictions start of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-start/tet:te-label/tet:technology" {
/*
  when "../../../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
*/

```

```
    }
  */
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions end of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-end/tet:te-label/tet:technology" {
/*
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
*/
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label;
  }
}

/* Augment label restrictions step of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:label-restrictions/tet:label-restriction/"
  + "tet:label-step/tet:technology" {
/*
  when "../..../..../..../nw:network-types/tet:te-topology/"
    + "ethtetopo:eth-tran-topology" {
    description "Ethernet TE label";
  }
*/
  description "Ethernet label.";
  case eth {
    uses etht-types:eth-label-step;
  }
}
}

<CODE ENDS>
```

5. Considerations and Open Issue

Editor Notes: This section is used to note temporary discussion/conclusion that to be fixed in the future version, and will be removed before publication. 201902: we have noticed that Ethernet is the only client signal (on the perspective of OTN) which need a topology. So it is possible that the title of this document will be changed to "A YANG Data Model for Ethernet Topology". The proposal of this work is that the document will follow up the progress of draft-zheng-ccamp-client-signal-yang, with draft-zheng-ccamp-client-tunnel-yang together. (solved in -06) 201902: will have to align with TE topology model, currently is a totally different format with necessary parameters, a big change is expected. (solved in -06.)

6. IANA Considerations

It is proposed that IANA should assign new URIs from the "IETF XML Registry" [RFC3688] as follows:

URI: urn:ietf:params:xml:ns:yang:ietf-eth-te-topology
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

This document registers following YANG modules in the YANG Module Names registry [RFC7950].

name:	ietf-eth-te-topology
namespace:	urn:ietf:params:xml:ns:yang:ietf-eth-te-topology
prefix:	ethtetopo
reference:	RFC XXXX (This document)

7. Manageability Considerations

TBD.

8. Security Considerations

The data following the model defined in this document is exchanged via, for example, the interface between an orchestrator and a transport network controller. The security concerns mentioned in [I-D.ietf-teas-yang-te-topo] for using ietf-te-topology.yang model also applies to this document.

The YANG module defined in this document can be accessed via the RESTCONF protocol defined in [RFC8040], or maybe via the NETCONF protocol [RFC6241].

There are a number of data nodes defined in the YANG module which are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., POST) to these data nodes without proper protection can have a negative effect on network operations.

Editors note: to list specific subtrees and data nodes and their sensitivity/vulnerability.

9. Acknowledgements

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10. Contributors

Yanlei Zheng
China Unicom
Email: zhengyl@dimpt.com

Zhe Liu
Huawei Technologies,
Email: liuzhe123@huawei.com

Zheyu Fan
Huawei Technologies,
Email: fanzheyu2@huawei.com

Sergio Belotti
Nokia,
Email: sergio.belotti@nokia.com

Yingxi Yao
Shanghai Bell,
yingxi.yao@nokia-sbell.com

Giuseppe Fioccola
Huawei Technologies
giuseppe.fioccola@huawei.com

11. References

11.1. Normative References

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11.2. Informative References

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Authors' Addresses

Haomian Zheng
Huawei Technologies
H1-1-A043S Huawei Industrial Base, Songshanhu
Dongguan, Guangdong 523808
China

Email: zhenghaomian@huawei.com

Aihua Guo
Individual

Email: aihuaguo.ietf@gmail.com

Italo Busi
Huawei Technologies

Email: Italo.Busi@huawei.com

Yunbin Xu
CAICT

Email: xuyunbin@caict.ac.cn

Yang Zhao
China Mobile

Email: zhaoyangyjy@chinamobile.com

Xufeng Liu
Volta Networks

Email: xufeng.liu.ietf@gmail.com