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A YANG model to manage the optical interface parameters for an external transponder in a WDM network

draft-dharini-ccamp-dwdm-if-param-yang-04

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.

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Status of This Memo

This Internet-Draft will expire on September 2, 2018.

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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 avaiable 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 |              DWDM Network Elements              | Rs
   +--+ | |  | \                                       / |  |  | +--+
   Tx L1--|->|   \    +------+            +------+   /   |--|-->Rx L1
   +---+  |  |    |   |      |  +------+  |      |  |    |  |    +--+
   +---+  |  |    |   |      |  |      |  |      |  |    |  |    +--+
   Tx L2--|->| OM |-->|------|->|ROADM |--|------|->| OD |--|-->Rx L2
   +---+  |  |    |   |      |  |      |  |      |  |    |  |    +--+
   +---+  |  |    |   |      |  +------+  |      |  |    |  |    +--+
   Tx L3--|->|   /    | DWDM |    |  ^    | DWDM |   \   |--|-->Rx L3
   +---+  |  | /      | Link +----|--|----+ Link |     \ |  |    +--+
          +-----------+           |  |           +----------+
                               +--+  +--+
                               |        |
                            Rs v        | Ss
                            +-----+  +-----+
                            |RxLx |  |TxLx |
                            +-----+  +-----+
   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 netwoks

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 treshold 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 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 osnr-margin?                int32
       |  +--ro q-margin?                   int32
       |  +--ro fec-info?                   string
```

```
   |  +--ro fec-bitrate?                  string
   |  +--ro fec-gain?                     string
   |  +--rw fec-ber-mantissa-threshold?   uint32
   |  +--rw fec-ber-exponent-threshold?   int32
   |  +--ro number-of-lanes?              uint32
   |  +--ro min-laser-temperature?        int32
   |  +--ro max-laser-temperature?        int32
   |  +--ro min-rx-optical-power?         dbm-t
   |  +--ro max-rx-optical-power?         dbm-t
   |  +--ro min-chromatic-dispersion?     int32
   |  +--ro max-chromatic-dispersion?     int32
   |  +--ro min-diff-group-delay?         int32
   |  +--ro max-diff-group-delay?         int32
   |  +--ro modulation-format?            string
   |  +--rw bits-per-symbol?              uint32
   |  +--rw num-symbols-in-alphabet?      uint32
   |  +--rw symbols-index?                uint32
   |  +--ro i-center?                     int32
   |  +--ro q-center?                     int32
   |  +--ro i-noise-variance?             int32
   |  +--ro q-noise-variance?             int32
   |  +--ro a-noise-variance?             int32
   |  +--ro p-noise-variance?             int32
   +--ro if-supported-mode
   |  +--ro number-of-modes-supported?   uint32
   |  +--ro mode-list* [mode-id]
   |     +--ro mode-id                       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 osnr-margin?                  int32
   |     +--ro 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 min-rx-optical-power?         dbm-t
   |     +--ro max-rx-optical-power?         dbm-t
   |     +--ro min-chromatic-dispersion?     int32
   |     +--ro max-chromatic-dispersion?     int32
   |     +--ro min-diff-group-delay?         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 i-center?                     int32
          |     +--ro q-center?                     int32
          |     +--ro i-noise-variance?             int32
          |     +--ro q-noise-variance?             int32
          |     +--ro a-noise-variance?             int32
          |     +--ro p-noise-variance?             int32
          +--rw current-opt-if-och-mode-params
             +--rw mode-id?                          string
             +--ro osnr-margin?                      int32
             +--ro q-margin?                         int32
             +--rw central-frequency?                uint32
             +--rw output-power?                     int32
             +--ro 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 fec-ber-mantissa?                 uint32
             +--ro 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 ietf-ext-xponder-wdm-if {
    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.

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        as authors of the code.  All rights reserved.

        Redistribution and use in source and binary forms, with or
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        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 "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 diff. between polariz. tca";
                }
                enum max-pol-skew-diff-tca{
                  description " The Skew between the two polariz. 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 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 input-power {
                type int32;
                units ".01dbm";
                config false;
                description "The current 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  fec-ber-mantissa-threshold {
                  type uint32;
                  description " Mantissa of the FEC BER threshold";

                 }
                 leaf  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-constellation {
                description "Optical constellation parameters";
                leaf i-center {
                   type int32;
                   units ".0001";
                   config false;
                   description "The In-phase coordinate of the selected
                                constellation symbol for this mode";
                 }
                 leaf q-center {
                   type int32;
                   units ".0001";
                   config false;
                   description "The Quadrature coordinate of the selected
                                constellation symbol for this mode";
                 }
                 leaf i-noise-variance {
                   type int32;
```

```
                units ".001";
                config false;
                description "The Variance of the in-phase noise
                             component for this mode";
              }
              leaf q-noise-variance {
                type int32;
                units ".001";
                config false;
                description "The Variance of the quadrature noise
                             component for this mode";
              }
              leaf a-noise-variance {
                type int32;
                units ".001";
                config false;
                description "The Variance of the radial noise
                             component for this mode";
              }
              leaf p-noise-variance {
                type int32;
                units ".001";
                config false;
                description "The Variance of the phase noise
                             component for this mode";
              }
         }

         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  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.";

              }
              uses opt-if-och-constellation;

         }

         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 interface";
            }
            leaf max-laser-temperature {
                type  int32;
                units ".01C";
                config false;
                description
                       "Maximum Laser Temperature of this mode for
                          this interface";
            }
            leaf min-rx-optical-power {
                type dbm-t;
                config false;
                description
                        "Minimum rx optical power of this mode for
                          this interface";
            }
            leaf max-rx-optical-power {
                type dbm-t;
                config false;
                description
                        "Maximum rx optical power of this mode for
                          this interface";
```

```
            }
            leaf min-chromatic-dispersion {
                type int32;
                config false;
                description
                        "Minimum chromatic dispersion of this mode
                          for this interface";
            }
            leaf max-chromatic-dispersion {
                type int32;
                config false;
                description
                         "Maximum chromatic dispersion of this
                           mode for this interface";
            }
            leaf min-diff-group-delay {
                type int32;
                config false;
                description
                         "Minimum Differential group delay of this
                           mode for this interface";
            }
            leaf max-diff-group-delay  {
                type int32;
                config false;
                description
                         "Maximum Differential group delay of this
                           mode for this interface";
            }
             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  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  fec-ber-mantissa {
               type uint32;
               config false;
               description " Pre fec FEC errored words mantissa";
              }
              leaf  fec-ber-exponent {
               type int32;
               config false;
               description " Pre fec 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 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-input-power {
                      type dbm-t;
                      config false;
                      description "The minimum input power of this
                                   interface";
                   }
                   leaf max-input-power {
                      type dbm-t;
                      config false;
                      description "The maximum input power of this
                                   interface";
                   }
                   leaf min-output-power {
                      type dbm-t;
                      config false;
                      description "The minimum output power of this
                                   interface";
                   }
                   leaf max-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]. he 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

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11. References

11.1. Normative References

[ITU.G694.1]
International Telecommunications Union, "Spectral grids for WDM applications: DWDM frequency grid", ITU-T Recommendation G.694.1, June 2002.

[ITU.G698.2]
International Telecommunications Union, "Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces", ITU-T Recommendation G.698.2, November 2009.

[ITU.G709]
International Telecommunications Union, "Interface for the Optical Transport Network (OTN)", ITU-T Recommendation G.709, March 2003.

[ITU.G7710]
International Telecommunications Union, "Common equipment management function requirements", ITU-T Recommendation G.7710, May 2008.

[ITU.G798]
International Telecommunications Union, "Characteristics of optical transport network hierarchy equipment functional blocks", ITU-T Recommendation G.798, October 2010.

[ITU.G8201]
International Telecommunications Union, "Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)", ITU-T Recommendation G.8201, April 2011.

[ITU.G826]
International Telecommunications Union, "End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections", ITU-T Recommendation G.826, November 2009.

[ITU.G872]
International Telecommunications Union, "Architecture of optical transport networks", ITU-T Recommendation G.872, November 2001.

[ITU.G874]
International Telecommunications Union, "Management aspects of optical transport network elements", ITU-T Recommendation G.874, July 2010.

[ITU.G874.1]
International Telecommunications Union, "Optical transport network (OTN): Protocol-neutral management information model for the network element view", ITU-T Recommendation G.874.1, January 2002.

[ITU.G959.1]
International Telecommunications Union, "Optical transport network physical layer interfaces", ITU-T Recommendation G.959.1, November 2009.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC2578] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Structure of Management Information Version 2 (SMIv2)", STD 58, RFC 2578, DOI 10.17487/RFC2578, April 1999, <https://www.rfc-editor.org/info/rfc2578>.

[RFC2579] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Textual Conventions for SMIv2", STD 58, RFC 2579, DOI 10.17487/RFC2579, April 1999, <https://www.rfc-editor.org/info/rfc2579>.

[RFC2580] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Conformance Statements for SMIv2", STD 58, RFC 2580, DOI 10.17487/RFC2580, April 1999, <https://www.rfc-editor.org/info/rfc2580>.

[RFC2863] McCloghrie, K. and F. Kastenholz, "The Interfaces Group MIB", RFC 2863, DOI 10.17487/RFC2863, June 2000, <https://www.rfc-editor.org/info/rfc2863>.

[RFC3591] Lam, H-K., Stewart, M., and A. Huynh, "Definitions of Managed Objects for the Optical Interface Type", RFC 3591, DOI 10.17487/RFC3591, September 2003, <https://www.rfc-editor.org/info/rfc3591>.

[RFC6205] Otani, T., Ed. and D. Li, Ed., "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, DOI 10.17487/RFC6205, March 2011, <https://www.rfc-editor.org/info/rfc6205>.

11.2. Informative References

[I-D.ietf-ccamp-dwdm-if-mng-ctrl-fwk]
Kunze, R., Grammel, G., Beller, D., and G. Galimberti, "A framework for Management and Control of DWDM optical interface parameters", draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk-00 (work in progress), April 2016.

[RFC2629] Rose, M., "Writing I-Ds and RFCs using XML", RFC 2629, DOI 10.17487/RFC2629, June 1999, <https://www.rfc-editor.org/info/rfc2629>.

[RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", RFC 3410, DOI 10.17487/RFC3410, December 2002, <https://www.rfc-editor.org/info/rfc3410>.

[RFC4054] Strand, J., Ed. and A. Chiu, Ed., "Impairments and Other Constraints on Optical Layer Routing", RFC 4054, DOI 10.17487/RFC4054, May 2005, <https://www.rfc-editor.org/info/rfc4054>.

[RFC4181] Heard, C., Ed., "Guidelines for Authors and Reviewers of MIB Documents", BCP 111, RFC 4181, DOI 10.17487/RFC4181, September 2005, <https://www.rfc-editor.org/info/rfc4181>.

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.

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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-dharinigert-ccamp-dwdm-if-lmp-06

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.G694.1] and its extensions.

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Table of Contents

1. Introduction

This extension addresses the use cases described by "draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk". 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".

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 (OADM).

```
          +-------------------------------------------------+
       Ss |              DWDM Network Elements              | Rs
   +--+ | |  | \                                       / |  |  | +--+
   Tx L1--|->|   \    +------+            +------+   /   |--|-->Rx L1
   +---+  |  |    |   |      |  +------+  |      |  |    |  |    +--+
   +---+  |  |    |   |      |  |      |  |      |  |    |  |    +--+
   Tx L2--|->| OM |-->|------|->|ROADM |--|------|->| OD |--|-->Rx L2
   +---+  |  |    |   |      |  |      |  |      |  |    |  |    +--+
   +---+  |  |    |   |      |  +------+  |      |  |    |  |    +--+
   Tx L3--|->|   /    | DWDM |    |  ^    | DWDM |   \   |--|-->Rx L3
   +---+  |  | /      | Link +----|--|----+ Link |     \ |  |    +--+
          +------------+          |  |           +----------+
                               +--+  +--+
                               |        |
                            Rs v        | Ss
                            +-----+  +-----+
                            |RxLx |  |TxLx |
                            +-----+  +-----+
```

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])

```
          +------+ Ss    +------+       +------+    Rs +------+
          |      | ----- |      |       |      | ----- |      |
          | OXC1 | ----- | OLS1 | ===== | OLS2 | ----- | OXC2 |
          |      | ----- |      |       |      | ----- |      |
          +------+       +------+       +------+       +------+
            ^  ^             ^              ^             ^  ^
            |  |             |              |             |  |
            |  +-----LMP-----+              +-----LMP-----+  |
            |                                                |
            +----------------------LMP-----------------------+
```

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.G709"/>
Rs/Ss   : reference points in between the OXC and the OLS

Figure 2: Extended LMP Model

3. Use Cases

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

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.G698.2]/ITU-T G.698.1 [ITU.G698.1]/ ITU-T G.959.1 [ITU.G959.1]

```
  - OCh_General                  (sub-object Type = TBA)
  - OCh_ApplicationIdentier      (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-galikunze-ccamp-dwdm-if-snmp-mib" and "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|  A.I. Type    |         A.I. length           |
 | Application   |   in use      |                               |
 | Identifier    |               |                               |
 | Number in use |               |                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |           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.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        OUI                                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              OUI cont.        |          Vendor value         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Vendor Value                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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 identifiers this entry - 8 bits

3. Application Indentifier 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:

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

```
|               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.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          OUI                                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               OUI cont.       |           Vendor value        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             Vendor Value                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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:

```
 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)            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Output Power                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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:

```
 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)  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Current Input Power                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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)
```

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12. References

12.1. Normative References

[I-D.ietf-ccamp-dwdm-if-mng-ctrl-fwk]
Kunze, R., Grammel, G., Beller, D., Galimberti, G., and J. Meuric, "A framework for Management and Control of DWDM optical interface parameters", draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk-07 (work in progress), September 2017.

[ITU.G694.1]
International Telecommunications Union, ""Spectral grids for WDM applications: DWDM frequency grid"", ITU-T Recommendation G.698.2, February 2012.

[ITU.G698.2]
International Telecommunications Union, "Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces", ITU-T Recommendation G.698.2, November 2009.

[ITU.G709]
International Telecommunications Union, "Interface for the Optical Transport Network (OTN)", ITU-T Recommendation G.709, February 2012.

[ITU.G872]
International Telecommunications Union, "Architecture of optical transport networks", ITU-T Recommendation G.872, October 2012.

[ITU.G874.1]
International Telecommunications Union, "Optical transport network (OTN): Protocol-neutral management information model for the network element view", ITU-T Recommendation G.874.1, October 2012.

[RFC4054] Strand, J., Ed. and A. Chiu, Ed., "Impairments and Other Constraints on Optical Layer Routing", RFC 4054, DOI 10.17487/RFC4054, May 2005, <https://www.rfc-editor.org/info/rfc4054>.

[RFC4204] Lang, J., Ed., "Link Management Protocol (LMP)", RFC 4204, DOI 10.17487/RFC4204, October 2005, <https://www.rfc-editor.org/info/rfc4204>.

[RFC4209] Fredette, A., Ed. and J. Lang, Ed., "Link Management Protocol (LMP) for Dense Wavelength Division Multiplexing (DWDM) Optical Line Systems", RFC 4209, DOI 10.17487/RFC4209, October 2005, <https://www.rfc-editor.org/info/rfc4209>.

[RFC6205] Otani, T., Ed. and D. Li, Ed., "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, DOI 10.17487/RFC6205, March 2011, <https://www.rfc-editor.org/info/rfc6205>.

12.2. Informative References

[RFC2629] Rose, M., "Writing I-Ds and RFCs using XML", RFC 2629, DOI 10.17487/RFC2629, June 1999, <https://www.rfc-editor.org/info/rfc2629>.

[RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", RFC 3410, DOI 10.17487/RFC3410, December 2002, <https://www.rfc-editor.org/info/rfc3410>.

[RFC4181] Heard, C., Ed., "Guidelines for Authors and Reviewers of MIB Documents", BCP 111, RFC 4181, DOI 10.17487/RFC4181, September 2005, <https://www.rfc-editor.org/info/rfc4181>.

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March 5, 2018

A Yang Data Model for L1 Connectivity Service Model (L1CSM)

draft-fioccola-ccamp-l1csm-yang-01

Abstract

This document provides a YANG data model for Layer 1 Connectivity Service Model (L1CSM).

Status of this Memo

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Table of Contents

1. Introduction

This document provides a YANG data model for L1VPN Connectivity Service Model (L1CSM). The intent of this document is to provide a transport service model exploiting Yang data model, which can be utilized by a client network controller to initiate a service request connectivity request as well as retrieving service states toward a transport network controller communicating with the client controller via a Netconf/Restconf interface.

[RFC4847] provides a framework and service level requirements for Layer 1 Virtual Private Networks (L1VPNs). It classifies service models as management-based service model, signaling-based service model (Basic Mode) and signaling and routing service model (Enhanced Mode).

In the management-based service model, customer management systems and provider management systems communicate with each other. Customer management systems access provider management systems to request layer 1 connection setup/deletion between a pair of CEs. Customer management systems may obtain additional information, such as resource availability information and monitoring information, from provider management systems. There is no control message exchange between a CE and PE.

In the signaling-based service model (Basic Model), the CE-PE interface's functional repertoire is limited to path setup signaling only. In the Signaling and routing service model (Enhanced Mode), the CE-PE interface provides the signaling capabilities as in the Basic Mode, plus permits limited exchange of information between the control planes of the provider and the customer to help such functions as discovery of customer network routing information (i.e., reachability or TE information in remote customer sites), or parameters of the part of the provider's network dedicated to the customer.

The primary focus of this document is to describe L1CS YANG model required for the instantiation of point-to-point L1VPN service. A L1VPN is a service offered by a core layer 1 network to provide layer 1 connectivity between two or more customer sites where the customer has some control over the establishment and type of the connectivity.

The model presented in Section 3 is in consistent with [MEF-L1CS].

1.1. Deployment Scenarios

Figure 1 depicts a deployment scenario of the L1VPN SDN control-based service model for an external customer instantiating L1 point-to-point connectivity to the provider.

```
                             +------------+
                             |  Customer  |
                             |   Service  |
                             |Orchestrator|
                             +------------+
                                   |
                     .. .. .. .. ..|.. .. .. .. ..
                   :             |              :
                     :     +--------------------+     :
                     :     |                    |     :
                     :     |    +----------+    |     :
                     :     |    | Network  |    |     :
                     :     |    |   SDN    |    |     :
                     :     |    |Controller|    |     :
                     :     |    |/NMS/EMS  |    |     :
                     :     |    +----------+    |     :
                     :     |                    |     :
                     :     |                    |     :
           +----+    :   +----+    +----+    +----+   :   +----+
           | CE |----:---| PE |----| P  |----| PE |---:---| CE |
           +----+    :   +----+    +----+    +----+   :   +----+
                     :     |                    |     :
                     :     |                    |     :
                     :     +--------------------+     :
                     :     |                    |     :
                     :     |<-Provider network->|     :

                 Customer                          Customer
                 Interface                         Interface
```

Figure 1: L1VPN SDN Controller/EMS/NMS-Based Service Model: External Customer

With this scenario, the customer service orchestrator interfaces with the network SDN controller of the provider using Customer Service Model as defined in [Service-Yang].

Figure 2 depicts another deployment scenario for internal customer (e.g., higher-layer service management department(s)) interfacing the layer 1 transport network department. With this scenario, a multi-service backbone is characterized such that each service department of a provider (e.g., L2/3 services) that receives the same provider’s L1VPN service provides a different kind of higher-layer service. The customer receiving the L1VPN service (i.e., each service department) can offer its own services, whose payloads can be any layer (e.g., ATM, IP, TDM). The layer 1 transport network and each service network belong to the same organization, but may be managed separately. The Service SDN Controller is the control/management entity owned by higher-layer service department (e.g., L2/3 VPN) whereas the Network SDN Controller is the control/management entity responsible for Layer 1 connectivity service. The CE's in Figure 2 are L2/3 devices that interface with L1 PE devices.

```
                             +----------+
                             | Service  |
                             |   SDN    |
                             |Controller|
                             |/EMS/NMS  |
                             | for L2/3 |
                             +----------+
                                   |
                                   |
                                   |
                           +--------------------+
                           |                    |
                           |    +----------+    |
                           |    | Network  |    |
                           |    |   SDN    |    |
                           |    |Controller|    |
                           |    |/EMS/NMS  |    |
                           |    | for L1VPN|    |
                           |    +----------+    |
                           |                    |
                           |                    |
           +----+        +----+    +----+    +----+      +----+
           | CE |--------| PE |----| P  |----| PE |------| CE |
           +----+        +----+    +----+    +----+      +----+
              |            |                    |          |
              |            |                    |          |
              |            +--------------------+          |
              |            |                    |          |
              |            |<------------------>|          |
              |               Provider Network             |
              |                  For Layer 1               |
             |<------------------------------------------>|
                          Provider Network for L2/3
```

Figure 2: L1VPN SDN Controller/EMS/NMS-Based Service Model: Internal Customer

The benefit is that the same layer 1 transport network resources are shared by multiple services. A large capacity backbone network (data plane) can be built economically by having the resources shared by multiple services usually with flexibility to modify topologies, while separating the control functions for each service department. Thus, each customer can select a specific set of features that are needed to provide their own service [RFC4847].

1.2. Terminology

Refer to [RFC4847] and [RFC5253] for the key terms used in this document.

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

o client

o configuration data

o server

o state data

The following terms are defined in [RFC6020] and are not redefined here:

o augment

o data model

o data node

The terminology for describing YANG data models is found in [RFC6020].

1.3. Tree diagram

A simplified graphical representation of the data model is presented in Section x.

The meaning of the symbols in these diagrams is as follows:

o Brackets "[" and "]" enclose list keys.

o Curly braces "{" and "}" contain names of optional features that make the corresponding node conditional.

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 and "*" denotes a "list" or "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.

2. Definitions

TDB

3. L1SM YANG Model (Tree Structure)

```
module: ietf-l1csm
    +--rw l1cs
       +--rw access
       |  +--rw uni-list* [UNI-ID]
       |     +--rw UNI-ID               string
       |     +--rw protocol?            identityref
       |     +--rw coding?              identityref
       |     +--rw optical_interface?   identityref
       +--rw service
          +--rw service-list* [subscriber-l1vc-id]
             +--rw subscriber-l1vc-id    string
             +--rw service-config
                +--rw subscriber-l1vc-id?            string
                +--rw subscriber-l1vc-ep-ingress?   ->
/l1cs/access/uni-list/UNI-ID
                +--rw subscriber-l1vc-ep-egress?    ->
/l1cs/access/uni-list/UNI-ID
                +--rw client-protocol?              identityref
                +--rw time-start?                   yang:date-and-time
                +--rw time-interval?                int64
                +--rw CoS_Name?                     string
```

```
                   +--rw performance-metric?           identityref
```

4. L1SM YANG Code

The YANG code is as follows:

<CODE BEGINS> file "ietf-l1csm@2018-03-05.yang"

```
module ietf-l1csm {
        yang-version 1.1;
        namespace "urn:ietf:params:xml:ns:yang:ietf-l1csm";
          prefix "l1csm";

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

        organization
               "Internet Engineering Task Force (IETF) CCAMP WG";

        contact

           "Editor: G. Fioccolla (giuseppe.fioccola@telecomitalia.it)
            Editor: K. Lee (kwangkoog.lee@kt.com)
            Editor: Y. Lee (leeyoung@huawei.com)
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            Editor: O. Gonzalez de-Dios (oscar.gonzalezdedios@telefonica.com)
            Editor: D. Ceccarelli (daniele.ceccarelli@ericsson.com)";


        description
                "this module describes Layer 1 connectivity service model for
                 subscriber Layer 1 Connectivity Services and Attributes";

        revision 2018-03-05 {
                description
                        "Initial revision.";
                        reference "to add the draft name";


        }

          identity protocol-type {
                    description
```

```
                              "base identity from which client protocol
type is derived.";
          }

          identity aGigE {
                    base protocol-type;
                    description
                              "GigE protocol type";
          }

          identity a10GigE_WAN {
                    base protocol-type;
                    description
                              "10GigE-WAN protocol type";
          }

          identity a10GigE_LAN {
                    base protocol-type;
                    description
                              "10GigE-LAN protocol type";
          }

          identity a40GigE {
                    base protocol-type;
                    description
                              "40GigE protocol type";
          }

          identity a100GigE {
                    base protocol-type;
                    description
                              "100GigE protocol type";
          }

          identity FC-100 {
                    base protocol-type;
                    description
                              "Fiber Channel - 100 protocol type";
          }

          identity FC-200 {
                    base protocol-type;
                    description
                              "Fiber Channel - 200 protocol type";
          }
```

```
    identity FC-400 {
            base protocol-type;
            description
                    "Fiber Channel - 400 protocol type";
    }

    identity FC-800 {
            base protocol-type;
            description
                    "Fiber Channel - 800 protocol type";
    }

    identity FC-1200 {
            base protocol-type;
            description
                    "Fiber Channel - 1200 protocol type";
    }

    identity FC-1600 {
            base protocol-type;
            description
                    "Fiber Channel - 1600 protocol type";
    }

    identity FC-3200 {
            base protocol-type;
            description
                    "Fiber Channel - 3200 protocol type";
    }

    identity STM-1 {
            base protocol-type;
            description
                    "SDH STM-1 protocol type";
    }

    identity STM-4 {
            base protocol-type;
            description
                    "SDH STM-4 protocol type";
    }

    identity STM-16 {
            base protocol-type;
```

```
            description
                    "SDH STM-16 protocol type";
    }

    identity STM-64 {
            base protocol-type;
            description
                    "SDH STM-64 protocol type";
    }

    identity STM-256 {
            base protocol-type;
            description
                    "SDH STM-256 protocol type";
    }

    identity OC-3 {
            base protocol-type;
            description
                    "SONET OC-3 protocol type";
    }

    identity OC-12 {
            base protocol-type;
            description
                    "SONET OC-12 protocol type";
    }

    identity OC-48 {
            base protocol-type;
            description
                    "SONET OC-48 protocol type";
    }

    identity OC-192 {
            base protocol-type;
            description
                    "SONET OC-192 protocol type";
    }

    identity OC-768 {
            base protocol-type;
            description
                    "SONET OC-768 protocol type";
    }
```

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

          identity a1000X-PCS-36 {
                    base coding-func;
                    description
                              "PCS clause 36 coding function that
corresponds to 1000BASE-X";
          }

          identity a10GW-PCS-49-WIS-50 {
                    base coding-func;
                    description
                              "PCS clause 49 and WIS clause 50 coding func
that corresponds to 10GBASE-W (WAN PHY)";
          }

          identity a10GR-PCS-49 {
                    base coding-func;
                    description
                              "PCS clause 49 coding function that
corresponds to 10GBASE-R (LAN PHY)";
          }

          identity a40GR-PCS-82 {
                    base coding-func;
                    description
                              "PCS clause 82 coding function that
corresponds to 40GBASE-R";
          }

          identity a100GR-PCS-82 {
                    base coding-func;
                    description
                              "PCS clause 82 coding function that
corresponds to 100GBASE-R";
          }

          /* coding func needs to expand for Fiber Channel, SONET, SDH  */

          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";
          }

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

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

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

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

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

```
          }

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

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

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

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

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

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

          identity ER4-PMD-clause-88 {
```

```
                    base optical-interface-func;
                    description
                              "ER4-PMD-clause-88 Optical Interface function
for 100GBASE-R PCS-82";
          }

          /* optical interface func needs to expand for Fiber Channel, SONET
and SDH */

          identity performance-metriclist {
                    description "list of performance metric";
          }

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

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

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

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

          identity One-way-Availability {
                    base performance-metriclist;
                    description "one-way-availability";
          }



          grouping protocol-coding-optical_interface {
                    description
                              "describes <p,c,o>";
                         leaf protocol {
                              type identityref {
```

```
                                   base protocol-type;
                              }
                              description "Physical layer L1VC client
protocol service attribute";
                         }

                         leaf coding {
                              type identityref {
                                   base coding-func;
                              }
                              description "coding function";
                         }

                         leaf optical_interface {
                              type identityref {
                                  base optical-interface-func;
                              }
                              description "optical-interface-function";
                         }
          }

        grouping uni-attributes {
                    description
                              "uni-service-attributes";

                              leaf UNI-ID {
                                        type string;
                                        description "the UNI id of UNI
Service Attributes";
                              }

                              uses protocol-coding-optical_interface;

          }

          grouping subscriber-l1vc-sls-service-attribute {
                    description
                              "The value of the Subscriber L1VC SLS
(Service Level Specification) Service Attribute expressed in a 4-tuple of the
form.";

                              leaf time-start {
                                        type yang:date-and-time;
                                        description "a time that represent
the date and time for the start of the SLS";
```

```
                              }

                              leaf time-interval {
                                        type int64;
                                        units seconds;
                                        description "a time interval
(e.g., 1 month) that is used in conjunction wuth time-start to specify a
contiguous sequence of time intervals T for determining when performance
objectives are met.";
                              }

                              leaf CoS_Name {
                                        type string;
                                        description "a Class of Service
Name used by the Subscriber L1VC End Point Class of Service Identifier Service
Attribute.";
                              }

                              leaf performance-metric {
                                        type identityref {
                                             base performance-metriclist;
                                        }
                                        description "list of performance
metric";
                              }
          }

          grouping subscriber-l1vc-service-attributes {
                    description
                              "subscriber layer 1 connection service
service level";

                    leaf subscriber-l1vc-id {
                              type string;
                              description "subscriber L1VC identifier";
                    }

                    leaf subscriber-l1vc-ep-ingress {
                         type leafref {
                         path "/l1cs/access/uni-list/UNI-ID";
                         }
                         description "this is one end of subscriber L1VC end
point ID value = UNI-1";
                    }
```

```
                    leaf subscriber-l1vc-ep-egress {
                         type leafref {
                         path "/l1cs/access/uni-list/UNI-ID";
                         }
                         description "this is the other end of subscriber
L1VC end point ID value = UNI-2";
                    }

                    leaf client-protocol {
                         type identityref {
                              base protocol-type;
                         }
                         description "One of Ethernet, Fiber Channel, SONET,
SDH";
                    }

                    uses subscriber-l1vc-sls-service-attribute;
          }



          grouping subscriber-attributes {
                    description
                              "subscriber attributes";

                    uses subscriber-l1vc-service-attributes;

          }



        container l1cs {
                description
                        "serves as a top-level container for a list of layer 1
connection services (l1cs)";

                    container access {
                        description "UNI configurations";

                         list uni-list {
                              key "UNI-ID";
                              description "uni identifier";
                              uses uni-attributes {
                                   description "UNI attributes
information";
```

```
                              }
                         }

                    }

                    container service {
                         description "L1VC service";
                         list service-list {
                        key "subscriber-l1vc-id";
                        description
                                "an unique identifier of a service";

                        leaf subscriber-l1vc-id {
                                type string;
                                description "a unique service identifier for
L1VC.";
                        }
                        container service-config {
                                description "service-config container";


                              uses subscriber-attributes;


                        }//end of service-config
                         }//end of service list
                    } //end of service container


        }//service top container
}

   <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 writable/deletable (i.e., "config true") These data nodes may be considered sensitive or vulnerable in some network environments.

6. IANA Considerations

This document registers the following namespace URIs in the IETF XML registry [RFC3688]:

```
--------------------------------------------------------------------
URI: urn:ietf:params:xml:ns:yang:ietf-l1csm
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-l1csm
namespace:    urn:ietf:params:xml:ns:yang:ietf-l1csm
reference:    RFC XXXX (TDB)
--------------------------------------------------------------------
```

7. Acknowledgments

The authors would like to thank Italo Busi for his helpful comments and valuable contributions.

8. References

8.1. Normative References

[MEF-L1CS] "Subscriber Layer 1 Connectivity Service Attributes", Working Draft (WD) v0.09 December 13, 2017.

8.2. Informative References

[RFC4847] T. Takeda (Editor), "Framework and Requirements for Layer 1 Virtual Private Networks", RFC 4847, April 2007.

[RFC5253] T. Takeda, "Applicability Statement for Layer 1 Virtual Private Network (L1VPN) Basic Mode", RFC 5253, July 2008.

[Service-Yang] Q. Wu, et al, "Service Models Explained", draft-wu-opsawg-service-model-explained, Work in progress.

9. Contributors

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Internet-Draft Cisco
Intended status: Informational R.Kunze
Expires: September 2, 2018 Deutsche Telekom
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Juniper
March 1, 2018

A YANG model to manage the optical parameters for in a WDM network
draft-galimbe-ccamp-iv-yang-05

Abstract

This memo defines a Yang model that translate the information model to support Impairment-Aware (IA) Routing and Wavelength Assignment (RWA) functionality. The information model is defined in draft-ietf-ccamp-wson-iv-info and draft-martinelli-ccamp-wson-iv-encode. This document defines proper encoding and extend to the models defined in draft-lee-ccamp-wson-yang tu support Impairment-Aware (IA) Routing and Wavelength Assignment (RWA) functions

The Yang model defined in this memo can be used for Optical Parameters monitoring and/or configuration of the multivendor Endpoints and ROADMs

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1. Introduction

This memo defines a Yang model that translates the existing mib module defined in draft-ietf-ccamp-wson-iv-info and draft-martinelli-ccamp-wson-iv-encode to provide the network impairment information to an SDN controller. One of the key SDN controller features is to support multi vendor network and support the service calculation and deployment in multilayer topologies, for the DWDM layer it is fundamentad that the SDN controller is aware of the optical impairments to verify the feasibility of new circuits before their provisioning. Although SDN controller will not apply exhaustive and accurate algorithms and the optical channel feasibility verification may have a degree of unreliability this function can work on a multivendor common set of parameter and algorithms to ensure the operator the best change to set a circuit. This document follows the same impairment definition and applicability of draft-ietf-ccamp-wson-iv-info.

The optical impairments related to the DWDM Transceiver are described by draft draft-dharini-ccamp-if-param-yang. Applications are defined in G.698.2 [ITU.G698.2] using optical interface parameters at the single-channel connection points between optical transmitters and the optical multiplexer, as well as between optical receivers and the optical demultiplexer in the DWDM system. This Recommendation uses a methodology which explicitly specify the details of the optical network between reference point Ss and Rs, e.g., the passive and active elements or details of the design.

This draft refers and supports the draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk

The building of a yang model describing the optical parameters allows the different vendors and operator to retrieve, provision and exchange information across multi-vendor domains in a standardized way. In addition to the parameters specified in ITU recommendations the Yang models support also the "vendor specific parameters".

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. Definition

For a detailed definition this draft refers to draft-ietf-ccamp-wson-iv-info.

5. Applicability

This document targets at Scenario C defined in [RFC6566] section 4.1.1. as approximate impairment estimation. The Approximate concept refer to the fact that this Information Model covers information mainly provided by [ITU.G680] Computational Model. Although the [RFC6566] provides no or little approximation the parameters described in this draft can be applied to the algorithms verifying the circuit feasibility in the new coherent non compensated DWDM networks In this case the impairments verification can reach a good reliability and accuracy. This draft does not address computational matters but provides all the information suitable to cover most of the full coherent network algoritms, not being exhaustive the information can give a acceptable or even good approximation in therm of connection feasibility. This may not be true for legacy compensated network.

6. Properties

For the signal properties this traft refers the draft-ietf-ccamp-wson-iv-info Ch.2.3 with some extension of the parameters.

7. 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 |                   DWDM Network                  | Rs
   +--+ | |  | \                                       / |  |  | +--+
   Tx L1--|->|   \                                   /   |--|-->Rx L1
   +---+  |  |    |             +------+            |    |  |    +--+
   +---+  |  |    |             |      |            |    |  |    +--+
   Tx L2--|->| OM |------------>|ROADM |-- -------->| OD |--|-->Rx L2
   +---+  |  |    |     DWDM    |      |    DWDM    |    |  |    +--+
   +---+  |  |    |     Link    +------+    Link    |    |  |    +--+
   Tx L3--|->|   /                |  ^               \   |--|-->Rx L3
   +---+  |  | /                  |  |                 \ |  |    +--+
          +-----------------------|--|----------------------+
                               +--+  +--+
                               |        |
                            Rs v        | Ss
                            +-----+  +-----+
                            |RxLx |  |TxLx |
                            +-----+  +-----+
   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 netwoks

7.1. 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. The set of parameters that could be managed are defined by the "application code" notation

The definitions of the optical parameters are provided below to increase the readability of the document, where the definition is ended by (R) the parameter can be retrieve with a read, when (W) it can be provisioned by a write, (R,W) can be either read or written.

7.1.1. Optical path from point Ss to Rs

The following parameters for the optical path from point S and R are defined in G.698.2 [ITU.G698.2].

Maximum and minimum (residual) chromatic dispersion:
These parameters define the maximum and minimum value of the optical path "end to end chromatic dispersion" (in ps/nm) that the system shall be able to tolerate. (R)

Minimum optical return loss at Ss:
These parameter defines minimum optical return loss (in dB) of the cable plant at the source reference point (Ss), including any connectors (R)

Maximum discrete reflectance between Ss and Rs:
Optical reflectance is defined to be the ratio of the reflected optical power present at a point, to the optical power incident to that point. Control of reflections is discussed extensively in ITU-T Rec. G.957 (R)

Maximum differential group delay:
Differential group delay (DGD) is the time difference between the fractions of a pulse that are transmitted in the two principal states of polarization of an optical signal. For distances greater than several kilometres, and assuming random (strong) polarization mode coupling, DGD in a fibre can be statistically modelled as having a Maxwellian distribution. (R)

Maximum polarization dependent loss:
The polarization dependent loss (PDL) is the difference (in dB) between the maximum and minimum values of the channel insertion loss (or gain) of the black link from point SS to RS due to a variation of the state of polarization (SOP) over all SOPs. (R)

Maximum inter-channel crosstalk:
Inter-channel crosstalk is defined as the ratio of total power in all of the disturbing channels to that in the wanted channel, where the wanted and disturbing channels are at different wavelengths. The parameter specify the isolation of a link conforming to the "black link" approach such that under the worst-case operating conditions the inter-channel crosstalk at any reference point RS is less than the maximum inter-channel crosstalk value (R)

Maximum interferometric crosstalk:
This parameter places a requirement on the isolation of a link conforming to the "black link" approach such that under the worst case operating conditions the interferometric crosstalk at any reference point RS is less than the maximum interferometric crosstalk value. (R)

Maximum optical path OSNR penalty:
The optical path OSNR penalty is defined as the difference between the Lowest OSNR at Rs and Lowest OSNR at Ss that meets the BER requirement (R)

Maximum ripple:
Although is defined in G.698.2 (R).

7.1.2. Rs and Ss Configuration

For the Rs and Ss configuration this draft refers the draft-dharini-ccamp-dwdm-if-param-yang while for the Rs-Ss extended parameters for coherent transmission interfaces refer to draft-dharini-ccamp-dwdm-if-param-yang

7.1.3. Table of Application Codes

For Application Codes configuration this draft refers the draft-dharini-ccamp-dwdm-if-param-yang

7.2. Use Cases

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

7.3. Optical Parameters for impairment validation in a WDM network

The ietf-opt-parameters-wdm is an augment to the ????. It allows the user to get and set the application Optical Parameters of a DWDM network.

```
module: ietf-opt-parameters-wdm
  augment /if:interfaces/if:interface:
    +--rw optical-transport
    |  +--rw attenuator-value?    attenuator-t
    |  +--rw offset?              decimal64
    |  +--rw channel-power-ref?   decimal64
    |  +--rw tilt-calibration?    tilt-t
    +--rw opwr-threshold-warning
    |  +--rw opwr-min?         dbm-t
    |  +--rw opwr-min-clear?   dbm-t
```

```
       |  +--rw opwr-max?         dbm-t
       +--rw gain-degrade-alarm
       |  +--rw gain-degrade-low?    dbm-t
       |  +--rw gain-degrade-high?   dbm-t
       +--rw power-degrade-high-alarm
       |  +--rw gain-degrade-high?   dbm-t
       +--rw power-degrade-low-alarm
       |  +--ro power-degrade-low?   dbm-t
       +--rw noise
       |  +--rw noise?   decimal64
       +--rw noise-sigma
       |  +--rw noise?   decimal64
       +--rw chromatic-dispersion
       |  +--rw noise-sigma?   decimal64
       +--rw chromatic-dispersion-slope
       |  +--rw chromatic-dispersion-slope?   decimal64
       +--rw pmd
       |  +--rw pmd?   decimal64
       +--rw pdl
       |  +--rw pdl?   decimal64
       +--rw drop-power
       |  +--rw drop-power?   decimal64
       +--rw drop-power-sigma
       |  +--rw noise?   decimal64
       +--rw ripple
       |  +--rw drop-power-sigma?   decimal64
       +--ro ch-noise-figure
       |  +--ro ch-noise-figure* [ch-noise-fig]
       |     +--ro ch-noise-fig       ch-noise-figure-point
       |     +--ro input-to-output?   decimal64
       |     +--ro input-to-drop?     decimal64
       |     +--ro add-to-output?     decimal64
       +--rw dgd
       |  +--rw dgd?   decimal64
       +--ro ch-isolation
       |  +--ro ch-isolation* [ch-isolat]
       |     +--ro ch-isolat       ch-isolation-cross
       |     +--ro ad-ch-isol?     decimal64
       |     +--ro no-ad-ch-iso?   decimal64
       +--rw ch-extinction
          +--rw cer?   decimal64
```

8. Structure of the Yang Module

ietf-opt-parameters-wdm is a top level model for the support of this feature.

9. Yang Module

The ietf-opt-parameters-wdm is defined as an extension to ietf interfaces ????.

```
<CODE BEGINS> file "ietf-opt-parameters-wdm.yang"

module ietf-opt-parameters-wdm {
  namespace "urn:ietf:params:xml:ns:yang:ietf-opt-parameters-wdm";
  prefix iietf-opt-parameters-wdm;


     import ietf-interfaces {
       prefix if;
     }

     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>


        Editor:   Gabriele Galimberti
                  <mailto:ggalimbe@cisco.com>";

     description
       "This module contains a collection of YANG definitions for
        collecting and configuring Optical Parameters
        in Optical Networks and calculate the circuit feasibility.

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        as authors of the code.  All rights reserved.

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        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 "2018-03-06" {
              description
                  "Revision 1.0";
              reference
                  "";
       }
       revision "2016-10-30" {
              description
                  "Initial revision.";
              reference
                "RFC XXXX: A YANG Data Model for Optical Paramenters
                of DWDM Networks
                   ";
       }



    typedef tilt-t {
       type decimal64 {
         fraction-digits 2;
         range "-5..5";
       }
       description "Tilt Type";
     }


     typedef signal-output-power-t {
         type decimal64 {
           fraction-digits 2;
           range "-10..30";
         }
       description "
         Amplifier Power provisioning ";
     }

     typedef active-channel-t {
       type union {
         type uint8 {
           range "0..200";
         }
       }
       description "
         Number of channels active on a span - and on an amplifier";
     }

     typedef dbm-t {
```

```
       type decimal64 {
         fraction-digits 2;
         range "-50..-30 | -10..5 | 10000000";
       }
       description "
         Amplifier Power in dBm ";
     }

     typedef attenuator-t {
       type decimal64 {
         fraction-digits 2;
         range "-15..-5";
       }
       description "
       Attenuation value (attenuator) applied after the Amplifier";
     }

     typedef ch-noise-figure-point {
       type decimal64 {
         fraction-digits 2;
         range "-15..-5";
       }
       description "
       Amplifier noise figure of point power";
     }

     typedef ch-isolation-cross {
       type decimal64 {
         fraction-digits 2;
         range "-15..-5";
       }
       description "
       cross channel isolation value";
     }

      grouping opwr-threshold-warning-grp {
       description "
         Minimum Optical Power threshold
           - this is used to rise Power alarm ";

       leaf opwr-min {
         type dbm-t;
         units "dBm";
         default -1;
         description "Minimum Power Value";
       }

       leaf opwr-min-clear {
```

```
          type dbm-t;
          units "dBm";
          default -1;
          description "threshold to clear Minimum Power value Alarm";
        }

        leaf opwr-max {
          type dbm-t;
          units "dBm";
          default 1;
          description "
            Maximum Optical Power threshold
             - this is used to rise Power alarm ";
        }
      }

      grouping gain-degrade-alarm-grp {
        description "
          Low Optical Power gain threshold
           - this is used to rise Power alarm ";

        leaf gain-degrade-low {
          type dbm-t;
          units "dBm";
          default -1;
          description "Low Gain Degrade Value";
        }

        leaf gain-degrade-high {
          type dbm-t;
          units "dBm";
          default 1;
          description "
            High Optical Power gain threshold
             - this is used to rise Power alarm ";
        }
      }

      grouping power-degrade-high-alarm-grp {
        description "
          High Optical Power gain alarm ";

        leaf gain-degrade-high {
          type dbm-t;
          units "dBm";
          default 1;
          description "Low Gain Degrade Value";
        }
```

```
     }

     grouping power-degrade-low-alarm-grp {
       description "
         Low Optical Power gain alarm ";

       leaf power-degrade-low {
         type dbm-t;
         units "dBm";
         default -1;
         config false;
         description "High Gain Degrade Value";
       }
     }


     grouping noise-grp {
       description "Noise feasibility";
       leaf noise {
         type decimal64 {
           fraction-digits 2;
         }
           units "dB";
          description "Noise feasibility - reference ITU-T G.680
          OSNR added to the signal by the OMS. The noise is intended
          per channel and is independent of the number of active
          channels in OMS";
       }
     }


     grouping noise-sigma-grp {
         description "Noise sigma feasibility";
       leaf noise-sigma {
         type decimal64 {
           fraction-digits 2;
         }
         units "dB";
         description "Noise Sigma feasibility - accuracy of the
             OSNR added to
            the signal by the OMS";
       }
     }

     grouping chromatic-dispersion-grp {
         description "Chromatic Dispersion";
       leaf chromatic-dispersion {
         type decimal64 {
```

```
          fraction-digits 2;
        }
        units "ps/nm";
        description "Chromatic Dispersion (CD) related to the OMS";
      }
    }

    grouping chromatic-dispersion-slope-grp {
        description "Chromatic Dispersion slope";
      leaf chromatic-dispersion-slope {
        type decimal64 {
          fraction-digits 2;
        }
        units "ps/nm^2";
        description "Chromatic Dispersion (CD) Slope related to
            the OMS";
      }
    }

    grouping pmd-grp {
        description "Polarization Mode Dispersion";
      leaf pmd {
        type decimal64 {
          fraction-digits 2;
        }
        units "ps";
        description "Polarization Mode Dispersion (PMD) related
            to OMS";
      }
    }

    grouping pdl-grp {
        description "Polarization Dependent Loss";
      leaf pdl {
        type decimal64 {
          fraction-digits 2;
        }
        units "dB";
        description "Polarization Dependent Loss (PDL) related to
              the OMS";
      }
    }

    grouping drop-power-grp {
        description "Drop power at DWDM if RX feasibility";
      leaf drop-power {
        type decimal64 {
          fraction-digits 2;
```

```
         }
         units "dBm";
         description "Drop Power value at the DWDM Transceiver RX
              side";
       }
     }

     grouping drop-power-sigma-grp {
         description "Drop power sigma at DWDM if RX feasibility ";
       leaf drop-power-sigma {
         type decimal64 {
           fraction-digits 2;
         }
         units "db";
         description "Drop Power Sigma value at the DWDM Transceiver
         RX side";
       }
     }

       grouping ripple-grp {
           description "Channel Ripple";
       leaf ripple {
         type decimal64 {
           fraction-digits 2;
         }
         units "db";
         description "Channel Ripple";
       }
     }

       grouping ch-noise-figure-grp {
       list ch-noise-figure {
           key "ch-noise-fig";
           description "Channel signal-spontaneous noise figure";

       leaf ch-noise-fig {
           type ch-noise-figure-point;
           description  "Channel signal-spontaneous noise
           figure point";
           }

       leaf input-to-output {
           type decimal64 {
             fraction-digits 2;
           }
           units "dB";
           description "from input port to output port";
         }
```

```
        leaf input-to-drop {
            type decimal64 {
              fraction-digits 2;
            }
            units "dB";
            description "from input port to drop port";
          }

        leaf add-to-output {
            type decimal64 {
              fraction-digits 2;
            }
            units "dB";
            description "from add port to output port";
          }
        }
        description "Channel signal-spontaneous noise figure";
      }

        grouping dgd-grp {
            description "Differential Group Delay";
        leaf dgd {
          type decimal64 {
            fraction-digits 2;
          }
          units "db";
          description "differential group delay";
        }
      }

        grouping ch-isolation-grp {
        list ch-isolation {
            key "ch-isolat";
            description "adjacent and not adjacent channel isolation";

        leaf ch-isolat {
            type ch-isolation-cross;
            description  "channel isolation from adjacent";
            }

        leaf ad-ch-isol {
            type decimal64 {
              fraction-digits 2;
            }
            units "dB";
            description "adjecent channel isolation";
          }
```

```
       leaf no-ad-ch-iso {
           type decimal64 {
             fraction-digits 2;
           }
           units "dB";
           description "non adjecent channel isolation";
         }
       }
       description "djacent and not adjacent channel isolation";
     }

       grouping ch-extinction-grp {
           description "Channel Extinsion";
       leaf cer {
         type decimal64 {
           fraction-digits 2;
         }
         units "db";
         description "channel extinction";
       }
     }

       grouping att-coefficient-grp {
         description "Attenuation coefficient (for a fibre segment)";
       leaf att {
         type decimal64 {
           fraction-digits 2;
         }
         units "db";
         description "Attenuation coefficient (for a fibre segment)";
       }
      }


     augment "/if:interfaces/if:interface" {
       when "if:type = 'ianaift:opticalTransport'" {
           description "Specific optical-transport Interface Data";
       }
       description "Specific optical-transport Interface Data";
       container optical-transport {
         description "Specific optical-transport Data";

         leaf attenuator-value {
           type attenuator-t;
           description "External attenuator value ";
         }

         leaf offset {
```

```
           type decimal64 {
             fraction-digits 2;
             range "-30..30";
           }
           description "Raman and power amplifiers offset";
         }

         leaf channel-power-ref {
           type decimal64 {
             fraction-digits 2;
             range "-10..15";
           }
           description "Optical power per channel";
         }

         leaf tilt-calibration {
           type tilt-t;
           description "Amplifier Tilt tuning";
         }
        }
        container opwr-threshold-warning {
           description "Optical power threshold warning";
         uses opwr-threshold-warning-grp;
             }
        container gain-degrade-alarm {
           description "Gain degrade alarm";
         uses gain-degrade-alarm-grp;
             }
        container power-degrade-high-alarm {
           description "Power degrade high aparm";
         uses power-degrade-high-alarm-grp;
             }
        container power-degrade-low-alarm {
           description "Power degrade low alarm";
         uses power-degrade-low-alarm-grp;
             }
        container noise {
           description "Channel Noise feasibility";
         uses noise-grp;
             }
        container noise-sigma {
           description "Channel Noise sigma feasibility";
         uses noise-grp;
             }
        container chromatic-dispersion {
           description "Chromatic Dispersion";
         uses noise-sigma-grp;
             }
```

```
        container chromatic-dispersion-slope {
           description "Chromatic Dispersion slope";
         uses chromatic-dispersion-slope-grp;
             }
        container pmd {
           description "Polarization Mode Dispersion";
         uses pmd-grp;
             }
        container pdl {
           description "Polarization Dependent Loss";
         uses pdl-grp;
             }
        container drop-power {
           description "Drop power at DWDM if RX feasibility";
         uses drop-power-grp;
             }
        container drop-power-sigma {
           description "Drop power sigma at DWDM if RX feasibility";
         uses noise-grp;
             }
        container ripple {
           description "Channel Ripple";
         uses drop-power-sigma-grp;
             }
        container ch-noise-figure {
           config false;
           description "Channel signal-spontaneous noise figure";
         uses ch-noise-figure-grp;
             }
        container dgd {
           description "Differential Group Delay";
         uses dgd-grp;
             }
        container ch-isolation {
           config false;
           description "adjacent and not adjacent channel isolation";
         uses ch-isolation-grp;
             }
        container ch-extinction {
           description "Channel Extinsion";
         uses ch-extinction-grp;
             }

      }
    }
   }

   <CODE ENDS>
```

10. Security Considerations

The YANG module defined in this memo is designed to be accessed via the NETCONF protocol [RFC6241]. he 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.

11. 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

12. Acknowledgements

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14. References

14.1. Normative References

[ITU.G694.1]
International Telecommunications Union, "Spectral grids for WDM applications: DWDM frequency grid", ITU-T Recommendation G.694.1, June 2002.

[ITU.G698.2]
International Telecommunications Union, "Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces", ITU-T Recommendation G.698.2, November 2009.

[ITU.G709]
International Telecommunications Union, "Interface for the Optical Transport Network (OTN)", ITU-T Recommendation G.709, March 2003.

[ITU.G7710]
International Telecommunications Union, "Common equipment management function requirements", ITU-T Recommendation G.7710, May 2008.

[ITU.G798]
International Telecommunications Union, "Characteristics of optical transport network hierarchy equipment functional blocks", ITU-T Recommendation G.798, October 2010.

[ITU.G8201]
International Telecommunications Union, "Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)", ITU-T Recommendation G.8201, April 2011.

[ITU.G826]
International Telecommunications Union, "End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections", ITU-T Recommendation G.826, November 2009.

[ITU.G872]
International Telecommunications Union, "Architecture of optical transport networks", ITU-T Recommendation G.872, November 2001.

[ITU.G874]
International Telecommunications Union, "Management aspects of optical transport network elements", ITU-T Recommendation G.874, July 2010.

[ITU.G874.1]
International Telecommunications Union, "Optical transport network (OTN): Protocol-neutral management information model for the network element view", ITU-T Recommendation G.874.1, January 2002.

[ITU.G959.1]
International Telecommunications Union, "Optical transport network physical layer interfaces", ITU-T Recommendation G.959.1, November 2009.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC2578] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Structure of Management Information Version 2 (SMIv2)", STD 58, RFC 2578, DOI 10.17487/RFC2578, April 1999, <https://www.rfc-editor.org/info/rfc2578>.

[RFC2579] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Textual Conventions for SMIv2", STD 58, RFC 2579, DOI 10.17487/RFC2579, April 1999, <https://www.rfc-editor.org/info/rfc2579>.

[RFC2580] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Conformance Statements for SMIv2", STD 58, RFC 2580, DOI 10.17487/RFC2580, April 1999, <https://www.rfc-editor.org/info/rfc2580>.

[RFC2863] McCloghrie, K. and F. Kastenholz, "The Interfaces Group MIB", RFC 2863, DOI 10.17487/RFC2863, June 2000, <https://www.rfc-editor.org/info/rfc2863>.

[RFC3591] Lam, H-K., Stewart, M., and A. Huynh, "Definitions of Managed Objects for the Optical Interface Type", RFC 3591, DOI 10.17487/RFC3591, September 2003, <https://www.rfc-editor.org/info/rfc3591>.

[RFC6205] Otani, T., Ed. and D. Li, Ed., "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, DOI 10.17487/RFC6205, March 2011, <https://www.rfc-editor.org/info/rfc6205>.

14.2. Informative References

[I-D.ietf-ccamp-dwdm-if-mng-ctrl-fwk] Kunze, R., Grammel, G., Beller, D., and G. Galimberti, "A framework for Management and Control of DWDM optical interface parameters", draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk-00 (work in progress), April 2016.

[RFC2629] Rose, M., "Writing I-Ds and RFCs using XML", RFC 2629, DOI 10.17487/RFC2629, June 1999, <https://www.rfc-editor.org/info/rfc2629>.

[RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", RFC 3410, DOI 10.17487/RFC3410, December 2002, <https://www.rfc-editor.org/info/rfc3410>.

[RFC4054] Strand, J., Ed. and A. Chiu, Ed., "Impairments and Other Constraints on Optical Layer Routing", RFC 4054, DOI 10.17487/RFC4054, May 2005, <https://www.rfc-editor.org/info/rfc4054>.

[RFC4181] Heard, C., Ed., "Guidelines for Authors and Reviewers of MIB Documents", BCP 111, RFC 4181, DOI 10.17487/RFC4181, September 2005, <https://www.rfc-editor.org/info/rfc4181>.

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.

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March 1, 2018

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-ggalimbe-ccamp-flex-if-lmp-04

Abstract

This experimental memo defines extensions to LMP(rfc4209) for managing Optical parameters associated with Wavelength Division Multiplexing (WDM) adding a set of parameters related to multicarrier DWDM interfaces to be used in Spectrum Switched Optical Networks (sson).

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Status of This Memo

Table of Contents

1. Introduction

This experimental extension addresses the use cases described by "draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk" to the Spectrum Switched Optical Network applications. 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 RFC4204 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 novelty is the interface configuration having a multiple carrier where the client signal is spread on. The parameters are not yet fully defined by ITU-, so this document can jast be seen as an experimental proposal not binding operators and vendors to comply and implement them

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 (OADM).

```
          +-------------------------------------------------+
       Ss |             DWDM Network Elements               | Rs
   +--+ | |  | \                                      / |  |  | +--+
   Tx L1--|->|   \    +------+            +------+   /   |--|-->Rx L1
   +---+  |  |    |   |      |  +------+  |      |  |    |  |    +--+
   +---+  |  | FX |   |      |  | FLEX |  |      |  | FX |  |    +--+
   Tx L2--|->| OM |-->|------|->|ROADM |--|------|->| OD |--|-->Rx L2
   +---+  |  |    |   |      |  |      |  |      |  |    |  |    +--+
   +---+  |  |    |   |      |  +------+  |      |  |    |  |    +--+
   Tx L3--|->|   /    | DWDM |    |  ^    | DWDM |   \   |--|-->Rx L3
   +---+  |  | /      | Link +----|--|----+ Link |     \ |  |    +--+
          +-----------+           |  |           +-----------+
                               +--+  +--+
                               |        |
                            Rs v        | Ss
                            +-----+  +-----+
                            |RxLx |  |TxLx |
                            +-----+  +-----+
```

Ss = Sender reference point at the DWDM network element
     tributary output, this can be a set of multiple transceivers
     carrying the same client payload.
Rs = Receiver reference point at the DWDM network element
     tributary input this can be a set of multiple transceivers
     carrying the same client payload.

FX OM = Flex-Spectrum Optical Mux
FX OD = Flex-Spectrum Optical Demux
Flex ROADM = Flex-Spectrum Optical Add Drop Mux (reconfigurable)

extending Fig. 5.1/G.698.2

Figure 1: Linear Single Channel approach

Figure 2 Extended LMP Model (from [RFC4209])

```
        +------+ Ss    +------+       +------+    Rs +------+
        |      | ----- |      |       |      | ----- |      |
        | OXC1 | ----- | OLS1 | ===== | OLS2 | ----- | OXC2 |
        |      | ----- |      |       |      | ----- |      |
        +------+       +------+       +------+       +------+
          ^  ^            ^              ^             ^  ^
          |  |            |              |             |  |
          |  +-----LMP-----+             +-----LMP-----+  |
          |                                               |
          +----------------------LMP----------------------+
```

OXC   : is an entity that contains Multiple carriers transponders
OLS   : generic Flex-Spectrum 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.G709"/>
Rs/Ss   : reference points in between the OXC and the OLS

Figure 2: Extended LMP Model

3. Use Cases

The set of paramentes exchanged between OXC and OLS is to support the Spectrum Switched Optical Network in therms of Number of Sub-carriers available at the transceiver and their characteristics to provide the SSON control plane all the information suitable to calculate the path and the optical feasibility

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 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 SSON extension
- Multi carrier Transceiver   (sub-object Type = TBA)

5. Multi carrier Transceiver

These are a set of general parameters extending the description in [G698.2] and [G.694.1]. ITU-T working groups are working to detail most of parameters and an update of the TLV may be required.

Other than the Application Identifier described in [G698.2] and draft-dharinigert-ccamp-dwdm-if-lmp the parameters to describe a multicarrier transceiver are describes as follows:

1. Modulation format: indicates the Transceiver capabilities to support a single or multiple modulation format like: BPSK, DC-DP-BSPSK, QPSK, DP-QPSK, QAM16, DP-QAM16, DC-DP-QAM16, 64QAM.
2. FEC: indicates the FEC types the transceiver can support
3. baud rate: symbols rate, basically this identify the channel symbols number per second
4. Num Carriers: number of (sub)carriers the trasceiver can support and can be "mapped" in a Mediachannel
5. Bits/symbol: number of bit per simbol (aka spectral efficiency)
6. Subcarrier band (minimum distance between subcarriers) in GHz
7. Guard band (required guard band at the side of media channel)
8. Sub-carrier TX Power: output optical power the transceiver can provide
9. Sub-carrier RX Power: Input optical power Range the transceiver can support, this is known also as Sensitivity

10 Max-pol-power-difference: max power difference between the polarised components

11 Max-pol-skew-difference: maw Skew between polarised signal and subcarriers supported by the transceiver

12. Sub-carrier OSNR robustness

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)            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|S|I|         Modulation ID     |               FEC             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          baud rate  (Symbol Rate)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Number of subcarriers    |           Bit/Symbol          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          subcarrier band      |          guard band           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
   |                       sub-carrier TX power                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      sub-carrier RX power HIGH                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      sub-carrier RX power LOW                 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Max-pol-power-difference                 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Max-pol-skew-difference                  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         sub-carrier OSNR                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

     - S: standardized format;
     - I: input / output (1 / 0)
     - Modulation Format: is the modulation type:
           BPSK, DC DP BSPSK, QPSK, DP QPSK, 8QAM, 16QAM, 64QAM,
           Hybrid, etc.
            - <TBD> (ITU-T reference)
            - value > 32768 (first bit is 1): custom defined values
           Value 0 is reserved to be used if no value is defined
     - FEC: the signal Forward Error Corrections type (16-bit
           unsigned integer), the defined values are:
            - <TBD> (ITU-T reference)
            - 32768 (first bit is 1): custom defined values
           Value 0 is reserved to be used if no value is defined
     - Baud Rate: the signal symbol rate (IEEE 32-bit float,
           in bauds/s)
           Value 0 is reserved to be used if no value is defined
     - Num Carriers
     - Bits/symbol
     - Subcarrier band (minimum distance between subcarriers)
     - Guard band (required guard band at the side of media channel)
     - Sub-carrier Transmit Power
     - Sub-carrier Receive HIGH Power range (Sensitivity)
     - Sub-carrier Receive LOW Power range (Sensitivity)
     - Sub-carrier OSNR robustness
     - Max-pol-power-difference
     - Max-pol-skew-difference
     - Sub-carrier OSNR
```

Figure 3: Multi carrier Transceiver

6. 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.

7. 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"/>)
- Multi carrier Transceiver (sub-object Type = TBA)

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9. References

9.1. Normative References

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Kunze, R., Grammel, G., Beller, D., Galimberti, G., and J. Meuric, "A framework for Management and Control of DWDM optical interface parameters", draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk-07 (work in progress), September 2017.

[ITU.G694.1]
International Telecommunications Union, ""Spectral grids for WDM applications: DWDM frequency grid"", ITU-T Recommendation G.698.2, February 2012.

[ITU.G698.2]
International Telecommunications Union, "Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces", ITU-T Recommendation G.698.2, November 2009.

[ITU.G709]
International Telecommunications Union, "Interface for the Optical Transport Network (OTN)", ITU-T Recommendation G.709, February 2012.

[ITU.G872]
International Telecommunications Union, "Architecture of optical transport networks", ITU-T Recommendation G.872, October 2012.

[ITU.G874.1]
International Telecommunications Union, "Optical transport network (OTN): Protocol-neutral management information model for the network element view", ITU-T Recommendation G.874.1, October 2012.

[RFC4054] Strand, J., Ed. and A. Chiu, Ed., "Impairments and Other Constraints on Optical Layer Routing", RFC 4054, DOI 10.17487/RFC4054, May 2005, <https://www.rfc-editor.org/info/rfc4054>.

[RFC4204] Lang, J., Ed., "Link Management Protocol (LMP)", RFC 4204, DOI 10.17487/RFC4204, October 2005, <https://www.rfc-editor.org/info/rfc4204>.

[RFC4209] Fredette, A., Ed. and J. Lang, Ed., "Link Management Protocol (LMP) for Dense Wavelength Division Multiplexing (DWDM) Optical Line Systems", RFC 4209, DOI 10.17487/RFC4209, October 2005, <https://www.rfc-editor.org/info/rfc4209>.

[RFC6205] Otani, T., Ed. and D. Li, Ed., "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, DOI 10.17487/RFC6205, March 2011, <https://www.rfc-editor.org/info/rfc6205>.

9.2. Informative References

[RFC2629] Rose, M., "Writing I-Ds and RFCs using XML", RFC 2629, DOI 10.17487/RFC2629, June 1999, <https://www.rfc-editor.org/info/rfc2629>.

[RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", RFC 3410, DOI 10.17487/RFC3410, December 2002, <https://www.rfc-editor.org/info/rfc3410>.

[RFC4181] Heard, C., Ed., "Guidelines for Authors and Reviewers of MIB Documents", BCP 111, RFC 4181, DOI 10.17487/RFC4181, September 2005, <https://www.rfc-editor.org/info/rfc4181>.

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Signaling extensions for Media Channel sub-carriers configuration in Spectrum Switched Optical Networks (SSON) in Lambda Switch Capable (LSC) Optical Line Systems.

draft-ggalimbe-ccamp-flexigrid-carrier-label-03

Abstract

This memo defines the signaling extensions for managing Spectrum Switched Optical Network (SSON) parameters shared between the Client and the Network and inside the Network in accordance to the model described in RFC 7698. The extensions are in accordance and extending the parameters defined in ITU-T Recommendation G.694.1.[ITU.G694.1] and its extensions and G.872.[ITU.G872].

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1. Introduction

Generalised Multiprotocol Label Switched (GMPLS) is widely used in Wavelength Switched Optical Network (WSON) to support the optical circuits set-up through the signalling between Core Nodes and Edge Nodes. This extension addresses the use cases described by [RFC7698] Ch.3.3 and supports the information, needed in Spectrum Switched Optical Network (SSON), to signal a Media Channel and the associated carriers set request. The new set of parameters is related to the Media Channel and the carrier(s) routed with it and keep the backward compatibility with the WSON signalling. In particular this memo wants do address the use cases where the SSON LSP (the Media Channel in RFC7698) carries multiple carrier (OTSi) containing same Payload. The set of the carriers can be seen as single Logical circuit. This memo can be considered as the extension of [RFC7792]. The contents and the parameters reflect the experimental activity on IP over SSON recently done by some vendors and research consortia.

Figure 1 shows how the multiple carrier are mapped into a Media Channel. A set of parameters must be shared on the UNI to allow the GMPLS to do the proper routing and Spectrum Assignment and decide the carrier position.

```
   +------+       +------+  _________  +------+       +------+
   | E.N. |       | C.N. | /        /\ | C.N. |       | E.N. |
   |  OTS1| ----- |      ||        |  ||      | ----- |OTS1  |
 ==|  OTS2| ----- |      || Media  |  ||      | ----- |OTS2  |==
 ==|  OTS3| ----- |      || Channel|  ||      | ----- |OTS3  |==
   |  OTS4| ----- |      ||        |  ||      | ----- |OTS4  |
   |      |       | ROADM| \________\/ | ROADM|       |      |
   +------+       +------+            +------+       +------+
         ^         ^                         ^         ^
         |         |                         |         |
         +---UNI---+                         +---UNI---+


E.N. = Edge Node - UNI Client
C.N. = Core Node - UNI Network
ROADM = Lambda/Spectrum switch
Media Channel = the optical circuit
OTSi = Carriers belonging to the same Network Media Channel (or
       Super Channel)
UNI = Signalig interface
```

Figure 1: Multi carrier LSP

2. Client interface parameters

The Edge Node interface can have one or multiple carriers (OTSi). All the carrier have the same characteristics and are provisionable in terms of:

Number of subcarriers:
   This parameter indicates the number of subcarriers available for the super-channel in case the Transceiver can support multiple carrier circuits.

Central frequency (see G.694.1 Table 1):
   This parameter indicates the Central frequency value that Ss and Rs will be set to work (in THz). See the details in Section 6/

G.694.1 or based on "n" value explanation and the following "k" values definition in case of multicarrier transceivers.

Central frequency granularity:
This parameter indicates the Central frequency granularity supported by the transceiver, this value is combined with k and n value to calculate the central frequency of the carrier or sub-carriers.

Minimum channel spacing:
This is the minimum nominal difference in frequency (in GHz) between two adjacent channels (or carriers) depending on the Transceiver characteristics.

Bit rate / Baud rate of optical tributary signals:
Optical Tributary Signal bit (for NRZ signals) rate or Symbol (for Multiple bit per symbol) rate .

FEC Coding:
This parameter indicate what Forward Error Correction (FEC) code is used at Ss and Rs (R/W) (not mentioned in G.698.2). .

Wavelength Range (see G.694.1): [ITU.G694.1]
This parameter indicate minimum and maximum wavelength spectrum in a definite wavelength Band (L, C and S).

Modulation format:
This parameter indicates the list of supported Modulation Formats and the provisioned Modulation Format..

Inter carrier skew:
This parameter indicates, in case of multi-carrier transceivers the maximum skew between the sub-carriers supported by the transceiver.

Laser Output power:
This parameter provisions the Transceiver Output power, it can be either a setting and measured value.

receiver input power:
This parameter provisions the Min and MAX input pover suppotred by the Transceiver, i.e. Receiver Sensitivity.

The above parameters are related to the Edge Node Transceiver and are used by the Core Network GMPLS in order to calculate the optical feasibility and the spectrum allocation. The parameters can be shared between the Client and the Network via LMP or provisioned to the Network by an EMS or an operator OSS.

3. Use Cases

The use cases are described in draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk and [RFC7698]

4. Signalling Extensions

Some of the above parameters can be applied to RFC7792 (SENDER_TSPEC/ FLOWSPEC). The above parameters could be applied to [RFC4208] scenarios but they are valid also in case of non UNI scenarios. The [RFC6205] parameters remain valid.

4.1. New LSP set-up parameters

When the E.N. wants to request to the C.N. a new circuit set-up request or the GMPLS wants to signal in the SSON network the Optical Interface characteristics the following parameters will be provided to the C.N.:

Number of available subcarriers (c):
This parameter is an integer and identifies the number of Client ports connected to the Core ports available to suport the requested circuit

Total bandwidth request:
e.g. 200Gb, 400Gb, 1Tb - it is the bandwidth (payload) to be carried by the multiple carrier circuit

Policy (strict/loose):
Strict/loose referred to B/W and subcarrier number. This is to give some flexibility to the GMPLS in order to commit client request.

Subcarrier bandwidth tunability:
(optional) e.g. 34Ghz, 48GHz.

Figure 2: The format of the this sub-object is as follows:

The TLV define the resource constraints for the requested Media Channel.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|S|B|     Reserved              |         Carrier Number        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Total Bandwidth                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: SSON LSP set-up request

Carrier Number: number of carrier to be allocated for the requested
      channel (16-bit unsigned integer)
      If Carrier Number == 0 no constraint set on the number of
      carriers to be used

S strict number of subcarrier
  - S = 0 the number of requested carriers is the maximum number
            that can be allocated (a lower value can be allocated if
            the requested bandwidth is satisfied)
  - S = 1 the number of requested carriers is strict (must be > 0)

Total Bandwidth: the requested total bandwidth to be supported by
      the Media Channel (32-bit IEEE float, bytes/s)
      If Total Bandwidth == 0: no bandwidth constraint is defined
      (B must be 0)

B Bandwidth constraints
  - B = 0: the value is the maximum requested bandwidth (a lower
            value can be allocated if resources are not available)
  - B = 1: the requested bandwidth is the minimum value to be
            allocated (a higher value can be allocated if requested
            by the physical constraints of the ports)

Reserved: unused bit (for future use, should be 0)

Note: bandwidth unit is defined in accordance to RFC 3471
    chap. 3.1.2 Bandwith Encoding specification. Bandwidth higher
    than 40Gb/s values must be defined (e.g. 100Gb/s, 150Gb/s
    400Gb/s, etc.)

TLV Usage:
Head UNI-C PATH: requested traffic constraints, the Head UNI-N node
     must satisfy when reserving the optical resources and defining
     the carriers configuration
The TLV can be omitted: no traffic constraints is defined (resources
     allocated by UNI-N based on a local policy)

4.2. Extension to LSP set-up reservation

Once the GMPLS has calculated the Media Channel path, the Spectrum Allocation, the Sub-carrier number and frequency, the modulation format, the FEC and the Transmit power, sends back to the E.N. the path set-up confirmation providing the values of the calculated paramenters:

Media Channel:
   (Grid, C.S., Identifier m and n). as indicated in RFC7699
   Section 4.1

Modulation format:
This parameter indicates the Modulation Formats to be set in the Transceivers.

FEC Coding:
This parameter indicate what Forward Error Correction (FEC) code must be used by the Transceivers (not mentioned in G.698). .

Bit rate / Baud rate of optical tributary signals:
Optical tributary signal bit (for NRZ signals) rate or Symbol (for Multiple bit per symbol) rate.

List of subcarriers:
This parameter indicates the subcarriers to be used for the super-channel in case the Transceiver can support multiple carrier Circuits.

Central frequency granularity (J):
This parameter indicates the Central frequency granularity supported by the transceiver, this value is combined with K and n value to calculate the central frequency on the carrier or sub-carriers.

Central frequency (see G.694.1 Table 1):
Grid, Identifiers, central frequency and granularity.

Laser Output power:
This parameter provisions the Transceiver Output power, it can be either a setting and measured value.

Circuit Path, RRO, etc:
All these info are defined in [RFC4208].

Path Error:
e.g. no path exist, all the path error defined in [RFC4208].

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

The TLV defines the carriers signal configuration.
All carriers in a Media Channel MUST have the same configuration.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Modulation Format      |              FEC              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         baud rate  (Symbol Rate)              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: OCh_General

```
Traffic Type
    - Modulation Format: is the modulation type:
          BPSK, DC DP BSPSK, QPSK, DP QPSK, 8QAM, 16QAM, 64QAM,
          Hybrid, etc.
          - <TBD> (ITU-T reference)
          - value > 32768 (first bit is 1): custom defined values
          Value 0 is reserved to be used if no value is defined
    - FEC: the signal Forward Error Corrections type (16-bit
           unsigned integer), the defined values are:
           - <TBD> (ITU-T reference)
           - 32768 (first bit is 1): custom defined values
           Value 0 is reserved to be used if no value is defined
    - Baud Rate: the signal symbol rate (IEEE 32-bit float,
           in bauds/s)
           Value 0 is reserved to be used if no value is defined
```

Notes:

- The request from the Head UNI-C node can specify only a subset of the parameters (e.g. the Modulation and the baud rate but not the FEC) but setting to 0 the undefined parameters.
- Custom codes (values > 0x8000) interpretation is a local installation matter.

TLV Usage:

- Head UNI-C PATH: used to force specific transponder configurations
- Head UNI-N RESV: set selected configuration on head node
- Tail UNI-N PATH: set selected configuration on tail node

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

For Each carrier inside the Media Channel the TLV is used:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Carrier Identifier       |               j               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               k                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            sub-TLVs                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: Sub-Carrier parameters

Carrier set-up:

- Carrier identifier field: sub-carrier identifier inside the mediachannel. Identifies the carrier position inside the Media Channel (16-bit unsigned integer)
- J field: granularity of the channel spacing, can be a multiple of 0.01GHz. - default value is 0.1GHz.
- K field: positive or negative integer (including 0) to multiply by J and identify the Carrier Position inside the Media Channel, offset from media Channel Central frequency
- sub-TLVs: additional information related to carriers if needed.

In summary Carrier Frequency = MC-C.F. (in THz) + K * J GHz

```
                            m=8
  +-------------------------------X-------------------------------+
  |                               |                               |
  |           sub-carrier         |              sub-carrier      |
  |     +----------X----------+   |   +----------X----------+     |
  |     |        OTSi         |       |        OTSi         |     |
  |     |          o          |   |   |          o          |     |
  |     |          |          |       |          |          |     |
 -4  -3  -2  -1   0   1   2   3   4   5   6   7   8   9   10  11  12
--+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
                 |             n=4             |
                 K1    -236     |     +236     K2

  <------------------------ Media Channel ----------------------->
```

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

The defined sub-TLVs are:

Port Identifier

```
 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 (TBA)         |          Length (TBD)         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Port Identifier                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Port Identifier

Port Identifier: the local upstream optical logical identifier (32-bits integer, ifindex)

Notes:

- The Carrier Identifier is the logical circuit sub-lane position, a TLV for each value from 1 to the number of allocated carriers must be present.

- The association of a carrier to a local link optical port is a local link association (depending on the local ports physical configuration), the sub-TLV value MUST be set by head/tail nodes (with transit nodes not signaling its value).
  The local port identifier is the identifier of the local link port on the upstream node (with respect to the LSP nominal direction):
  - UNI-C port in head UNI link
  - UNI-N port in tail UNI link

TLV Usage:

- Head UNI-C PATH: used to force specific carrier frequency/ports [optional use, e.g. with external PCE scenario]
- Head UNI-N RESV: set selected configuration on head node
- Tail UNI-N PATH: set selected configuration on tail node

Figure 6: The format of this sub-object (Type = TBA, Length = TBD) is as follows:

Carrier Power:

```
 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 (TBA)         |          Length (TBD)         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          carrier power                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: Carrier Power

Carrier Power: the requested carrier transmit power (32-bits IEEE Float, dBm), optionally used to notify the configured power (in UNI client side) or force the power to the to the UNI client).

TLV Usage:
- Head UNI-C PATH: used to force specific carrier frequency/ports (optional use, e.g. with external PCE scenario)
- Head UNI-N RESV: set selected configuration on head node
- Tail UNI-N PATH: set selected configuration on tail node

4.3. RSVP Protocol Extensions considerations

The additional information described in the draft, is related to the Media Channel supported traffic. It could be encoded in the SENDER_TSPEC/FLOW_SPEC objects by extending the SSON_SENDER_TSPEC/ SSON_FLOW_SPEC defined in RFC 7792 (or defining a new C-Type) with an optional TLV list or it could be encoded in a newly defined entry (new OBJECT or new LSP_ATTRIBUTES OBJECT TLV)

This solution is consistent with other technology specific extensions (e.g. SDH), but requires the explicit handling of the extensions by all nodes.

Beside this, some of the additional information defined is local to the head/tail UNI link (e.g. the carrier/port association), while the traffic spec info should be valid end-to-end.

5. Security Considerations

GMPLS message security uses IPsec, as described in xxxx. This document only defines new UNI objects that are carried in existing UNI messages, similar to the UNI objects in xxx. This document does not introduce new security considerations.

6. IANA Considerations

T.B.D.

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8. References

8.1. Normative References

[ITU.G694.1]
International Telecommunications Union, ""Spectral grids for WDM applications: DWDM frequency grid"", ITU-T Recommendation G.698.2, February 2012.

[ITU.G698.2]
International Telecommunications Union, "Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces", ITU-T Recommendation G.698.2, November 2009.

[ITU.G709]
International Telecommunications Union, "Interface for the Optical Transport Network (OTN)", ITU-T Recommendation G.709, February 2012.

[ITU.G872]
International Telecommunications Union, "Architecture of optical transport networks", ITU-T Recommendation G.872, October 2012.

[ITU.G874.1]
International Telecommunications Union, "Optical transport network (OTN): Protocol-neutral management information model for the network element view", ITU-T Recommendation G.874.1, October 2012.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC3473] Berger, L., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Extensions", RFC 3473, DOI 10.17487/RFC3473, January 2003, <https://www.rfc-editor.org/info/rfc3473>.

[RFC3945] Mannie, E., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Architecture", RFC 3945, DOI 10.17487/RFC3945, October 2004, <https://www.rfc-editor.org/info/rfc3945>.

[RFC4208] Swallow, G., Drake, J., Ishimatsu, H., and Y. Rekhter, "Generalized Multiprotocol Label Switching (GMPLS) User-Network Interface (UNI): Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Support for the Overlay Model", RFC 4208, DOI 10.17487/RFC4208, October 2005, <https://www.rfc-editor.org/info/rfc4208>.

[RFC5920] Fang, L., Ed., "Security Framework for MPLS and GMPLS Networks", RFC 5920, DOI 10.17487/RFC5920, July 2010, <https://www.rfc-editor.org/info/rfc5920>.

[RFC6163] Lee, Y., Ed., Bernstein, G., Ed., and W. Imajuku, "Framework for GMPLS and Path Computation Element (PCE) Control of Wavelength Switched Optical Networks (WSONs)", RFC 6163, DOI 10.17487/RFC6163, April 2011, <https://www.rfc-editor.org/info/rfc6163>.

[RFC6205] Otani, T., Ed. and D. Li, Ed., "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, DOI 10.17487/RFC6205, March 2011, <https://www.rfc-editor.org/info/rfc6205>.

[RFC7698] Gonzalez de Dios, O., Ed., Casellas, R., Ed., Zhang, F., Fu, X., Ceccarelli, D., and I. Hussain, "Framework and Requirements for GMPLS-Based Control of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks", RFC 7698, DOI 10.17487/RFC7698, November 2015, <https://www.rfc-editor.org/info/rfc7698>.

[RFC7699] Farrel, A., King, D., Li, Y., and F. Zhang, "Generalized Labels for the Flexi-Grid in Lambda Switch Capable (LSC) Label Switching Routers", RFC 7699, DOI 10.17487/RFC7699, November 2015, <https://www.rfc-editor.org/info/rfc7699>.

[RFC7792] Zhang, F., Zhang, X., Farrel, A., Gonzalez de Dios, O., and D. Ceccarelli, "RSVP-TE Signaling Extensions in Support of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks", RFC 7792, DOI 10.17487/RFC7792, March 2016, <https://www.rfc-editor.org/info/rfc7792>.

8.2. Informative References

[RFC2629] Rose, M., "Writing I-Ds and RFCs using XML", RFC 2629, DOI 10.17487/RFC2629, June 1999, <https://www.rfc-editor.org/info/rfc2629>.

[RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", RFC 3410, DOI 10.17487/RFC3410, December 2002, <https://www.rfc-editor.org/info/rfc3410>.

[RFC4181] Heard, C., Ed., "Guidelines for Authors and Reviewers of MIB Documents", BCP 111, RFC 4181, DOI 10.17487/RFC4181, September 2005, <https://www.rfc-editor.org/info/rfc4181>.

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A YANG Data Model for Microwave Radio Link
draft-ietf-ccamp-mw-yang-04

Abstract

This document defines a YANG data model for control and management of the radio link interfaces, and their connectivity to packet (typically Ethernet) interfaces in a microwave/millimeter wave node. The data nodes for management of the interface protection functionality is broken out into a separate and generic YANG data model in order to make it available also for other interface types.

Status of This Memo

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Table of Contents

1. Introduction

This document defines a YANG data model for management and control of the radio link interface(s) and the relationship to packet (typically Ethernet) and/or TDM interfaces in a microwave/millimeter wave node. ETSI EN 302 217 series defines the characteristics and requirements of microwave/millimeter wave equipment and antennas. Especially ETSI EN 302 217-2 [EN302217-2] specifies the essential parameters for the systems operating from 1.4GHz to 86GHz. The data model includes configuration and state data according to the new Network Management Datastore Architecture [NMDA].

The design of the data model follows the framework for management and control of microwave and millimeter wave interface parameters defined in [I-D.ietf-ccamp-microwave-framework]. This framework identifies the need and the scope of the YANG data model, the use cases and requirements that the model needs to support. Moreover, it provides a detailed gap analysis to identify the missing parameters and functionalities of the existing and established models to support the specified use cases and requirements, and based on that recommends how the gaps should be filled with the development of the new model. According to the conclusion of the gap analysis, the structure of the data model is based on the structure defined in [I-D.ahlberg-ccamp-microwave-radio-link] and it augments [RFC7223bis] to align with the same structure for management of the packet interfaces. More specifically, the model will include interface layering to manage the capacity provided by a radio link terminal for the associated Ethernet and TDM interfaces, using the principles for interface layering described in [RFC7223bis] as a basis.

The data nodes for management of the interface protection functionality is broken out into a separate and generic YANG data module in order to make it available also for other interface types.

The designed YANG data model uses established microwave equipment and radio standards, such as ETSI EN 302 217-2, and the IETF: Radio Link Model[I-D.ahlberg-ccamp-microwave-radio-link] and the ONF: Microwave Modeling[ONF-model] as the basis for the definition of the detailed leafs/parameters, and proposes new ones to cover identified gaps which are analyzed in[I-D.ietf-ccamp-microwave-framework].

1.1. Terminology and Definitions

The following terms are used in this document:

Carrier Termination (CT) is an interface for the capacity provided over the air by a single carrier. It is typically defined by its transmitting and receiving frequencies.

Radio Link Terminal (RLT) is an interface providing packet capacity and/or TDM capacity to the associated Ethernet and/or TDM interfaces in a node and used for setting up a transport service over a microwave/millimeter wave link.

The following acronyms are used in this document:

ACM Adaptive Coding Modulation

ATPC Automatic Transmit Power Control

CM Coding Modulation

CT Carrier Termination

RLT Radio Link Terminal

RTPC Remote Transmit Power Control

XPIC Cross Polarization Interference Cancellation

MIMO Multiple-Input Multiple-Output

1.2. Tree Structure

A simplified graphical representation of the data model is used in chapter 3.1 of this this document. The meaning of the symbols in these diagrams is defined in [YANG-TREE].

2. 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].

3. Microwave Radio Link YANG Data Model

3.1. YANG Tree

```
module: ietf-microwave-radio-link
  +--rw radio-link-protection-groups
  |  +--rw protection-group* [name]
  |     +--rw name                           string
  |     +--rw architecture-type?             identityref
  |     +--rw members*                       if:interface-ref
  |     +--rw operation-type?                enumeration
  |     +--rw working-entity*                if:interface-ref
  |     +--rw revertive-wait-to-restore?     uint16
  |     +--rw hold-off-timer?                uint16
  |     +--rw status?                        identityref
  |     +---x external-commands
  |        +---w input
  |           +---w external-command?        identityref
  +--rw xpic-pairs {xpic}?
  |  +--rw xpic-pair* [name]
  |     +--rw name            string
  |     +--rw enabled?        boolean
  |     +--rw members*   if:interface-ref
  +--rw mimo-groups {mimo}?
     +--rw mimo-group* [name]
        +--rw name            string
        +--rw enabled?        boolean
        +--rw members*   if:interface-ref
```

```
     augment /if:interfaces/if:interface:
       +--rw id?                      string
       +--rw mode                     identityref
       +--rw carrier-terminations*   if:interface-ref
       +--rw rlp-groups*
       |       -> /radio-link-protection-groups/protection-group/name
       +--rw xpic-pairs*             -> /xpic-pairs/xpic-pair/name
       |       {xpic}?
       +--rw mimo-groups*            -> /mimo-groups/mimo-group/name
       |       {mimo}?
       +--rw tdm-connections* [tdm-type] {tdm}?
          +--rw tdm-type             identityref
          +--rw tdm-connections      uint16
     augment /if:interfaces/if:interface:
       +--rw carrier-id?                     string
       +--rw tx-enabled?                     boolean
       +--ro tx-oper-status?                 enumeration
       +--rw tx-frequency                    uint32
       +--rw rx-frequency?                   uint32
       +--rw duplex-distance?                uint32
       +--rw channel-separation              uint32
       +--rw polarization?                   enumeration
       +--rw power-mode                      enumeration
       +--rw maximum-nominal-power           power
       +--rw atpc-lower-threshold            power
       +--rw atpc-upper-threshold            power
       +--ro actual-transmitted-level?       power
       +--ro actual-received-level?          power
       +--rw coding-modulation-mode          enumeration
       +--rw selected-cm                     identityref
       +--rw selected-min-acm                identityref
       +--rw selected-max-acm                identityref
       +--ro actual-tx-cm?                   identityref
       +--ro actual-snir?                    decimal64
       +--ro actual-xpi?                     decimal64 {xpic}?
       +--rw ct-performance-thresholds
       |  +--rw received-level-alarm-threshold?      power
       |  +--rw transmitted-level-alarm-threshold?   power
       |  +--rw ber-alarm-threshold?                 enumeration
       +--rw if-loop?                        enumeration
       +--rw rf-loop?                        enumeration
       +--ro capabilities
       |  +--ro min-tx-frequency?          uint32
       |  +--ro max-tx-frequency?          uint32
       |  +--ro min-rx-frequency?          uint32
       |  +--ro max-rx-frequency?          uint32
       |  +--ro minimum-power?             power
       |  +--ro maximum-available-power?   power
       |  +--ro available-min-acm?         identityref
       |  +--ro available-max-acm?         identityref
```

```
       +--ro error-performance-statistics
       |  +--ro bbe?   yang:counter32
       |  +--ro es?    yang:counter32
       |  +--ro ses?   yang:counter32
       |  +--ro uas?   yang:counter32
       +--ro radio-performance-statistics
          +--ro min-rltm?   power
          +--ro max-rltm?   power
          +--ro min-tltm?   power
          +--ro max-tltm?   power
```

3.2. Explanation of the Microwave Data Model

The leafs in the Interface Management Module augmented by Radio Link Terminal (RLT) and Carrier Termination (CT) are not always applicable.

"/interfaces/interface/enabled" is not applicable for RLT. Enable and disable of an interface is done in the constituent CTs.

The packet related measurements "in-octets", "in-unicast-pkts", "in-broadcast-pkts", "in-multicast-pkts", "in-discards", "in-errors", "in-unknown-protos", "out-octets", "out-unicast-pkts", "out-broadcast-pkts", "out-multicast-pkts", "out-discards", "out-errors" are not within the scope of the microwave radio link domain and therefore not applicable for RLT and CT.

4. Microwave Radio Link YANG Module

This module imports typedefs and modules from [RFC6991], [RFC7223bis] and [RFC7224], and it references [TR102311], [EN302217-1], [EN301129], and [G.826].

<CODE BEGINS> file "ietf-microwave-radio-link@2018-03-03.yang"

```
module ietf-microwave-radio-link {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-microwave-radio-link";
  prefix mrl;

  import ietf-yang-types {
    prefix yang;
    reference "RFC 6991";
  }

  import ietf-interfaces {
    prefix if;
    reference "RFC 7223bis";
  // RFC Ed.: replace 7223bis with actual RFC number and remove
  // this note
  }
```

```
     import ietf-interface-protection {
       prefix ifprot;
       reference "RFC XXXX";
     // RFC Ed.: replace XXXX with actual RFC number and remove
     // this note
     }

     import iana-if-type {
       prefix ianaift;
       reference "RFC 7224";
     }

     organization
      "Internet Engineering Task Force (IETF) CCAMP WG";

    contact
      "WG List: <mailto:ccamp@ietf.org>

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     description
       "This is a module for the entities in
       a generic microwave system.

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       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.

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

     revision 2018-03-03 {
       description "Initial revision.";
       reference "RFC XXXX: A YANG Data Model for Microwave Radio Link";
     // RFC Ed.: replace XXXX with actual RFC number and remove
     // this note
     }
```

```
/*
 * Features
 */

feature xpic {
  description
    "Indicates that the device supports XPIC.";
  reference "ETSI TR 102 311";
}

feature mimo {
  description
    "Indicates that the device supports MIMO.";
  reference "ETSI TR 102 311";
}

feature tdm {
  description
    "Indicates that the device supports TDM.";
}

/*
 * Interface identities
 */

identity radio-link-terminal {
  base ianaift:iana-interface-type;
  description
    "Interface identity for a radio link terminal.";
}

identity carrier-termination {
  base ianaift:iana-interface-type;
  description
   "Interface identity for a carrier termination.";
}

/*
 * Radio-link-terminal mode identities
 */

identity rlt-mode {
  description
    "A description of the mode in which the radio link
    terminal is configured. The format is X plus Y.
    X represent the number of bonded carrier terminations.
    Y represent the number of protecting carrier
    terminations.";
}
```

```
     identity one-plus-zero {
       base rlt-mode;
       description
         "1 carrier termination only.";
     }

     identity one-plus-one {
       base rlt-mode;
       description
         "1 carrier termination
         and 1 protecting carrier termination.";
     }

     identity two-plus-zero {
       base rlt-mode;
       description
         "2 bonded carrier terminations.";
     }

     /*
      * Coding and modulation identities
      */

     identity coding-modulation {
       description
         "The coding and modulation schemes.";
     }

     identity half-bpsk-strong {
       base coding-modulation;
       description
         "Half BPSK strong coding and modulation scheme.";
     }

     identity half-bpsk {
       base coding-modulation;
       description
         "Half BPSK coding and modulation scheme.";
     }

     identity half-bpsk-light {
       base coding-modulation;
       description
         "Half BPSK light coding and modulation scheme.";
     }

     identity bpsk-strong {
       base coding-modulation;
       description
         "BPSK strong coding and modulation scheme.";
     }
```

```
     identity bpsk {
       base coding-modulation;
       description
         "BPSK coding and modulation scheme.";
     }

     identity bpsk-light {
       base coding-modulation;
       description
         "BPSK light coding and modulation scheme.";
     }

     identity qpsk {
       base coding-modulation;
       description
         "QPSK coding and modulation scheme.";
     }

     identity qam-4-strong {
       base coding-modulation;
       description
         "4 QAM strong coding and modulation scheme.";
     }

     identity qam-4 {
       base coding-modulation;
       description
         "4 QAM coding and modulation scheme.";
     }

     identity qam-4-light {
       base coding-modulation;
       description
         "4 QAM light coding and modulation scheme.";
     }

     identity qam-16-strong {
       base coding-modulation;
       description
         "16 QAM strong coding and modulation scheme.";
     }

     identity qam-16 {
       base coding-modulation;
       description
         "16 QAM coding and modulation scheme.";
     }
```

```
     identity qam-16-light {
       base coding-modulation;
       description
         "16 QAM light coding and modulation scheme.";
     }

     identity qam-32-strong {
       base coding-modulation;
       description
         "32 QAM strong coding and modulation scheme.";
     }

     identity qam-32 {
       base coding-modulation;
       description
         "32 QAM coding and modulation scheme.";
     }

     identity qam-32-light {
       base coding-modulation;
       description
         "32 QAM light coding and modulation scheme.";
     }

     identity qam-64-strong {
       base coding-modulation;
       description
         "64 QAM strong coding and modulation scheme.";
     }

     identity qam-64 {
       base coding-modulation;
       description
         "64 QAM coding and modulation scheme.";
     }

     identity qam-64-light {
       base coding-modulation;
       description
         "64 QAM light coding and modulation scheme.";
     }

     identity qam-128-strong {
       base coding-modulation;
       description
         "128 QAM strong coding and modulation scheme.";
     }
```

```
     identity qam-128 {
       base coding-modulation;
       description
         "128 QAM coding and modulation scheme.";
     }

     identity qam-128-light {
       base coding-modulation;
       description
         "128 QAM light coding and modulation scheme.";
     }

     identity qam-256-strong {
       base coding-modulation;
       description
         "256 QAM strong coding and modulation scheme.";
     }

     identity qam-256 {
       base coding-modulation;
       description
         "256 QAM coding and modulation scheme.";
     }

     identity qam-256-light {
       base coding-modulation;
       description
         "256 QAM light coding and modulation scheme.";
     }

     identity qam-512-strong {
       base coding-modulation;
       description
         "512 QAM strong coding and modulation scheme.";
     }

     identity qam-512 {
       base coding-modulation;
       description
         "512 QAM coding and modulation scheme.";
     }

     identity qam-512-light {
       base coding-modulation;
       description
         "512 QAM light coding and modulation scheme.";
     }
```

```
     identity qam-1024-strong {
       base coding-modulation;
       description
         "1024 QAM strong coding and modulation scheme.";
     }

     identity qam-1024 {
       base coding-modulation;
       description
         "1024 QAM coding and modulation scheme.";
     }

     identity qam-1024-light {
       base coding-modulation;
       description
         "1024 QAM light coding and modulation scheme.";
     }

     identity qam-2048-strong {
       base coding-modulation;
       description
         "2048 QAM strong coding and modulation scheme.";
     }

     identity qam-2048 {
       base coding-modulation;
       description
         "2048 QAM coding and modulation scheme.";
     }

     identity qam-2048-light {
       base coding-modulation;
       description
         "2048 QAM light coding and modulation scheme.";
     }

     identity qam-4096-strong {
       base coding-modulation;
       description
         "4096 QAM strong coding and modulation scheme.";
     }

     identity qam-4096 {
       base coding-modulation;
       description
         "4096 QAM coding and modulation scheme.";
     }
```

```
     identity qam-4096-light {
       base coding-modulation;
       description
         "4096 QAM light coding and modulation scheme.";
     }

     /*
      * TDM-type identities
      */

     identity tdm-type {
       description
         "A description of the type of TDM connection,
         also indicating the supported capacity of the
         connection.";
     }

     identity E1 {
       base tdm-type;
       description
         "E1 connection, 2,048 Mbit/s.";
     }

     identity STM-1 {
       base tdm-type;
       description
         "STM-1 connection, 155,52 Mbit/s.";
     }

     /*
      * Typedefs
      */

     typedef power {
       type decimal64 {
         fraction-digits 1;
       }
       description
         "Type used for power values, selected and measured.";
     }

     /*
      * Radio Link Terminal (RLT)
      */

     augment "/if:interfaces/if:interface" {
       when "if:type = 'mrl:radio-link-terminal'";
       description
         "Addition of data nodes for radio link terminal to
          the standard Interface data model, for interfaces of
          the type 'radio-link-terminal'.";
```

```
       leaf id {
         type string;
         default "";
         description
           "ID of the radio link terminal. Used by far-end when
            checking that it’s connected to the correct RLT.";
       }

       leaf mode {
         type identityref {
           base rlt-mode;
         }
         mandatory true;
         description
           "A description of the mode in which the radio link
            terminal is configured. The format is X plus Y.
            X represent the number of bonded carrier terminations.
            Y represent the number of protecting carrier
            terminations.";
       }

       leaf-list carrier-terminations {
         type if:interface-ref;
         must "/if:interfaces/if:interface[if:name = current()]"
            + "/if:type = ’mrl:carrier-termination’" {
           description
             "The type of interface must be
              ’carrier-termination’.";
         }
         min-elements 1;
         description
           "A list of references to carrier terminations
            included in the radio link terminal.";
       }

       leaf-list rlp-groups {
         type leafref {
           path "/mrl:radio-link-protection-groups/"
              + "mrl:protection-group/mrl:name";
         }
         description
           "A list of references to the carrier termination
            groups configured for radio link protection in this
            radio link terminal.";
       }
```

```
        leaf-list xpic-pairs {
          if-feature xpic;
          type leafref {
            path "/mrl:xpic-pairs/mrl:xpic-pair/mrl:name";
          }
          description
            "A list of references to the XPIC pairs used in this
             radio link terminal. One pair can be used by two
             terminals.";
          reference "ETSI TR 102 311";
        }

        leaf-list mimo-groups {
          if-feature mimo;
          type leafref {
            path "/mrl:mimo-groups/mrl:mimo-group/mrl:name";
          }
          description
            "A reference to the MIMO group used in this
             radio link terminal. One group can be used by more
             than one terminal.";
          reference "ETSI TR 102 311";
        }

        list tdm-connections {
          if-feature tdm;
          key "tdm-type";
          description
           "A list stating the number of active TDM connections
            of a specified tdm-type that is configured to be
            supported by the RLT.";
          leaf tdm-type {
            type identityref {
              base tdm-type;
            }
            description
              "The type of TDM connection, which also indicates
              the supported capacity.";
          }
          leaf tdm-connections {
            type uint16;
            mandatory true;
            description
              "Number of connections of the specified type.";
          }
        }
      }

      /*
       * Carrier Termination
       */
```

```
  augment "/if:interfaces/if:interface" {
    when "if:type = 'mrl:carrier-termination'";
    description
      "Addition of data nodes for carrier termination to
       the standard Interface data model, for interfaces
       of the type 'carrier-termination'.";

    leaf carrier-id {
      type string;
      default "A";
      description
        "ID of the carrier. (e.g. A, B, C or D)
         Used in XPIC & MIMO configurations to check that
         the carrier termination is connected to the correct
         far-end carrier termination. Should be the same
         carrier ID on both sides of the hop.
         Defaulted when not MIMO or XPIC.";
    }

    leaf tx-enabled {
      type boolean;
      default "false";
      description
        "Disables (false) or enables (true) the transmitter.
         Only applicable when the interface is enabled
         (interface:enabled = true) otherwise it's always
         disabled.";
    }

    leaf tx-oper-status {
      type enumeration {
        enum "off" {
          description "Transmitter is off.";
        }
        enum "on" {
          description "Transmitter is on.";
        }
        enum "standby" {
          description "Transmitter is in standby.";
        }
      }
      config false;
      description
        "Shows the operative status of the transmitter.";
    }
```

```
        leaf tx-frequency {
          type uint32;
          units "kHz";
          mandatory true;
          description
            "Selected transmitter frequency.";
        }

        leaf rx-frequency {
          type uint32;
          units "kHz";
          description
            "Selected receiver frequency.
             Overrides existing value in duplex-distance.
             Calculated from tx-frequency and duplex-distance if
             only duplex-distance is configured.
             Must match duplex-distance if both leaves are
             configured in a single operation.";
        }

        leaf duplex-distance {
          type uint32;
          units "kHz";
          description
            "Distance between Tx & Rx frequencies.
             Used to calculate rx-frequency when
             rx-frequency is not specifically configured.
             Overrides existing value in rx-frequency.
             Calculated from tx-frequency and rx-frequency if only
             rx-frequency is configured.
             Must match rx-frequency if both leaves are configured
             in a single operation.";
        }

        leaf channel-separation {
          type uint32;
          units "kHz";
          mandatory true;
          description
            "The amount of bandwidth allocated to a carrier. The distance
             between adjacent channels in a radio frequency channels
             arrangement";
          reference "ETSI EN 302 217-1";
        }
```

```
       leaf polarization {
         type enumeration {
           enum "horizontal" {
             description "Horizontal polarization.";
           }
           enum "vertical" {
             description "Vertical polarization.";
           }
           enum "not-specified" {
             description "Polarization not specified.";
           }
         }
         default "not-specified";
         description
           "Polarization - A textual description for info only.";
       }

       leaf power-mode {
         type enumeration {
           enum rtpc {
             description
               "Remote Transmit Power Control (RTPC).";
             reference "ETSI EN 302 217-1";
           }

           enum atpc {
             description
               "Automatic Transmit Power Control (ATPC).";
             reference "ETSI EN 302 217-1";
           }
         }
         mandatory true;
         description
           "A choice of Remote Transmit Power Control (RTPC)
            or Automatic Transmit Power Control (ATPC).";
       }

       leaf maximum-nominal-power {
         type power {
           range "-99..40";
         }
         units "dBm";
         mandatory true;
         description
           "Selected output power in RTPC mode and selected
            maximum output power in ATPC mode. Minimum output
            power in ATPC mode is the same as the system
            capability, available-min-output-power.";
         reference "ETSI EN 302 217-1";
       }
```

```
        leaf atpc-lower-threshold  {
          when "../power-mode = 'atpc'";
          type power {
            range "-99..-30";
          }
          units "dBm";
          mandatory true;
          description
            "The lower threshold for the input power at far-end
             used in the ATPC mode.";
          reference "ETSI EN 302 217-1";
        }

        leaf atpc-upper-threshold  {
          when "../power-mode = 'atpc'";
          type power {
            range "-99..-30";
          }
          units "dBm";
          mandatory true;
          description
            "The upper threshold for the input power at far-end
             used in the ATPC mode.";
          reference "ETSI EN 302 217-1";
        }

        leaf actual-transmitted-level {
          type power {
            range "-99..40";
          }
          units "dBm";
          config false;
          description
            "Actual transmitted power level (0.1 dBm resolution).";
          reference "ETSI EN 301 129";
        }

        leaf actual-received-level {
          type power {
            range "-99..-20";
          }
          units "dBm";
          config false;
          description
            "Actual received power level (0.1 dBm resolution).";
          reference "ETSI EN 301 129";
        }
```

```
       leaf coding-modulation-mode {
         type enumeration {
           enum single {
             description "a single modulation order only.";
             reference "ETSI EN 302 217-1";
           }
           enum adaptive {
             description "Adaptive coding/modulation.";
             reference "ETSI EN 302 217-1";
           }
         }
         mandatory true;
         description
           "A selection of single or
            adaptive coding/modulation mode.";
       }

       leaf selected-cm {
         when "../coding-modulation-mode = 'single'";
         type identityref {
           base coding-modulation;
         }
         mandatory true;
         description
           "Selected the single coding/modulation.";
       }

       leaf selected-min-acm {
         when "../coding-modulation-mode = 'adaptive'";
         type identityref {
           base coding-modulation;
         }
         mandatory true;
         description
           "Selected minimum coding/modulation.
            Adaptive coding/modulation shall not go
            below this value.";
       }

       leaf selected-max-acm {
         when "../coding-modulation-mode = 'adaptive'";
         type identityref {
           base coding-modulation;
         }
         mandatory true;
         description
           "Selected maximum coding/modulation.
            Adaptive coding/modulation shall not go
            above this value.";
       }
```

```
       leaf actual-tx-cm {
         type identityref {
            base coding-modulation;
         }
         config false;
         description
           "Actual coding/modulation in transmitting direction.";
       }

       leaf actual-snir {
         type decimal64 {
           fraction-digits 1;
           range "0..99";
         }
         units "dB";
         config false;
         description
           "Actual signal to noise plus interference ratio.
            (0.1 dB resolution).";
       }

       leaf actual-xpi {
         if-feature xpic;
         type decimal64 {
           fraction-digits 1;
           range "0..99";
         }
         units "dB";
         config false;
         description
           "The actual carrier to cross-polar interference.
            Only valid if XPIC is enabled. (0.1 dB resolution).";
         reference "ETSI TR 102 311";
       }

       container ct-performance-thresholds {
         description
           "Specification of thresholds for when alarms should
            be sent and cleared for various performance counters.";

         leaf received-level-alarm-threshold {
           type power {
             range "-99..-30";
           }
           units "dBm";
           default "-99";
           description
             "An alarm is sent when the received power level is
              below the specified threshold.";
           reference "ETSI EN 301 129";
         }
```

```
          leaf transmitted-level-alarm-threshold {
            type power {
              range "-99..40";
            }
            units "dBm";
            default "-99";
            description
              "An alarm is sent when the transmitted power level
               is below the specified threshold.";
            reference "ETSI EN 301 129";
          }

          leaf ber-alarm-threshold {
            type enumeration {
              enum "10e-9" {
                description "Threshold at 10e-9.";
              }
              enum "10e-8" {
                description "Threshold at 10e-8.";
              }
              enum "10e-7" {
                description "Threshold at 10e-7.";
              }
              enum "10e-6" {
                description "Threshold at 10e-6.";
              }
              enum "10e-5" {
                description "Threshold at 10e-5.";
              }
              enum "10e-4" {
                description "Threshold at 10e-4.";
              }
              enum "10e-3" {
                description "Threshold at 10e-3.";
              }
              enum "10e-2" {
                description "Threshold at 10e-2.";
              }
              enum "10e-1" {
                description "Threshold at 10e-1.";
              }
            }
            default "10e-6";
            description
              "Specification of at which BER an alarm should
               be raised.";
            reference "ETSI EN 302 217-1";
          }
        }
```

```
        leaf if-loop {
          type enumeration {
            enum disabled {
              description "Disables the IF Loop.";
            }
            enum client {
              description
                "Loops the signal back to the client side.";
            }
            enum radio {
              description
                "Loops the signal back to the radio side.";
            }
          }
          default "disabled";
          description
            "Enable (client/radio) or disable (disabled)
             the IF loop, which loops the signal back to
             the client side or the radio side.";
        }

        leaf rf-loop {
          type enumeration {
            enum disabled {
              description "Disables the RF Loop.";
            }
            enum client {
              description
                "Loops the signal back to the client side.";
            }
            enum radio {
              description
                "Loops the signal back to the radio side.";
            }
          }
          default "disabled";
          description
            "Enable (client/radio) or disable (disabled)
             the RF loop, which loops the signal back to
             the client side or the radio side.";
        }

        container capabilities {
          config false;
          description
            "Capabilities of the installed equipment and
             some selected configurations.";
```

```
        leaf min-tx-frequency {
          type uint32;
          units "kHz";
          description
            "Minimum Tx frequency possible to use.";
        }

        leaf max-tx-frequency {
          type uint32;
          units "kHz";
          description
            "Maximum Tx frequency possible to use.";
        }

        leaf min-rx-frequency {
          type uint32;
          units "kHz";
          description
            "Minimum Rx frequency possible to use.";
        }

        leaf max-rx-frequency {
          type uint32;
          units "kHz";
          description
            "Maximum Tx frequency possible to use.";
        }

        leaf minimum-power {
          type power;
          units "dBm";
          description
            "The minimum output power supported.";
          reference "ETSI EN 302 217-1";
        }

        leaf maximum-available-power {
          type power;
          units "dBm";
          description
            "The maximum output power supported.";
          reference "ETSI EN 302 217-1";
        }

        leaf available-min-acm {
          type identityref {
            base coding-modulation;
          }
          description
            "Minimum coding-modulation possible to use.";
        }
```

```
         leaf available-max-acm {
           type identityref {
             base coding-modulation;
           }
           description
             "Maximum coding-modulation possible to use.";
         }
       }

       container error-performance-statistics {
         config false;
         description
           "ITU-T G.826 error performance statistics relevant for
            a microwave/millimeter wave carrier.";

         leaf bbe {
           type yang:counter32;
           units "number of block errors";
           description
             "Number of Background Block Errors (BBE) during the
             interval. A BBE is an errored block not occurring as
             part of an SES.";
           reference "ITU-T G.826";
         }

         leaf es {
           type yang:counter32;
           units "seconds";
           description
             "Number of Errored Seconds (ES) since last reset.
              An ES is a one-second period with one or more errored
              blocks or at least one defect.";
           reference "ITU-T G.826";
         }

         leaf ses {
           type yang:counter32;
           units "seconds";
           description
             "Number of Severely Errored Seconds (SES) during the
              interval. SES is a one-second period which contains
              equal or more than 30% errored blocks or at least
              one defect. SES is a subset of ES.";
           reference "ITU-T G.826";
         }
```

```
          leaf uas {
            type yang:counter32;
            units "seconds";
            description
              "Number of Unavailable Seconds (UAS), that is, the
               total time that the node has been unavailable during
               a fixed measurement interval.";
            reference "ITU-T G.826";
          }
        }

        container radio-performance-statistics {
          config false;
          description
            "ETSI EN 301 129 radio physical interface statistics relevant
             for a carrier termination.";

          leaf min-rltm {
            type power {
              range "-99..-20";
            }
            units "dBm";
            description
              "Minimum received power level since last reset.";
            reference "ETSI EN 301 129";
          }

          leaf max-rltm {
            type power {
              range "-99..-20";
            }
            units "dBm";
            description
              "Maximum received power level since last reset.";
            reference "ETSI EN 301 129";
          }

          leaf min-tltm {
            type power {
              range "-99..40";
            }
            units "dBm";
            description
              "Minimum transmitted power level since last reset.";
            reference "ETSI EN 301 129";
          }
```

```
          leaf max-tltm {
            type power {
              range "-99..40";
            }
            units "dBm";
            description
              "Maximum transmitted power level since last reset.";
            reference "ETSI EN 301 129";
          }
        }
      }

      /*
       * Radio Link Protection Groups
       */

      container radio-link-protection-groups {
        description
          "Configuration of radio link protected groups (1+1) of
          carrier terminations in a radio link. More than one
          protected group per radio-link-terminal is allowed.";

        uses ifprot:protection-groups {

          refine protection-group/members {
            must "/if:interfaces/if:interface[if:name = current()]"
               + "/if:type = 'mrl:carrier-termination'" {
              description
                "The type of a protection member must be
                 'carrier-termination'.";
            }
          }

          refine protection-group/working-entity {
            must "/if:interfaces/if:interface[if:name =  current()]"
               + "/if:type = 'mrl:carrier-termination'" {
              description
                "The type of a working-entity must be
                 'carrier-termination'.";
            }
          }
        }
      }

      /*
       * XPIC & MIMO groups - Configuration data nodes
       */
```

```
      container xpic-pairs {
        if-feature xpic;
        description
          "Configuration of carrier termination pairs
           for operation in XPIC mode.";
        reference "ETSI TR 102 311";

        list xpic-pair {
          key "name";
          description
            "List of carrier termination pairs in XPIC mode.";

          leaf name {
            type string;
            description
              "Name used for identification of the XPIC pair.";
          }

          leaf enabled {
            type boolean;
            default "false";
            description
              "Enable(true)/disable(false) XPIC";
          }

          leaf-list members {
            type if:interface-ref;
            must "/if:interfaces/if:interface[if:name = current()]"
              + "/if:type = 'mrl:carrier-termination'" {
              description
                "The type of a member must be 'carrier-termination'.";
            }
            min-elements 2;
            max-elements 2;
            description
              "Association to XPIC pairs used in the radio link
               terminal.";
          }
        }
      }

      container mimo-groups {
        if-feature mimo;
        description
          "Configuration of carrier terminations
          for operation in MIMO mode.";
        reference "ETSI TR 102 311";

        list mimo-group {
          key "name";
          description
            "List of carrier terminations in MIMO mode.";
```

```
         leaf name {
           type string;
           description
             "Name used for identification of the MIMO group.";
         }

         leaf enabled {
           type boolean;
           default "false";
           description
             "Enable(true)/disable(false) MIMO";
         }

         leaf-list members {
           type if:interface-ref;
           must "/if:interfaces/if:interface[if:name = current()]"
              + "/if:type = 'mrl:carrier-termination'" {
             description
               "The type of a member must be 'carrier-termination'.";
           }
           min-elements 2;
           description
             "Association to a MIMO group if used in the radio
              link terminal.";
         }
       }
     }
   }

   <CODE ENDS>
```

5. Interface Protection YANG Module

The data nodes for management of the interface protection functionality is broken out from the Microwave Radio Link Module into a separate and generic YANG data module in order to make it available also for other interface types.

This module imports modules from [RFC7223bis], and it references [G.808.1].

```
   <CODE BEGINS> file "ietf-interface-protection@2018-03-03.yang"

   module ietf-interface-protection {
     yang-version 1.1;
     namespace "urn:ietf:params:xml:ns:yang:ietf-interface-protection";
     prefix ifprot;
```

```
     import ietf-interfaces {
       prefix if;
       reference "RFC7223bis";
     // RFC Ed.: replace 7223bis with actual RFC number and remove
     // this note
     }

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

       ID-draft editors:
         Jonas Ahlberg (jonas.ahlberg@ericsson.com);
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         Xi Li (Xi.Li@neclab.eu);
         Daniela Spreafico (daniela.spreafico@nokia.com)
         Marko Vaupotic (Marko.Vaupotic@aviatnet.com)";

     description
       "This is a module for the entities in
       a generic interface protection mechanism.

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       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.

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       authors of the code.  All rights reserved.";

     revision 2018-03-03 {
       description "Initial revision.";
       reference "RFC XXXX: A YANG Data Model for Microwave Radio Link";
     // RFC Ed.: replace XXXX with actual RFC number and remove
     // this note
     }

     /*
      * Protection architecture type identities
      */
```

```
     identity protection-architecture-type {
       description
         "protection architecture type";
       reference "ITU-T G.808.1";
     }

     identity one-plus-one-type {
       base protection-architecture-type;
       description
         "1+1, One interface protects
         another one interface.";
       reference "ITU-T G.808.1";
     }

     identity one-to-n-type {
       base protection-architecture-type;
       description
         "1:N, One interface protects
         n other interfaces.";
       reference "ITU-T G.808.1";
     }

     /*
      * Protection states identities
      */

     identity protection-states {
       description
        "Identities describing the status of the protection,
        in a group of interfaces configured in
        a protection mode.";
     }

     identity unprotected {
       base protection-states;
       description "Not protected";
     }

     identity protected {
       base protection-states;
       description "Protected";
     }

     identity unable-to-protect {
       base protection-states;
       description "Unable to protect";
     }

     /*
      * protection-external-commands identities
      */
```

```
     identity protection-external-commands{
       description
         "Protection external commands for trouble shooting
          purpose.";
       reference "ITU-T G.808.1";
     }

     identity manual-switch-working{
       base protection-external-commands;
       description
         "A switch action initiated by an operator command.
          It switches normal traffic signal to the working
          transport entity.";
       reference "ITU-T G.808.1";
     }

     identity manual-switch-protection{
       base protection-external-commands;
       description
         "A switch action initiated by an operator command.
          It switches normal traffic signal to the protection
          transport entity.";
       reference "ITU-T G.808.1";
     }

     identity forced-switch{
       base protection-external-commands;
       description
         "A switch action initiated by an operator command.
          It switches normal traffic signal to the protection
          transport entity and forces it to remain on that
          entity even when criteria for switching back to
          the original entity are fulfilled.";
       reference "ITU-T G.808.1";
     }

     identity lockout-of-protection{
       base protection-external-commands;
       description
         "A switch action temporarily disables access to the
          protection transport entity for all signals.";
       reference "ITU-T G.808.1";
     }
```

```
     identity freeze{
       base protection-external-commands;
       description
         "A switch action temporarily prevents any switch action
          to be taken and, as such, freezes the current state.
          Until the freeze is cleared, additional near-end external
          commands are rejected and fault condition changes and
          received APS messages are ignored..";
       reference "ITU-T G.808.1";
     }

     identity exercise{
       base protection-external-commands;
       description
         "A switch action to test if the APS communication is
          operating correctly. It is lower priority than any 'real'
          switch request..";
       reference "ITU-T G.808.1";
     }

     identity clear{
       base protection-external-commands;
       description
         "An action clears all switch commands.";
       reference "ITU-T G.808.1";
     }

     /*
      * Protection Groups
      */

     grouping protection-groups {
       description
         "Configuration of protected groups (1+1) of interfaces
         providing protection for each other. More than one protected
         group per higher-layer-interface is allowed.";

       list protection-group {
         key "name";
         description
         "List of protected groups of interfaces
         in a higher-layer-interface.";

         leaf name {
           type string;
           description
             "Name used for identification of the protection group";
         }
```

```
        leaf protection-architecture-type {
          type identityref{
            base protection-architecture-type;
          }
          default "ifprot:one-plus-one-type";
          description
            "The type of protection architecture used, e.g. one
            interface protecting one or several other interfaces.";
          reference "ITU-T G.808.1";
        }

        leaf-list members {
          type if:interface-ref;
          min-elements 2;
          description
            "Association to a group of interfaces configured for
            protection and used by a higher-layer-interface.";
        }

        leaf operation-type {
          type enumeration {
            enum "non-revertive" {
              description
                "In non revertive operation, the traffic does not
                return to the working interface if the switch requests
                are terminated.";
              reference "ITU-T G.808.1";
            }
            enum "revertive" {
              description
                "In revertive operation, the traffic always
                returns to (or remains on) the working interface
                if the switch requests are terminated.";
              reference "ITU-T G.808.1";
            }
          }
          default "non-revertive";
          description
            "The type of protection operation, i.e. revertive
            or non-revertive operation.";
        }

        leaf-list working-entity  {
          when "../operation-type = 'revertive'";
          type if:interface-ref;
          min-elements 1;
          description
            "The interfaces over which the traffic normally should
            be transported over when there is no need to use the
            protecting interface.";
        }
```

```
         leaf revertive-wait-to-restore {
           when "../operation-type = 'revertive'";
           type uint16;
           units "seconds";
           default "0";
           description
             "The time to wait before switching back to the working
             interface if operation-type is revertive.";
           reference "ITU-T G.808.1";
         }

         leaf hold-off-timer {
           type uint16;
           units "milliseconds";
           default "0";
           description
             "Time interval after the detection of a fault and its
             confirmation as a condition requiring the protection
             switching procedure.";
           reference "ITU-T G.808.1";
         }

         leaf status {
           type identityref {
             base protection-states;
           }
           description
             "Status of the protection, in a group of interfaces
              configured in a protection mode.";
           reference "ITU-T G.808.1";
         }

         action external-commands {
           input {
             leaf external-command {
               type identityref {
                 base protection-external-commands;
               }
               description
                 "Execution of protection external commands for
                 trouble shooting purpose.";
             }
           }
         }
       }
     }
   }

   <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 [RFC5246].

The NETCONF access control model [RFC6536] 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:

Interfaces of type radio-link-terminal:
/if:interfaces/if:interface/carrier-terminations,
/if:interfaces/if:interface/rlp-groups,
/if:interfaces/if:interface/xpic-pairs,
/if:interfaces/if:interface/mimo-groups, and
/if:interfaces/if:interface/tdm-connections:
These lists represent the configuration of the radio-link-terminal and it need to match the configuration of the radio-link-terminal on the other side of the radio link. Unauthorized access to these data nodes could interrupt the ability to forward traffic.

Interfaces of type carrier-termination:
/if:interfaces/if:interface/carrier-id,
/if:interfaces/if:interface/tx-enabled,
/if:interfaces/if:interface/tx-frequency,
/if:interfaces/if:interface/rx-frequency,
/if:interfaces/if:interface/duplex-distance,
/if:interfaces/if:interface/channel-separation,
/if:interfaces/if:interface/power-mode,
/if:interfaces/if:interface/maximum-nominal-power,
/if:interfaces/if:interface/atpc-lower-threshold,
/if:interfaces/if:interface/atpc-upper-threshold,
/if:interfaces/if:interface/coding-modulation-mode,
/if:interfaces/if:interface/selected-cm,
/if:interfaces/if:interface/selected-min-acm,
/if:interfaces/if:interface/selected-max-acm,
/if:interfaces/if:interface/if-loop, and
/if:interfaces/if:interface/rf-loop:

These data nodes represent the configuration of the carrier-termination and it need to match the configuration of the carrier-termination on the other side of the carrier. Unauthorized access to these data nodes could interrupt the ability to forward traffic.

Radio link protection:
/radio-link-protection-groups/protection-group:
This list of protection groups and the constituent data nodes represents the configuration of the protection of carrier terminations. Unauthorized access to these data nodes could interrupt the ability to forward traffic or remove the ability to perform a necessary protection switch.

XPIC:
/xpic-pairs:
This list represents the XPIC configuration of a pair carriers. Unauthorized access to these data nodes could interrupt the ability to forward traffic.

MIMO:
/mimo-groups:
This list represents the MIMO configuration of multiple carriers. Unauthorized access to these data nodes could interrupt the ability to forward traffic.

The security considerations of [RFC7223bis] also apply to this document.

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-microwave-radio-link
Registrant Contact: The IESG
XML: N/A; the requested URI is an XML namespace.

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

It is proposed that IANA should record YANG module names in the "YANG Module Names" registry [RFC6020] as follows:

Name: ietf-microwave-radio-link
Namespace: urn:ietf:params:xml:ns:yang:ietf-microwave-radio-link
Prefix: mrl
Reference: RFC XXXX

Name: ietf-interface-protection
Namespace: urn:ietf:params:xml:ns:yang:ietf-interface-protection
Prefix: ifprot
Reference: RFC XXXX

8. References

8.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

[RFC7223bis] Bjorklund, M., "A YANG Data Model for Interface Management", draft-bjorklund-netmod-rfc7223bis-00 (work in progress), September 2017.

[EN301129] ETSI, "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Synchronous Digital Hierarchy (SDH); System performance monitoring parameters of SDH DRRS", EN 301 129 V1.1.2, May 1995.

[EN302217-1] ETSI, "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 1: Overview, common characteristics and system-dependent requirements", EN 302 217-1 V3.0.5, June 2016.

[EN302217-2] ETSI, "Fixed Radio Systems; Characteristics and requirements for point to-point equipment and antennas; Part 2: Digital systems operating in frequency bands from 1 GHz to 86 GHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU", EN 302 217-2 V3.1.1, May 2017.

[G.808.1] ITU-T, "SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital networks ; General aspects Generic protection switching ; Linear trail and subnetwork protection", ITU-T Rec. G.808.1, May 2014.

[G.826] ITU-T, "SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital networks ; Quality and availability targets End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections", ITU-T Rec. G.826, December 2002.

[TR102311] ETSI, "Fixed Radio Systems; Point-to-point equipment; Specific aspects of the spatial frequency reuse method", ETSI TR 102 311 V1.2.1, November 2015.

[RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <https://www.rfc-editor.org/info/rfc3688>.

[RFC5246] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", RFC 5246, DOI 10.17487/RFC5246, August 2008, <https://www.rfc-editor.org/info/rfc5246>.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <https://www.rfc-editor.org/info/rfc6020>.

[RFC6241] Enns, R., Bjorklund, M., Schoenwaelder, J., and A. Bierman, "Network Configuration Protocol (NETCONF)", RFC 6241, June 2011.

[RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure Shell (SSH)", RFC 6242, June 2011.

[RFC6536] Bierman, A. and M. Bjorklund, "Network Configuration Protocol (NETCONF) Access Control Model", RFC 6536, March 2012.

[RFC6991] Schoenwaelder, J., "Common YANG Data Types", RFC 6991, July 2013.

[RFC7224] Bjorklund, M., "IANA Interface Type YANG Module", RFC 7224, May 2014.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <http://www.rfc-editor.org/info/rfc8040>.

8.2. Informative References

[NMDA] Bjorklund, M., Schoenwaelder, J., Shafer, P., Watsen, K., and R. Wilton, "Network Management Datastore Architecture", draft-ietf-netmod-revised-datastores-10 (work in progress), January 2018.

[I-D.ahlberg-ccamp-microwave-radio-link] Ahlberg, J., Carlson, J., Lund, H., Olausson, T., Ye, M., and M. Vaupotic, "Microwave Radio Link YANG Data Models", draft-ahlberg-ccamp-microwave-radio-link-01 (work in progress), May 2016.

[I-D.ietf-ccamp-microwave-framework]
Ahlberg, J., Contreras, L., Ye, M., Vaupotic, M., Tantsura, J., Kawada, K., Li, X., Akiyoshi, I., C. Bernardos, and D. Spreafico, "A framework for Management and Control of microwave and millimeter wave interface parameters", draft-ietf-ccamp-microwave-framework-05 (work in progress), October 2017.

[ONF-model] "Microwave Modeling - ONF Wireless Transport Group", May 2016.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <http://www.rfc-editor.org/info/rfc6241>.

[RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure Shell (SSH)", RFC 6242, DOI 10.17487/RFC6242, June 2011, <http://www.rfc-editor.org/info/rfc6242>.

[RFC6536] Bierman, A. and M. Bjorklund, "Network Configuration Protocol (NETCONF) Access Control Model", RFC 6536, DOI 10.17487/RFC6536, March 2012, <http://www.rfc-editor.org/info/rfc6536>.

[YANG-TREE] Bjorklund, M. and L. Berger, "YANG Tree Diagrams", draft-ietf-netmod-yang-tree-diagrams-06 (work in progress), February 2018.

Appendix A. Example: 1+0 and 2+0 configuration instances

This section gives simple examples of 1+0 and 2+0 instance using the YANG module defined in this draft. The examples are not intended as a complete module for 1+0 and 2+0 configuration.

A.1 1+0 instance

Figure A-1 shows a 1+0 example.

```
                 /--------- Radio Link ---------\
                  Near End              Far End

           +----------------+           +----------------+
           |  Radio Link    |           | Radio Link     |
           |  Terminal - A  |           | Terminal - B   |
           |                |           |                |
           |                |           |                |
           | +-----------+  |           | +-----------+  |
           | |           |  | Carrier A | |           |  |
           | |  Carrier  |  |<--------->| |  Carrier  |  |
           | |Termination|  |           | |Termination|  |
           | |    -1     |  |           | |   -1      |  |
           | +-----------+  |           | +-----------+  |
           |                |           |                |
           |                |           |                |
           +----------------+           +----------------+

     \--- Microwave Node ---/          \--- Microwave Node ---/
                   Figure A-1 1+0 example
```

The following instance shows the 1+0 configuration of Near End node.

```
"interface": [
   {
   //RLT-A
     "name": "RLT-A",
     "description": "Radio Link Terminal A",
     "type": "mrl:radio-link-terminal",
     "id": "RLT-A",
     "mode": "one-plus-zero",
     "carrier-terminations": [
       "RLT-A:CT-1",
     ],
   }
```

```
      {
      //CT-1
        "name": "RLT-A:CT-1",
        "description": "Carrier Termination 1",
        "type": "mrl:carrier-termination",
        "carrier-id": "A",
        "tx-enabled": true,
        "tx-oper-status": on
        "tx-frequency": 10728000,
        "duplex-distance": 644000,
        "channel-separation": 28,
        "polarization": not-specified,
        "power-mode": rtpc,
        "coding-modulation-mode": 0,
        "selected-cm": "qam-512"
      },
   ]
```


A.2 2+0 instance

   Figure A-2 shows a 2+0 example.

```
                 /--------- Radio Link ---------\
                  Near End              Far End

           +---------------+           +---------------+
           | Radio Link    |           | Radio Link    |
           | Terminal -A   |           | Terminal -B   |
           |               |           |               |
           |               |           |               |
           | +-----------+ |           | +-----------+ |
           | |           | | Carrier A | |           | |
           | |  Carrier  | |<--------->| |  Carrier  | |
           | |Termination| |           | |Termination| |
           | |    -1     | |           | |     -1    | |
           | +-----------+ |           | +-----------+ |
           |               |           |               |
           | +-----------+ |           | +-----------+ |
           | |           | | Carrier B | |           | |
           | |  Carrier  | |<--------->| |  Carrier  | |
           | |Termination| |           | |Termination| |
           | |    -2     | |           | |     -2    | |
           | +-----------+ |           | +-----------+ |
           |               |           |               |
           +---------------+           +---------------+

     \--- Microwave Node ---/          \--- Microwave Node ---/]
                Figure A-2 2+0 example
```

The following instance shows the 2+0 configuration of Near End node.


```
"interface": [
   {
   //RLT-A
     "name": "RLT-A",
     "description": "Radio Link Terminal A",
     "type": "mrl:radio-link-terminal",
     "id": "RLT-A",
     "mode": "two-plus-zero",
     "carrier-terminations": [
       "RLT-A:CT-1",
       "RLT-A:CT-2"
     ],
   }

   {
   //CT-1
     "name": "RLT-A:CT-1",
     "description": "Carrier Termination 1",
     "type": "mrl:carrier-termination",
     "carrier-id": "A",
     "tx-enabled": true,
     "tx-oper-status": on
     "tx-frequency": 10728000,
     "duplex-distance": 644000,
     "channel-separation": 28,
     "polarization": not-specified,
     "power-mode": rtpc,
     "coding-modulation-mode": 0,
     "selected-cm": "qam-512"
   },

   {
   //CT-2
     "name": "RLT-A:CT-2",
     "description": "Carrier Termination 2",
     "type": "mrl:carrier-termination",
     "carrier-id": "B",
     "tx-enabled": true,
     "tx-oper-status": on
     "tx-frequency": 10618000,
     "duplex-distance": 644000,
     "channel-separation": 28,
     "polarization": not-specified,
     "power-mode": rtpc,
     "coding-modulation-mode": 0,
     "selected-cm": "qam-512"
   },
]
```

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Abstract

Transport network domains, including Optical Transport Network (OTN) and Wavelength Division Multiplexing (WDM) networks, are typically deployed based on a single vendor or technology platforms. They are often managed using proprietary interfaces to dedicated Element Management Systems (EMS), Network Management Systems (NMS) and increasingly Software Defined Network (SDN) controllers.

A well-defined open interface to each domain management system or controller is required for network operators to facilitate control automation and orchestrate end-to-end services across multi-domain networks. These functions may be enabled using standardized data models (e.g. YANG), and appropriate protocol (e.g., RESTCONF).

This document analyses the applicability of the YANG models being defined by IETF (TEAS and CCAMP WGs in particular) to support OTN single and multi-domain scenarios.

Table of Contents

1. Introduction

Transport of packet services are critical for a wide-range of applications and services, including: data center and LAN interconnects, Internet service backhauling, mobile backhaul and enterprise Carrier Ethernet Services. These services are typically setup using stovepipe NMS and EMS platforms, often requiring propriety management platforms and legacy management interfaces. A clear goal of operators will be to automate setup of transport services across multiple transport technology domains.

A common open interface (API) to each domain controller and or management system is pre-requisite for network operators to control multi-vendor and multi-domain networks and enable also service provisioning coordination/automation. This can be achieved by using standardized YANG models, used together with an appropriate protocol (e.g., RESTCONF).

This document analyses the applicability of the YANG models being defined by IETF (TEAS and CCAMP WGs in particular) to support OTN single and multi-domain scenarios.

1.1. Scope of this document

This document assumes a reference architecture, including interfaces, based on the Abstraction and Control of Traffic-Engineered Networks (ACTN), defined in [ACTN-Frame].

The focus of this document is on the MPI (interface between the Multi Domain Service Coordinator (MDSC) and a Physical Network Controller (PNC), controlling a transport network domain).

It is worth noting that the same MPI analyzed in this document could be used between hierarchical MDSC controllers, as shown in Figure 4 of [ACTN-Frame].

Detailed analysis of the CMI (interface between the Customer Network Controller (CNC) and the MDSC) as well as of the interface between service and network orchestrators are outside the scope of this document. However, some considerations and assumptions about the information could be described when needed.

The relationship between the current IETF YANG models and the type of ACTN interfaces can be found in [ACTN-YANG]. Therefore, it considers the TE Topology YANG model defined in [TE-TOPO], with the OTN Topology augmentation defined in [OTN-TOPO] and the TE Tunnel YANG model defined in [TE-TUNNEL], with the OTN Tunnel augmentation defined in [OTN-TUNNEL].

The analysis of how to use the attributes in the I2RS Topology YANG model, defined in [I2RS-TOPO], is for further study.

The ONF Technical Recommendations for Functional Requirements for the transport API in [ONF TR-527] and the ONF transport API multi-domain examples in [ONF GitHub] have been considered as an input for defining the reference scenarios analyzed in this document.

1.2. Assumptions

This document is making the following assumptions, still to be validated with TEAS WG:

1. The MDSC can request, at the MPI, a PNC to setup a Transit Tunnel Segment using the TE Tunnel YANG model: in this case, since the endpoints of the E2E Tunnel are outside the domain controlled by that PNC, the MDSC would not specify any source or destination TTP (i.e., it would leave the source, destination, src-tp-id and dst-tp-id attributes empty) and it would use the explicit-route-object list to specify the ingress and egress links of the Transit Tunnel Segment.

2. Each PNC provides to the MDSC, at the MPI, the list of available timeslots on the inter-domain links using the TE Topology YANG model and OTN Topology augmentation. The TE Topology YANG model in [TE-TOPO] is being updated to report the label set information.

This document is also making the following assumptions, still to be validated with CCAMP WG:

2. Terminology

Domain: defined as a collection of network elements within a common realm of address space or path computation responsibility [RFC5151]

E-LINE: Ethernet Line

EPL: Ethernet Private Line

EVPL: Ethernet Virtual Private Line

OTN: Optical Transport Network

Service: A service in the context of this document can be considered as some form of connectivity between customer sites across the network operator’s network [RFC8309]

Service Model: As described in [RFC8309] it describes a service and the parameters of the service in a portable way that can be used uniformly and independent of the equipment and operating environment.

UNI: User Network Interface

MDSC: Multi-Domain Service Coordinator

CNC: Customer Network Controller

PNC: Provisioning Network Controller

MAC Bridging: Virtual LANs (VLANs) on IEEE 802.3 Ethernet network

3. Conventions used in this document

3.1. Topology and traffic flow processing

The traffic flow between different nodes is specified as an ordered list of nodes, separated with commas, indicating within the brackets the processing within each node:

```
<node> (<processing>){, <node> (<processing>)}
```

The order represents the order of traffic flow being forwarded through the network.

The processing can be either an adaptation of a client layer into a server layer "(client -> server)" or switching at a given layer "([switching])". Multi-layer switching is indicated by two layer switching with client/server adaptation: "([client] -> [server])".

For example, the following traffic flow:

```
C-R1 ([PKT] -> ODU2), S3 ([ODU2]), S5 ([ODU2]), S6 ([ODU2]),
C-R3 (ODU2 -> [PKT])
```

Node C-R1 is switching at the packet (PKT) layer and mapping packets into an ODU2 before transmission to node S3. Nodes S3, S5 and S6 are switching at the ODU2 layer: S3 sends the ODU2 traffic to S5 which then sends it to S6 which finally sends to C-R3. Node C-R3 terminates the ODU2 from S6 before switching at the packet (PKT) layer.

The paths of working and protection transport entities are specified as an ordered list of nodes, separated with commas:

```
<node> {, <node>}
```

The order represents the order of traffic flow being forwarded through the network in the forward direction. In case of bidirectional paths, the forward and backward directions are selected arbitrarily, but the convention is consistent between working/protection path pairs as well as across multiple domains.

3.2. JSON code

This document provides some detailed JSON code examples to describe how the YANG models being developed by IETF (TEAS and CCAMP WG in particular) can be used.

The examples are provided using JSON because JSON code is easier for humans to read and write.

Different objects need to have an identifier. The convention used to create mnemonic identifiers is to use the object name (e.g., S3 for node S3), followed by its type (e.g., NODE), separated by an "-", followed by "-ID". For example, the mnemonic identifier for node S3 would be S3-NODE-ID.

JSON language does not support the insertion of comments that have been instead found to be useful when writing the examples. This document inserts comments into the JSON code as JSON name/value pair with the JSON name string starting with the "//" characters. For example, when describing the example of a TE Topology instance representing the ODU Abstract Topology exposed by the Transport PNC, the following comment has been added to the JSON code:

```
"// comment": "ODU Abstract Topology @ MPI",
```

The JSON code examples provided in this document have been validated against the YANG models following the validation process described in Appendix B, which would not consider the comments.

In order to have successful validation of the examples, some numbering scheme has been defined to assign identifiers to the different entities which would pass the syntax checks. In that case, to simplify the reading, another JSON name/value pair, formatted as a comment and using the mnemonic identifiers is also provided. For example, the identifier of node S3 (S3-NODE-ID) has been assumed to be "10.0.0.3" and would be shown in the JSON code example using the two JSON name/value pair:

```
"// te-node-id": "S3-NODE-ID",

"te-node-id": "10.0.0.3",
```

The first JSON name/value pair will be automatically removed in the first step of the validation process while the second JSON name/value pair will be validate against the YANG model definitions.

4. Scenarios Description

4.1. Reference Network

The physical topology of the reference network is shown in Figure 1. It represents an OTN network composed of three transport network domains providing transport services to an IP customer network through eight access links:

```
                ........................
   ..........   :                      :
            :   :   Network domain 1   :   .............
    Customer:   :                      :   :           :
     domain :   :     S1 -------+      :   :  Network  :
            :   :    /           \     :   :  domain 3 :   ..........
      C-R1 ------- S3 ----- S4    \    :   :           :   :
            :   :    \        \    S2 --------+        :   :Customer
            :   :     \        \    |  :   :   \       :   : domain
            :   :      S5       \   |  :   :    \      :   :
      C-R2 ------+    /  \       \  |  :   :    S31 --------- C-R7
            :   : \  /    \       \ |  :   :   /   \   :   :
            :   :  S6 ---- S7 ---- S8 ------ S32   S33 ------ C-R8
            :   : /        |       |   :   : / \   /   :   :.......
      C-R3 ------+         |       |   :   :/   S34    :          :
            :   :..........|.......|...:   /    /      :          :
    ........:              |       |      /:.../.......:          :
                           |       |     /    /                   :
                ...........|.......|..../..../...                 :
                :          |       |   /    /   :    ..............
                : Network  |       |  /    /    :    :
                : domain 2 |       | /    /     :    :Customer
                :         S11 ---- S12   /      :    : domain
                :        /          | \ /       :    :
                :     S13     S14   | S15 ------------- C-R4
                :     |  \   /   \  |    \      :    :
                :     |   S16     \ |     \     :    :
                :     |  /         S17 -- S18 --------- C-R5
                :     | /             \   /     :    :
                :    S19 ---- S20 ---- S21 ------------ C-R6
                :                               :    :
                :...............................:    :.............
```

Figure 1 Reference network

The transport domain control architecture, shown in Figure 2, follows the ACTN architecture and framework document [ACTN-Frame], and functional components:

```
                           --------------
                          |              |
                          |     CNC      |
                          |              |
                           --------------
                                 |
             ....................|....................... CMI
                                 |
                          ----------------
                         |                |
                         |      MDSC      |
                         |                |
                          ----------------
                            /   |    \
                           /    |     \
            ............../.....|......\................ MPIs
                         /      |       \
                        /   ----------   \
                       /   |   PNC2   |   \
                      /     ----------     \
             ----------         |           \
            |   PNC1   |      -----          \
             ----------     (       )      ----------
                 |         (         )    |   PNC3   |
               -----      (  Network  )    ----------
             (       )    (  Domain 2 )        |
            (         )    (         )       -----
           (  Network  )    (       )      (       )
           (  Domain 1 )      -----       (         )
            (         )                  (  Network  )
             (       )                   (  Domain 3 )
               -----                      (         )
                                           (       )
                                             -----
```

Figure 2 Controlling Hierarchy

The ACTN framework facilitates the detachment of the network and service control from the underlying technology and help the customer express the network as desired by business needs. Therefore, care must be taken to keep minimal dependency on the CMI (or no dependency at all) with respect to the network domain technologies.

The MPI instead requires some specialization according to the domain technology.

In this document we address the use case where the CNC controls: the customer IP network and requests, at the CMI, transport connectivity among IP routers to an MDSC which coordinates, via three MPIs, the control of a multi-domain transport network via three PNCs.

The interfaces within scope of this document are the three MPIs, while the interface between the CNC and the IP routers is out of scope of this document. It is also assumed that the CMI allows the CNC to provide all the information that is required by the MDSC to properly configure the transport connectivity requested by the customer.

4.1.1. Single-Domain Scenario

In case the CNC requests transport connectivity between IP routers attached to the same transport domain (e.g., between C-R1 and C-R3), the MDSC can pass the service request to the PNC (e.g., PNC1) and let the PNC takes decisions about how to implement the service.

4.1.2. Multi-Domain Scenario

In case the CNC requests transport connectivity between IP routers attached to different transport domain (e.g., between C-R1 and C-R5), the MDSC can split the service request into tunnel segment configuration and then pass to multiple PNCs (PNC1 and PNC2 in this example) and let the PNC takes decisions about how to deploy the service.

4.2. Topology Abstractions

Abstraction provides a selective method for representing connectivity information within a domain. There are multiple methods to abstract a network topology. This document assumes the abstraction method defined in [RFC7926]:

> "Abstraction is the process of applying policy to the available TE information within a domain, to produce selective information that represents the potential ability to connect across the domain. Thus, abstraction does not necessarily offer all possible connectivity options, but presents a general view of potential connectivity according to the policies that determine how the domain’s administrator wants to allow the domain resources to be used."

[TE-Topo] Describes a YANG base model for TE topology without any technology specific parameters. Moreover, it defines how to abstract for TE-network topologies.

[ACTN-Frame] Provides the context of topology abstraction in the ACTN architecture and discusses a few alternatives for the abstraction methods for both packet and optical networks. This is an important consideration since the choice of the abstraction method impacts protocol design and the information it carries. According to [ACTN-Frame], there are three types of topology:

o White topology: This is a case where the PNC provides the actual network topology to the MDSC without any hiding or filtering. In this case, the MDSC has the full knowledge of the underlying network topology;

o Black topology: The entire domain network is abstracted as a single virtual node with the access/egress links without disclosing any node internal connectivity information;

o Grey topology: This abstraction level is between black topology and white topology from a granularity point of view. This is abstraction of TE tunnels for all pairs of border nodes. We may further differentiate from a perspective of how to abstract internal TE resources between the pairs of border nodes:

  - Grey topology type A: border nodes with a TE links between them in a full mesh fashion;

  - Grey topology type B: border nodes with some internal abstracted nodes and abstracted links.

Each PNC should provide the MDSC a topology abstraction of the domain’s network topology.

Each PNC provides topology abstraction of its own domain topology independently from each other and therefore it is possible that different PNCs provide different types of topology abstractions.

The MPI operates on the abstract topology regardless on the type of abstraction provided by the PNC.

To analyze how the MPI operates on abstract topologies independently from the topology abstraction provided by each PNC and, therefore, that that different PNCs can provide different topology abstractions, it is assumed that:

o PNC1 provides a topology abstraction which exposes at the MPI an abstract node and an abstract link for each physical node and link within network domain 1

o PNC2 provides a topology abstraction which exposes at the MPI a single abstract node (representing the whole network domain) with abstract links representing only the inter-domain physical links

o PNC3 provides a topology abstraction which exposes at the MPI two abstract nodes (AN31 and AN32). They abstract respectively nodes S31+S33 and nodes S32+S34. At the MPI, only the abstract nodes should be reported: the mapping between the abstract nodes (AN31 and AN32) and the physical nodes (S31, S32, S33 and S34) should be done internally by the PNC.

The MDSC should be capable to stitch together each abstracted topology to build its own view of the multi-domain network topology. The process may require suitable oversight, including administrative configuration and trust models, but this is out of scope for this document.

A method and process for topology abstraction for the CMI is required, and will be discussed in a future revision of this document.

4.3. Service Configuration

In the following scenarios, it is assumed that the CNC is capable to request service connectivity from the MDSC to support IP routers connectivity.

The type of services could depend of the type of physical links (e.g. OTN link, ETH link or SDH link) between the routers and transport network.

The control of different adaptations inside IP routers, C-Ri (PKT -> foo) and C-Rj (foo -> PKT), are assumed to be performed by means that are not under the control of, and not visible to, the MDSC nor to the PNCs. Therefore, these mechanisms are outside the scope of this document.

It is just assumed that the CNC is capable to request the proper configuration of the different adaptation functions inside the customer’s IP routers, by means which are outside the scope of this document.

4.3.1. ODU Transit

The physical links interconnecting the IP routers and the transport network can be OTN links. In this case, the physical/optical interconnections below the ODU layer are supposed to be pre-configured and not exposed at the MPI to the MDSC.

To setup a 10Gb IP link between C-R1 and C-R5, an ODU2 end-to-end data plane connection needs be created between C-R1 and C-R5, crossing transport nodes S3, S1, S2, S31, S33, S34, S15 and S18 which belong to different PNC domains.

The traffic flow between C-R1 and C-R5 can be summarized as:

```
C-R1 ([PKT] -> ODU2), S3 ([ODU2]), S1 ([ODU2]), S2 ([ODU2]),
S31 ([ODU2]), S33 ([ODU2]), S34 ([ODU2]),
S15 ([ODU2]), S18 ([ODU2]), C-R5 (ODU2 -> [PKT])
```

It is assumed that the CNC requests, via the CMI, the setup of an ODU2 transit service, providing all the information that the MDSC needs to understand that it shall setup a multi-domain ODU2 segment connection between nodes S3 and S18.

In case the CNC needs the setup of a 10Gb IP link between C-R1 and C-R3 (single-domain service request), the traffic flow between C-R1 and C-R3 can be summarized as:

```
C-R1 ([PKT] -> ODU2), S3 ([ODU2]), S5 ([ODU2]), S6 ([ODU2]),
C-R3 (ODU2 -> [PKT])
```

Since the CNC is unaware of the transport network domains, it requests the setup of an ODU2 transit service in the same way as before, regardless the fact the fact that this is a single-domain service.

It is assumed that the information provided at the CMI is sufficient for the MDSC to understand that this is a single-domain service request.

The MDSC can then just request PNC1 to setup a single-domain ODU2 data plane segment connection between nodes S3 and S6.

4.3.2. EPL over ODU

The physical links interconnecting the IP routers and the transport network can be Ethernet links.

To setup a 10Gb IP link between C-R1 and C-R5, an EPL service needs to be created between C-R1 and C-R5, supported by an ODU2 end-to-end data plane connection between transport nodes S3 and S18, crossing transport nodes S1, S2, S31, S33, S34 and S15 which belong to different PNC domains.

The traffic flow between C-R1 and C-R5 can be summarized as:

```
C-R1 ([PKT] -> ETH), S3 (ETH -> [ODU2]), S1 ([ODU2]),
S2 ([ODU2]), S31 ([ODU2]), S33 ([ODU2]), S34 ([ODU2]),
S15 ([ODU2]), S18 ([ODU2] -> ETH), C-R5 (ETH -> [PKT])
```

It is assumed that the CNC requests, via the CMI, the setup of an EPL service, providing all the information that the MDSC needs to understand that it shall coordinate the three PNCs to setup a multi-domain ODU2 end-to-end connection between nodes S3 and S18 as well as the configuration of the adaptation functions inside nodes S3 and S18: S3 (ETH -> [ODU2]), S18 ([ODU2] -> ETH), S18 (ETH -> [ODU2]) and S3 ([ODU2] -> ETH).

In case the CNC needs the setup of a 10Gb IP link between C-R1 and C-R3 (single-domain service request), the traffic flow between C-R1 and C-R3 can be summarized as:

```
C-R1 ([PKT] -> ETH), S3 (ETH -> [ODU2]), S5 ([ODU2]),
S6 ([ODU2] -> ETH), C-R3 (ETH-> [PKT])
```

As described in section 4.3.1, the CNC requests the setup of an EPL service in the same way as before and the information provided at the CMI is sufficient for the MDSC to understand that this is a single-domain service request.

The MDSC can then just request PNC1 to setup a single-domain EPL service between nodes S3 and S6. PNC1 can take care of setting up the single-domain ODU2 end-to-end connection between nodes S3 and S6 as well as of configuring the adaptation functions on these edge nodes.

4.3.3. Other OTN Clients Services

[ITU-T G.709] defines mappings of different client layers into ODU. Most of them are used to provide Private Line services over an OTN transport network supporting a variety of types of physical access links (e.g., Ethernet, SDH STM-N, Fibre Channel, InfiniBand, etc.).

The physical links interconnecting the IP routers and the transport network can be any of these types.

In order to setup a 10Gb IP link between C-R1 and C-R5 using, for example SDH physical links between the IP routers and the transport network, an STM-64 Private Line service needs to be created between C-R1 and C-R5, supported by ODU2 end-to-end data plane connection between transport nodes S3 and S18, crossing transport nodes S1, S2, S31, S33, S34 and S15 which belong to different PNC domains.

The traffic flow between C-R1 and C-R5 can be summarized as:

```
C-R1 ([PKT] -> STM-64), S3 (STM-64 -> [ODU2]), S1 ([ODU2]),
S2 ([ODU2]), S31 ([ODU2]), S33 ([ODU2]), S34 ([ODU2]),
S15 ([ODU2]), S18 ([ODU2] -> STM-64), C-R5 (STM-64 -> [PKT])
```

As described in section 4.3.2, it is assumed that the CNC is capable, via the CMI, to request the setup of an STM-64 Private Line service, providing all the information that the MDSC needs to coordinate the setup of a multi-domain ODU2 connection as well as the adaptation functions on the edge nodes.

In the single-domain case (10Gb IP link between C-R1 and C-R3), the traffic flow between C-R1 and C-R3 can be summarized as:

```
C-R1 ([PKT] -> STM-64), S3 (STM-64 -> [ODU2]), S5 ([ODU2]),
S6 ([ODU2] -> STM-64), C-R3 (STM-64 -> [PKT])
```

As described in section 4.3.1, the CNC requests the setup of an STM-64 Private Line service in the same way as before and the information provided at the CMI is sufficient for the MDSC to understand that this is a single-domain service request.

As described in section 4.3.2, the MDSC could just request PNC1 to setup a single-domain STM-64 Private Line service between nodes S3 and S6.

4.3.4. EVPL over ODU

When the physical links interconnecting the IP routers and the transport network are Ethernet links, it is also possible that different Ethernet services (e.g., EVPL) can share the same physical link using different VLANs.

To setup two 1Gb IP links between C-R1 to C-R3 and between C-R1 and C-R5, two EVPL services need to be created, supported by two ODU0 end-to-end connections respectively between S3 and S6, crossing transport node S5, and between S3 and S18, crossing transport nodes S1, S2, S31, S33, S34 and S15 which belong to different PNC domains.

Since the two EVPL services are sharing the same Ethernet physical link between C-R1 and S3, different VLAN IDs are associated with different EVPL services: for example, VLAN IDs 10 and 20 respectively.

The traffic flow between C-R1 and C-R5 can be summarized as:

```
C-R1 ([PKT] -> VLAN), S3 (VLAN -> [ODU0]), S1 ([ODU0]),
S2 ([ODU0]), S31 ([ODU0]), S33 ([ODU0]), S34 ([ODU0]),
S15 ([ODU0]), S18 ([ODU0] -> VLAN), C-R5 (VLAN -> [PKT])
```

The traffic flow between C-R1 and C-R3 can be summarized as:

```
C-R1 ([PKT] -> VLAN), S3 (VLAN -> [ODU0]), S5 ([ODU0]),
S6 ([ODU0] -> VLAN), C-R3 (VLAN -> [PKT])
```

As described in section 4.3.2, it is assumed that the CNC is capable, via the CMI, to request the setup of these EVPL services, providing all the information that the MDSC needs to understand that it need to request PNC1 to setup an EVPL service between nodes S3 and S6 (single-domain service request) and it also needs to coordinate the setup of a multi-domain ODU0 connection between nodes S3 and S16 as well as the adaptation functions on these edge nodes.

4.3.5. EVPLAN and EVPTree Services

When the physical links interconnecting the IP routers and the transport network are Ethernet links, multipoint Ethernet services (e.g, EPLAN and EPTree) can also be supported. It is also possible that multiple Ethernet services (e.g, EVPL, EVPLAN and EVPTree) share the same physical link using different VLANs.

Note - it is assumed that EPLAN and EPTree services can be supported by configuring EVPLAN and EVPTree with port mapping.

Since this EVPLAN/EVPTree service can share the same Ethernet physical links between IP routers and transport nodes (e.g., with the EVPL services described in section 4.3.4), a different VLAN ID (e.g., 30) can be associated with this EVPLAN/EVPTree service.

In order to setup an IP subnet between C-R1, C-R2, C-R3 and C-R5, an EVPLAN/EVPTree service needs to be created, supported by two ODUflex end-to-end connections respectively between S3 and S6, crossing transport node S5, and between S3 and S18, crossing transport nodes S1, S2, S31, S33, S34 and S15 which belong to different PNC domains.

Some MAC Bridging capabilities are also required on some nodes at the edge of the transport network: for example Ethernet Bridging capabilities can be configured in nodes S3 and S6:

o MAC Bridging in node S3 is needed to select, based on the MAC Destination Address, whether received Ethernet frames should be forwarded to C-R1 or to the ODUflex terminating on node S6 or to the other ODUflex terminating on node S18;

o MAC bridging function in node S6 is needed to select, based on the MAC Destination Address, whether received Ethernet frames should be sent to C-R2 or to C-R3 or to the ODUflex terminating on node S3.

In order to support an EVPTree service instead of an EVPLAN, additional configuration of the Ethernet Bridging capabilities on the nodes at the edge of the transport network is required.

The traffic flows between C-R1 and C-R3, between C-R3 and C-R5 and between C-R1 and C-R5 can be summarized as:

```
C-R1 ([PKT] -> VLAN), S3 (VLAN -> [MAC] -> [ODUflex]),
S5 ([ODUflex]), S6 ([ODUflex] -> [MAC] -> VLAN),
C-R3 (VLAN -> [PKT])

C-R3 ([PKT] -> VLAN), S6 (VLAN -> [MAC] -> [ODUflex]),
S5 ([ODUflex]), S3 ([ODUflex] -> [MAC] -> [ODUflex]),
S1 ([ODUflex]), S2 ([ODUflex]), S31 ([ODUflex]),
S33 ([ODUflex]), S34 ([ODUflex]),
S15 ([ODUflex]), S18 ([ODUflex] -> VLAN), C-R5 (VLAN -> [PKT])

C-R1 ([PKT] -> VLAN), S3 (VLAN -> [MAC] -> [ODUflex]),
S1 ([ODUflex]), S2 ([ODUflex]), S31 ([ODUflex]),
S33 ([ODUflex]), S34 ([ODUflex]),
S15 ([ODUflex]), S18 ([ODUflex] -> VLAN), C-R5 (VLAN -> [PKT])
```

As described in section 4.3.2, it is assumed that the CNC is capable, via the CMI, to request the setup of this EVPLAN/EVPTree service, providing all the information that the MDSC needs to understand that it need to request PNC1 to setup an ODUflex connection between nodes S3 and S6 (single-domain service request) and it also needs to coordinate the setup of a multi-domain ODUflex connection between nodes S3 and S16 as well as the MAC bridging and the adaptation functions on these edge nodes.

In case the CNC needs the setup of an EVPLAN/EVPTree service only between C-R1, C-R2 and C-R3 (single-domain service request), it would request the setup of this service in the same way as before and the information provided at the CMI is sufficient for the MDSC to understand that this is a single-domain service request.

The MDSC can then just request PNC1 to setup a single-domain EVPLAN/EVPTree service between nodes S3 and S6. PNC1 can take care of setting up the single-domain ODUflex end-to-end connection between nodes S3 and S6 as well as of configuring the MAC bridging and the adaptation functions on these edge nodes.

4.3.6. Dynamic Service Configuration

Given the service established in the previous sections, there is a demand for an update of some service characteristics. A straightforward approach would be terminate the current service and replace with a new one. Another more advanced approach would be dynamic configuration, in which case there will be no interruption for the connection.

An example application would be updating the SLA information for a certain connection. For example, an ODU transit connection is set up according to section 4.3.1, with the corresponding SLA level of 'no protection'. After the establishment of this connection, the user would like to enhance this service by providing a restoration after potential failure, and a request is generated on the CMI. In this case, after receiving the request, the MDSC would need to send an update message to the PNC, changing the SLA parameters in TE Tunnel model. Then the connection characteristic would be changed by PNC, and a notification would be sent to MDSC for acknowledgement.

4.4. Multi-function Access Links

Some physical links interconnecting the IP routers and the transport network can be configured in different modes, e.g., as OTU2 or STM-64 or 10GE.

This configuration can be done a-priori by means outside the scope of this document. In this case, these links will appear at the MPI either as an ODU Link or as a STM-64 Link or as a 10GE Link (depending on the a-priori configuration) and will be controlled at the MPI as discussed in section 4.3.

It is also possible not to configure these links a-priori and give the control to the MPI to decide, based on the service configuration, how to configure it.

For example, if the physical link between C-R1 and S3 is a multi-functional access link while the physical links between C-R7 and S31 and between C-R5 and S18 are STM-64 and 10GE physical links respectively, it is possible to configure either an STM-64 Private Line service between C-R1 and C-R7 or an EPL service between C-R1 and C-R5.

The traffic flow between C-R1 and C-R7 can be summarized as:

```
C-R1 ([PKT] -> STM-64), S3 (STM-64 -> [ODU2]), S1 ([ODU2]),
S2 ([ODU2]), S31 ([ODU2] -> STM-64), C-R3 (STM-64 -> [PKT])
```

The traffic flow between C-R1 and C-R5 can be summarized as:

```
C-R1 ([PKT] -> ETH), S3 (ETH -> [ODU2]), S1 ([ODU2]),
S2 ([ODU2]), S31 ([ODU2]), S33 ([ODU2]), S34 ([ODU2]),
S15 ([ODU2]), S18 ([ODU2] -> ETH), C-R5 (ETH -> [PKT])
```

As described in section 4.3.2, it is assumed that the CNC is capable, via the CMI, to request the setup either an STM-64 Private Line service between C-R1 and C-R7 or an EPL service between C-R1 and C-R5, providing all the information that the MDSC needs to understand that it need to coordinate the setup of a multi-domain ODU2 connection, either between nodes S3 and S31, or between nodes S3 and S18, as well as the adaptation functions on these edge nodes, and in particular whether the multi-function access link on between C-R1 and S3 should operate as an STM-64 or as a 10GE link.

4.5. Protection and Restoration Configuration

Protection switching provides a pre-allocated survivability mechanism, typically provided via linear protection methods and would be configured to operate as 1+1 unidirectional (the most common OTN protection method), 1+1 bidirectional or 1:n bidirectional. This ensures fast and simple service survivability.

Restoration methods would provide capability to reroute and restore connectivity traffic around network faults, without the network penalty imposed with dedicated 1+1 protection schemes.

This section describes only services which are protected with linear protection and with dynamic restoration.

The MDSC needs to be capable to coordinate different PNCs to configure protection switching when requesting the setup of the protected connectivity services described in section 4.3.

Since in these service examples, switching within the transport network domain is performed only in the OTN ODU layer, also protection switching within the transport network domain can only be provided at the OTN ODU layer.

4.5.1. Linear Protection (end-to-end)

In order to protect any service defined in section 4.3 from failures within the OTN multi-domain transport network, the MDSC should be capable to coordinate different PNCs to configure and control OTN linear protection in the data plane between nodes S3 and node S18.

It is assumed that the OTN linear protection is configured to with 1+1 unidirectional protection switching type, as defined in [ITU-T G.808.1] and [ITU-T G.873.1], as well as in [RFC4427].

In these scenarios, a working transport entity and a protection transport entity, as defined in [ITU-T G.808.1], (or a working LSP and a protection LSP, as defined in [RFC4427]) should be configured in the data plane.

Two cases can be considered:

- In one case, the working and protection transport entities pass through the same PNC domains:

```
Working transport entity:   S3, S1, S2,
                    S31, S33, S34,
                    S15, S18

Protection transport entity: S3, S4, S8,
                    S32,
                    S12, S17, S18
```

- In another case, the working and protection transport entities can pass through different PNC domains:

```
Working transport entity:   S3, S5, S7,
                    S11, S12, S17, S18

Protection transport entity: S3, S1, S2,
                    S31, S33, S34,
                    S15, S18
```

The PNCs should be capable to report to the MDSC which is the active transport entity, as defined in [ITU-T G.808.1], in the data plane.

Given the fast dynamic of protection switching operations in the data plane (50ms recovery time), this reporting is not expected to be in real-time.

It is also worth noting that with unidirectional protection switching, e.g., 1+1 unidirectional protection switching, the active transport entity may be different in the two directions.

4.5.2. Segmented Protection

To protect any service defined in section 4.3 from failures within the OTN multi-domain transport network, the MDSC should be capable to request each PNC to configure OTN intra-domain protection when requesting the setup of the ODU2 data plane connection segment.

If PNC1 provides linear protection, the working and protection transport entities could be:

    Working transport entity: S3, S1, S2

    Protection transport entity: S3, S4, S8, S2

If PNC2 provides linear protection, the working and protection transport entities could be:

    Working transport entity: S15, S18

    Protection transport entity: S15, S12, S17, S18

If PNC3 provides linear protection, the working and protection transport entities could be:

    Working transport entity: S31, S33, S34

    Protection transport entity: S31, S32, S34

4.5.3. End-to-End Dynamic restoration

To restore any service defined in section 4.3 from failures within the OTN multi-domain transport network, the MDSC should be capable to coordinate different PNCs to configure and control OTN end-to-end dynamic Restoration in the data plane between nodes S3 and node S18. For example, the MDSC can request the PNC1, PNC2 and PNC3 to create a service with no-protection, MDSC set the end-to-end service with the dynamic restoration.

```
      Working transport entity:   S3, S1, S2,
                                  S31, S33, S34,
                                  S15, S18
```

When a link failure between S1 and s2 occurred in network domain 1, PNC1 does not restore the tunnel and send the alarm notification to the MDSC, MDSC will perform the end-to-end restoration.

```
      Restored transport entity:   S3, S4, S8,
                                   S12, S15, S18
```

4.5.4. Segmented Dynamic Restoration

To restore any service defined in section 4.3 from failures within the OTN multi-domain transport network, the MDSC should be capable to coordinate different PNCs to configure and control OTN segmented dynamic Restoration in the data plane between nodes S3 and node S18.

```
      Working transport entity:   S3, S1, S2,
                                  S31, S33, S34,
                                  S15, S18
```

When a link failure between S1 and s2 occurred in network domain 1, PNC1 will restore the tunnel and send the alarm or tunnel update notification to the MDSC, MDSC will update the restored tunnel.

```
      Restored transport entity:   S3, S4, S8, S2
                                   S31, S33, S34,
                                   S15, S18
```

When a link failure between network domain 1 and network domain 2 occurred, PNC1 and PNC2 will send the alarm notification to the MDSC, MDSC will update the restored tunnel.

```
      Restored transport entity:   S3, S4, S8,
                                   S12, S15, S18
```

In order to improve the efficiency of recovery, the controller can establish a recovery path in a concurrent way. When the recovery fails in one domain or one network element, the rollback operation should be supported.

The creation of the recovery path by the controller can use the method of "make-before-break", in order to reduce the impact of the recovery operation on the services.

4.6. Service Modification and Deletion

To be discussed in future versions of this document.

4.7. Notification

To realize the topology update, service update and restoration function, following notification type should be supported.

1. Object create

2. Object delete

3. Object state change

4. Alarm

Because there are three types of topology abstraction type defined in section Section 4.2., the notification should also be abstracted. The PNC and MDSC should coordinate together to determine the notification policy, such as when an intra-domain alarm occurred, the PNC may not report the alarm but the service state change notification to the MDSC.

4.8. Path Computation with Constraint

It is possible to have constraint during path computation procedure, typical cases include IRO/XRO and so on. This information is carried in the TE Tunnel model and used when there is a request with constraint. Consider the example in section 4.3.1, the request can be a Tunnel from C-R1 to C-R5 with an IRO from S2 to S31, then a qualified feedback would become:

```
C-R1 ([PKT] -> ODU2), S3 ([ODU2]), S1 ([ODU2]), S2 ([ODU2]),
S31 ([ODU2]), S33 ([ODU2]), S34 ([ODU2]),
S15 ([ODU2]), S18 ([ODU2]), C-R5 (ODU2 -> [PKT])
```

If the request covers the IRO from S8 to S12, then the above path would not be qualified, while a possible computation result may be:

```
C-R1 ([PKT] -> ODU2), S3 ([ODU2]), S1 ([ODU2]), S2 ([ODU2]),
S8 ([ODU2]), S12 ([ODU2]), S15 ([ODU2]), S18 ([ODU2]), C-R5 (ODU2 ->
[PKT])
```

Similarly, the XRO can be represented by TE tunnel model as well.

When there is a technology specific network (e.g, OTN), the corresponding technology (OTN) model should also be used to specify the tunnel information on MPI, with the constraint included in TE Tunnel model.

5. YANG Model Analysis

This section provides a high-level overview of how IETF YANG models can be used at the MPIs, between the MDSC and the PNCs, to support the scenarios described in section 4.

Section 5.1 describes the different topology abstractions provided to the MDSC by each PNC via its own MPI.

Section 0 describes how the MDSC can coordinate different requests to different PNCs, via their own MPIs, to setup different services, as defined in section 4.3.

Section 5.3 describes how the protection scenarios can be deployed, including end-to-end protection and segment protection, for both intra-domain and inter-domain scenario.

5.1. YANG Models for Topology Abstraction

Each PNC reports its respective abstract topology to the MDSC, as described in section 4.1.2.

5.1.1. Domain 1 Topology Abstraction

PNC1 provides the required topology abstraction to expose at its MPI toward the MDSC (called "MPI1") one TE Topology instance for the ODU layer (called "MPI1 ODU Topology"), containing one TE Node (called "ODU Node") for each physical node, as shown in Figure 3. below.

```
                  ..................................
                  :                                :
                  :   ODU Abstract Topology @ MPI  :
                  :        Gotham City Area        :
                  :     Metro Transport Network    :
                  :                                :
                  :        +----+        +----+    :
                  :        |    |S1-1    |    |S2-1:
                  :        | S1 |--------| S2 |- - - - -(C-R4)
                  :        +----+    S2-2+----+    :
                  :     S1-2/               |S2-3  :
                  :    S3-2/ Robinson Park  |      :
                  :    +----+   +----+      |      :
                  :    |    |3 1|    |      |      :
        (C-R1)- - - - -| S3 |---| S4 |      |      :
                  :S3-1+----+   +----+      |      :
                  :   S3-4 \        \S4-2   |      :
                  :         \S5-1    \      |      :
                  :        +----+     \     |      :
                  :        |    |      \S8-3|      :
                  :        | S5 |       \   |      :
                  :        +----+ Metro  \  |S8-2  :
        (C-R2)- - - - -   2/ E  \3 Main   \ |      :
                  :S6-1 \ /3 a E \1 Ring   \|      :
                  :    +----+s-n+----+   +----+    :
                  :    |    |t d|    |   |    |S8-1:
                  :    | S6 |---| S7 |---| S8 |- - - - -(C-R5)
                  :    +----+4 2+----+3 4+----+    :
                  :     /                          :
        (C-R3)- - - - -                            :
                  :S6-2                            :
                  :................................:
```

Figure 3 Abstract Topology exposed at MPI1 (MPI1 ODU Topology)

The ODU Nodes in Figure 3 are using the same names as the physical nodes to simplify the description of the mapping between the ODU Nodes exposed by the Transport PNCs at the MPI and the physical nodes in the data plane. This does not correspond to the reality of the usage of the topology model, as described in section 4.3 of [TE-TOPO], in which renaming by the client it is necessary.

As described in section 4.1.2, it is assumed that the physical links between the physical nodes are pre-configured up to the OTU4 trail using mechanisms which are outside the scope of this document. PNC1 exports at MPI1 one TE Link (called "ODU Link") for each of these OTU4 trails.

5.1.2. Domain 2 Grey (Type A) Topology Abstraction

PNC2 provides the required topology abstraction to expose at its MPI towards the MDSC (called "MPI2") only one abstract node (i.e., AN2), with only inter-domain and access links, is reported at the MPI2.

5.1.3. Domain 3 Grey (Type B) Topology Abstraction

PNC3 provides the required topology abstraction to expose at its MPI towards the MDSC (called "MPI3") only two abstract nodes (i.e., AN31 and AN32), with internal links, inter-domain links and access links.

5.1.4. Multi-domain Topology Stitching

As assumed in the beginning of this section, MDSC does not have any knowledge of the topologies of each domain until each PNC reports its own abstraction topology, so the MDSC needs to merge together the abstract topologies provided by different PNCs, at the MPIs, to build its own topology view, as described in section 4.3 of [TE-TOPO].

Given the topologies reported from multiple PNCs, the MDSC need to stitch the multi-domain topology and obtain the full map of topology. The topology of each domain main be in an abstracted shape (refer to section 5.2 of [ACTN-Frame] for different level of abstraction), while the inter-domain link information must be complete and fully configured by the MDSC.

The inter-domain link information is reported to the MDSC by the two PNCs, controlling the two ends of the inter-domain link.

The MDSC needs to understand how to "stitch" together these inter-domain links.

One possibility is to use the plug-id information, defined in [TE-TOPO]: two inter-domain links reporting the same plug-id value can be merged as a single intra-domain link within any MDSC native topology. The value of the reported plug-id information can be either assigned by a central network authority, and configured within the two PNC domains, or it can be discovered using automatic discovery mechanisms (e.g., LMP-based, as defined in [RFC6898]).

In case the plug-id values are assigned by a central authority, it is under the central authority responsibility to assign unique values.

In case the plug-id values are automatically discovered, the information discovered by the automatic discovery mechanisms needs to be encoded as a bit string within the plug-id value. This encoding is implementation specific but the encoding rules need to be consistent across all the PNCs.

In case of co-existence within the same network of multiple sources for the plug-id (e.g., central authority and automatic discovery or even different automatic discovery mechanisms), it is recommended that the plug-id namespace is partitioned to avoid that different sources assign the same plug-id value to different inter-domain link. The encoding of the plug-id namespace within the plug-id value is implementation specific but needs to be consistent across all the PNCs.

Another possibility is to pre-configure, either in the adjacent PNCs or in the MDSC, the association between the inter-domain link identifiers (topology-id, node-id and tp-id) assigned by the two adjacent PNCs to the same inter-domain link.

This last scenario requires further investigation and will be discussed in a future version of this document.

5.1.5. Access Links

Access links in Figure 3. are shown as ODU Links: the modeling of the access links for other access technologies is currently an open issue.

The modeling of the access link in case of non-ODU access technology has also an impact on the need to model ODU TTPs and layer transition capabilities on the edge nodes (e.g., nodes S2, S3, S6 and S8 in Figure 3.).

If, for example, the physical NE S6 is implemented in a "pizza box", the data plane would have only set of ODU termination resources (where up to 2xODU4, 4xODU3, 20xODU2, 80xODU1, 160xODU0 and

160xODUflex can be terminated). The traffic coming from each of the 10GE access links can be mapped into any of these ODU terminations.

Instead if, for example, the physical NE S6 can be implemented as a multi-board system where access links reside on different/dedicated access cards with separated set of ODU termination resources (where up to 1xODU4, 2xODU3, 10xODU2, 40xODU1, 80xODU0 and 80xODUflex for each resource can be terminated). The traffic coming from one 10GE access links can be mapped only into the ODU terminations which reside on the same access card.

The more generic implementation option for a physical NE (e.g., S6) would be case is of a multi-board system with multiple access cards with separated sets of access links and ODU termination resources (where up to 1xODU4, 2xODU3, 10xODU2, 40xODU1, 80xODU0 and 80xODUflex for each resource can be terminated). The traffic coming from each of the 10GE access links on one access card can be mapped only into any of the ODU terminations which reside on the same access card.

In the last two cases, only the ODUs terminated on the same access card where the access links resides can carry the traffic coming from that 10GE access link. Terminated ODUs can instead be sent to any of the OTU4 interfaces

In all these cases, terminated ODUs can be sent to any of the OTU4 interfaces assuming the implementation is based on a non-blocking ODU cross-connect.

If the access links are reported via MPI in some, still to be defined, client topology, it is possible to report each set of ODU termination resources as an ODU TTP within the ODU Topology of Figure 1. and to use either the inter-layer lock-id or the transitional link, as described in sections 3.4 and 3.10 of [TE-TOPO], to correlate the access links, in the client topology, with the ODU TTPs, in the ODU topology, to which access link are connected to.

5.2. YANG Models for Service Configuration

The service configuration procedure is assumed to be initiated (step 1 in Figure 4) at the CMI from CNC to MDSC. Analysis of the CMI models is (e.g., L1SM, L2SM, Transport-Service, VN, et al.) is outside the scope of this document.

As described in section 4.3, it is assumed that the CMI YANG models provides all the information that allows the MDSC to understand that it needs to coordinate the setup of a multi-domain ODU connection (or connection segment) and, when needed, also the configuration of the adaptation functions in the edge nodes belonging to different domains.

```
                                 |
                                 | {1}
                                 V
                          ----------------
                         |           {2}  |
                         | {3}  MDSC      |
                         |                |
                          ----------------
                           ^     ^      ^
                    {3.1}  |     |      |
                 +---------+     |{3.2} |
                 |               |      +----------+
                 |               V                 |
                 |           ----------            |{3.3}
                 |          |   PNC2   |           |
                 |           ----------            |
                 |               ^                 |
                 V               | {4.2}           |
             ----------          V                 |
            |   PNC1   |       -----               V
             ----------      (Network)        ----------
                 ^          ( Domain 2)      |   PNC3   |
                 | {4.1}   (          _)      ----------
                 V          (        )            ^
               -----       C==========D           | {4.3}
             (Network)    /  (       ) \          V
            ( Domain 1)  /     -----    \       -----
           (           )/                \    (Network)
           A===========B                  \  ( Domain 3)
          / (         )                    \(            )
      AP-1   (       )                      X===========Z
               -----                         (         ) \
                                              (       )   AP-2
                                                -----
```

Figure 4 Multi-domain Service Setup

As an example, the objective in this section is to configure a transport service between C-R1 and C-R5. The cross-domain routing is assumed to be C-R1 <-> S3 <-> S2 <-> S31 <-> S33 <-> S34 <->S15 <-> S18 <-> C-R5.

According to the different client signal type, there is different adaptation required.

After receiving such request, MDSC determines the domain sequence, i.e., domain 1 <-> domain 2 <-> domain 3, with corresponding PNCs and inter-domain links (step 2 in Figure 4).

As described in [PATH-COMPUTE], the domain sequence can be determined by running the MDSC own path computation on the MDSC internal topology, defined in section 5.1.4, if and only if the MDSC has enough topology information. Otherwise the MDSC can send path computation requests to the different PNCs (steps 2.1, 2.2 and 2.3 in Figure 4) and use this information to determine the optimal path on its internal topology and therefore the domain sequence.

The MDSC will then decompose the tunnel request into a few tunnel segments via tunnel model (including both TE tunnel model and OTN tunnel model), and request different PNCs to setup each intra-domain tunnel segment (steps 3, 3.1, 3.2 and 3.3 in Figure 4).

Assume that each intra-domain tunnel segment can be set up successfully, and each PNC response to the MDSC respectively. Based on each segment, MDSC will take care of the configuration of both the intra-domain tunnel segment and inter-domain tunnel via corresponding MPI (via TE tunnel model and OTN tunnel model). More specifically, for the inter-domain configuration, the ts-bitmap and tpn attributes need to be configured using the OTN Tunnel model [xxx]. Then the end-to-end OTN tunnel will be ready.

In any case, the access link configuration is done only on the PNCs that control the access links (e.g., PNC-1 and PNC-3 in our example) and not on the PNCs of transit domain (e.g., PNC-2 in our example). Access link will be configured by MDSC after the OTN tunnel is set up. Access configuration is different and dependent on the different type of service. More details can be found in the following sections.

5.2.1. ODU Transit Service

In this scenario, the access links are configured as ODU Links.

As described in section 4.3.1, the CNC needs to setup an ODU2 end-to-end connection, supporting an IP link, between C-R1 and C-R5 and requests via the CMI to the MDSC the setup of an ODU transit service.

From the topology information described in section 5.1 above, the MDSC understands that C-R1 is attached to the access link terminating on S3-1 LTP in the ODU Topology exposed by PNC1 and that C-R5 is attached to the access link terminating on AN2-1 LTP in the ODU Topology exposed by PNC2.

Based on the assumption 0) in section 1.2, MDSC would then request the PNC1 to setup an ODU2 (Transit Segment) Tunnel between S3-1 and S6-2 LTPs:

- o Source and Destination TTPs are not specified (since it is a Transit Tunnel)

- o Ingress and egress points are indicated in the explicit-route-objects of the primary path:

  - o The first element of the explicit-route-objects references the access link terminating on S3-1 LTP

  - o Last element of the explicit-route-objects references the access link terminating on S6-2 LTP

The configuration of the timeslots used by the ODU2 connection within the transport network domain (i.e., on the internal links) is a matter of the Transport PNC and its interactions with the physical network elements and therefore is outside the scope of this document.

However, the configuration of the timeslots used by the ODU2 connection at the edge of the transport network domain (i.e., on the access links) needs to take into account not only the timeslots available on the physical nodes at the edge of the transport network domain (e.g., S3 and S6) but also on the devices, outside of the transport network domain, connected through these access links (e.g., C-R1 and C-R3).

Based on the assumption 2) in section 1.2, the MDSC, when requesting the Transport PNC to setup the (Transit Segment) ODU2 Tunnel, it would also configure the timeslots to be used on the access links. The MDSC can know the timeslots which are available on the edge OTN Node (e.g., S3 and S6) from the OTN Topology information exposed by the Transport PNC at the MPI as well as the timeslots which are available on the devices outside of the transport network domain (e.g., C-R1 and C-R3), by means which are outside the scope of this document.

The Transport PNC performs path computation and sets up the ODU2 cross-connections within the physical nodes S3, S5 and S6, as shown in section 4.3.1.

The Transport PNC reports the status of the created ODU2 (Transit Segment) Tunnel and its path within the ODU Topology as shown in Figure 5 below:

```
                   ..................................
                   :                                :
                   :   ODU Abstract Topology @ MPI  :
                   :                                :
                   :        +----+        +----+    :
                   :        |    |        |    |    :
                   :        | S1 |--------| S2 |- - - - -(C-R4)
                   :        +----+        +----+    :
                   :         /              |       :
                   :        /               |       :
                   :    +----+   +----+     |       :
                   :    |    |   |    |     |       :
         (C-R1)- - - - -  S3 |---| S4 |     |       :
                   :S3-1 <<== +   +----+    |       :
                   :       =        \       |       :
                   :       = \       \      |       :
                   :       == ---+    \     |       :
                   :        =    |     \    |       :
                   :        = S5 |      \   |       :
                   :        == --+       \  |       :
         (C-R2)- - - - -     =  \         \ |       :
                   :S6-1 \ / =   \         \|       :
                   :    +--- =   +----+   +----+    :
                   :    |    =   |    |   |    |    :
                   :    | S6 = --| S7 |---| S8 |- - - - -(C-R5)
                   :    +--- =   +----+   +----+    :
                   :     /   =                      :
         (C-R3)- - - - -  <<==                      :
                   :S6-2                            :
                   :................................:
```

Figure 5 ODU2 Transit Tunnel

5.2.2. EPL over ODU Service

In this scenario, the access links are configured as Ethernet Links.

As described in section 4.3.2, the CNC needs to setup an EPL service, supporting an IP link, between C-R1 and C-R3 and requests this service at the CMI to the MDSC.

MDSC needs to setup an EPL service between C-R1 and C-R3 supported by an ODU2 end-to-end connection between S3 and S6.

As described in section 5.1.5 above, it is not clear in this case how the Ethernet access links between the transport network and the IP router, are reported by the PNC to the MDSC.

If the 10GE physical links are not reported as ODU links within the ODU topology information, described in section 5.1.1 above, than the MDSC will not have sufficient information to know that C-R1 and C-R3 are attached to nodes S3 and S6.

Assuming that the MDSC knows how C-R1 and C-R3 are attached to the transport network, the MDSC would request the Transport PNC to setup an ODU2 end-to-end Tunnel between S3 and S6.

This ODU Tunnel is setup between two TTPs of nodes S3 and S6. In case nodes S3 and S6 support more than one TTP, the MDSC should decide which TTP to use.

As discussed in 5.1.5, depending on the different hardware implementations of the physical nodes S3 and S6, not all the access links can be connected to all the TTPs. The MDSC should therefore not only select the optimal TTP but also a TTP that would allow the Tunnel to be used by the service.

It is assumed that in case node S3 or node S6 supports only one TTP, this TTP can be accessed by all the access links.

Once the ODU2 Tunnel setup has been requested, unless there is a one-to-one relationship between the S3 and S6 TTPs and the Ethernet access links toward C-R1 and C-R3 (as in the case, described in section 5.1.5, where the Ethernet access links reside on different/dedicated access card such that the ODU2 tunnel can only carry the Ethernet traffic from the only Ethernet access link on the same access card where the ODU2 tunnel is terminated), the MDSC also needs to request the setup of an EPL service from the access links on S3 and S6, attached to C-R1 and C-R3, and this ODU2 Tunnel.

5.2.3. Other OTN Client Services

In this scenario, the access links are configured as one of the OTN clients (e.g., STM-64) links.

As described in section 4.3.3, the CNC needs to setup an STM-64 Private Link service, supporting an IP link, between C-R1 and C-R3 and requests this service at the CMI to the MDSC.

MDSC needs to setup an STM-64 Private Link service between C-R1 and C-R3 supported by an ODU2 end-to-end connection between S3 and S6.

As described in section 5.1.5 above, it is not clear in this case how the access links (e.g., the STM-N access links) between the transport network and the IP router, are reported by the PNC to the MDSC.

The same issues, as described in section 5.2.2, apply here:

- o the MDSC needs to understand that C-R1 and C-R3 are connected, thought STM-64 access links, with S3 and S6

- o the MDSC needs to understand which TTPs in S3 and S6 can be accessed by these access links

- o the MDSC needs to configure the private line service from these access links through the ODU2 tunnel

5.2.4. EVPL over ODU Service

In this scenario, the access links are configured as Ethernet links, as described in section 5.2.2 above.

As described in section 4.3.4, the CNC needs to setup EVPL services, supporting IP links, between C-R1 and C-R3, as well as between C-R1 and C-R4 and requests these services at the CMI to the MDSC.

MDSC needs to setup two EVPL services, between C-R1 and C-R3, as well as between C-R1 and C-R4, supported by ODU0 end-to-end connections between S3 and S6 and between S3 and S2 respectively.

As described in section 5.1.5 above, it is not clear in this case how the Ethernet access links between the transport network and the IP router, are reported by the PNC to the MDSC.

The same issues, as described in section 5.1.5 above, apply here:

- o the MDSC needs to understand that C-R1, C-R3 and C-R4 are connected, thought the Ethernet access links, with S3, S6 and S2

- o the MDSC needs to understand which TTPs in S3, S6 and S2 can be accessed by these access links o the MDSC needs to configure the EVPL services from these access links through the ODU0 tunnels

In addition, the MDSC needs to get the information that the access links on S3, S6 and S2 are capable to support EVPL (rather than just EPL) as well as to coordinate the VLAN configuration, for each EVPL service, on these access links (this is a similar issue as the timeslot configuration on access links discussed in section 4.3.1 above).

5.3. YANG Models for Protection Configuration

5.3.1. Linear Protection (end-to-end)

To be discussed in future versions of this document.

5.3.2. Segmented Protection

To be discussed in future versions of this document.

6. Detailed JSON Examples

6.1. JSON Examples for Topology Abstractions

6.1.1. Domain 1 White Topology Abstraction

Section 5.1.1 describes how PNC1 can provide a white topology abstraction to the MDSC via the MPI. Figure 3. is an example of such ODU Topology.

This section provides the detailed JSON code describing how this ODU Topology is reported by the PNC, using the [TE-TOPO] and [OTN-TOPO] YANG models at the MPI.

JSON code "mpi1-otn-topology.json" has been provided at in the appendix of this document.

6.2. JSON Examples for Service Configuration

6.2.1. ODU Transit Service

Section 5.2.1 describes how the MDSC can request PNC1, via the MPI, to setup an ODU2 transit service over an ODU Topology described in section 5.1.1.

This section provides the detailed JSON code describing how the setup of this ODU2 transit service can be requested by the MDSC, using the [TE-TUNNEL] and [OTN-TUNNEL] YANG models at the MPI.

JSON code "mpi1-odu2-service-config.json" has been provided at in the appendix of this document.

6.3. JSON Example for Protection Configuration

To be added

7. Security Considerations

This section is for further study

8. IANA Considerations

This document requires no IANA actions.

9. References

9.1. Normative References

[RFC7926] Farrel, A. et al., "Problem Statement and Architecture for Information Exchange between Interconnected Traffic-Engineered Networks", BCP 206, RFC 7926, July 2016.

[RFC4427] Mannie, E., Papadimitriou, D., "Recovery (Protection and Restoration) Terminology for Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4427, March 2006.

[ACTN-Frame] Ceccarelli, D., Lee, Y. et al., "Framework for Abstraction and Control of Transport Networks", draft-ietf-teas-actn-framework, work in progress.

[ITU-T G.709] ITU-T Recommendation G.709 (06/16), "Interfaces for the optical transport network", June 2016.

[ITU-T G.808.1] ITU-T Recommendation G.808.1 (05/14), "Generic protection switching - Linear trail and subnetwork protection", May 2014.

[ITU-T G.873.1] ITU-T Recommendation G.873.1 (05/14), "Optical transport network (OTN): Linear protection", May 2014.

[TE-TOPO] Liu, X. et al., "YANG Data Model for TE Topologies", draft-ietf-teas-yang-te-topo, work in progress.

[OTN-TOPO] Zheng, H. et al., "A YANG Data Model for Optical Transport Network Topology", draft-ietf-ccamp-otn-topo-yang, work in progress.

[CLIENT-TOPO] Zheng, H. et al., "A YANG Data Model for Client-layer Topology", draft-zheng-ccamp-client-topo-yang, work in progress.

[TE-TUNNEL] Saad, T. et al., "A YANG Data Model for Traffic Engineering Tunnels and Interfaces", draft-ietf-teas-yang-te, work in progress.

[PATH-COMPUTE] Busi, I., Belotti, S. et al, "Yang model for requesting Path Computation", draft-busibel-teas-yang-path-computation, work in progress.

[OTN-TUNNEL] Zheng, H. et al., "OTN Tunnel YANG Model", draft-ietf-ccamp-otn-tunnel-model, work in progress.

[CLIENT-SVC] Zheng, H. et al., "A YANG Data Model for Optical Transport Network Client Signals", draft-zheng-ccamp-otn-client-signal-yang, work in progress.

9.2. Informative References

[RFC5151] Farrel, A. et al., "Inter-Domain MPLS and GMPLS Traffic Engineering --Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions", RFC 5151, February 2008.

[RFC6898] Li, D. et al., "Link Management Protocol Behavior Negotiation and Configuration Modifications", RFC 6898, March 2013.

[RFC8309] Wu, Q. et al., "Service Models Explained", RFC 8309, January 2018.

[ACTN-YANG] Zhang, X. et al., "Applicability of YANG models for Abstraction and Control of Traffic Engineered Networks", draft-zhang-teas-actn-yang, work in progress.

[I2RS-TOPO] Clemm, A. et al., "A Data Model for Network Topologies", draft-ietf-i2rs-yang-network-topo, work in progress.

[ONF TR-527] ONF Technical Recommendation TR-527, "Functional Requirements for Transport API", June 2016.

[ONF GitHub] ONF Open Transport (SNOWMASS)
https://github.com/OpenNetworkingFoundation/Snowmass-ONFOpenTransport

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This document was prepared using 2-Word-v2.0.template.dot.

Appendix A. Detailed JSON Examples

A.1. JSON Code: mpi1-otn-topology.json

The JSON code for this use case is currently located on GitHub at:

https://github.com/danielkinguk/transport-nbi/blob/master/Internet-Drafts/Applicability-Statement/01/mpi1-otn-topology.json

A.2. JSON Code: mpi1-odu2-service-config.json

The JSON code for this use case is currently located on GitHub at:

https://github.com/danielkinguk/transport-nbi/blob/master/Internet-Drafts/Applicability-Statement/01/mpi1-odu2-service-config.json

Appendix B. Validating a JSON fragment against a YANG Model

The objective is to have a tool that allows validating whether a piece of JSON code is compliant with a YANG model without using a client/server.

B.1. DSDL-based approach

The idea is to generate a JSON driver file (JTOX) from YANG, then use it to translate JSON to XML and validate it against the DSDL schemas, as shown in Figure 6.

Useful link: https://github.com/mbj4668/pyang/wiki/XmlJson

```
                        (2)
            YANG-module ---> DSDL-schemas (RNG,SCH,DSRL)
                   |                  |
                   | (1)              |
                   |                  |
      Config/state  JTOX-file         | (4)
             \     |                  |
              \    |                  |
               \   V                  V
      JSON-file------------> XML-file ----------------> Output
                 (3)
```

Figure 6 - DSDL-based approach for JSON code validation

In order to allow the use of comments following the convention defined in section Section 2. without impacting the validation process, these comments will be automatically removed from the JSON-file that will be validate.

B.2. Why not using a XSD-based approach

This approach has been analyzed and discarded because no longer supported by pyang.

The idea is to convert YANG to XSD, JSON to XML and validate it against the XSD, as shown in Figure 7:

```
                (1)
YANG-module ---> XSD-schema - \       (3)
                               +--> Validation
JSON-file------> XML-file ----/
                (2)
```

Figure 7 - XSD-based approach for JSON code validation

The pyang support for the XSD output format was deprecated in 1.5 and removed in 1.7.1. However pyang 1.7.1 is necessary to work with YANG 1.1 so the process shown in Figure 7 will stop just at step (1).

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DLEP DiffServ Aware Credit Window Extension
draft-ietf-manet-dlep-da-credit-extension-04

Abstract

This document defines an extension to the DLEP protocol that enables a DiffServ aware credit-window scheme for destination-specific and shared flow control. The extension is logically composed of two mechanisms. The first provides credit window control, the second identifies how flows are identified and mapped to a credit window.

Status of This Memo

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Table of Contents

1. Introduction

The Dynamic Link Exchange Protocol (DLEP) is defined in [RFC8175]. It provides the exchange of link related control information between DLEP peers. DLEP peers are comprised of a modem and a router. DLEP defines a base set of mechanisms as well as support for possible extensions. This document defines one such extension.

The base DLEP specification does not include any flow control capability. There are various flow control techniques theoretically possible with DLEP. For example, a credit-window scheme for destination-specific flow control which provides aggregate flow control for both modem and routers has been proposed in [I-D.ietf-manet-credit-window].

This document defines a DLEP extension which provides a flow control mechanism for traffic sent from a router to a modem. Flow control is provided using one or more logical "Credit Windows", each of which will typically be supported by an associated virtual or physical queue. Traffic sent by a router will use traffic flow classification information provided by the modem to identify which traffic is associated with each credit window. (For general background on traffic classification see [RFC2475] Section 2.3.) Credit windows may be shared or dedicated on a per flow basis. The extension is structured to allow for reuse of the defined credit window based flow control with different traffic classification techniques.

This document defines traffic classification based on DLEP destination and DiffServ [RFC2475] DSCPs (differentiated services codepoints). The defined mechanism allows for credit windows to be shared across traffic sent to multiple DLEP destinations and DSCPs, or used exclusively for traffic sent to a particular destination and/or DSCP. The extension also supports the "wildcard" matching of any DSCP. Traffic classification information is provided such that it can be readily extended to support non-DSCP related traffic classification techniques, or be used by non-credit window related extensions, such as [I-D.ietf-manet-dlep-pause-extension].

The extension defined in this document is referred to as "DiffServ Aware Credit Window" or, more simply, the "DA Credit" extension. Future extensions are expected to define traffic classification techniques other than DiffServ, e.g., IEEE 802.1 Q priority code points or even 5-tuple IP flows.

This document defines a new DLEP Extension Type Value in Section 3 which is used to indicate support for the extension. Two new messages are defined in Section 4.2 and five new DLEP data items in Section 4.3 are defined to support credit window control. A single data item is defined in Section 5.1 to support traffic classification in general, as well as identification of flows based on DSCPs.

1.1. Key Words

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.

2. Extension Overview

The DA Credit extension can be used to support credit based flow control of traffic sent from a router to a modem. The extension can be used to support DiffServ and per DLEP destination based flow control. Both types of DLEP endpoints, i.e., a router and a modem, negotiate the use of extension during session initialization, see Section 5.2 [RFC8175]. When using this extension, data traffic is allowed to be sent by the router to the modem only when there are credits available.

Credits are managed on a per logical "Credit Windows" basis. Each credit window can be thought of as corresponding to a queue within a modem. Modems pass to the router information on their credit windows and identify each via a "Credit Window Identifier", or "CID". In addition to the CID, credit window information includes an initial credit window size, as well as the maximum size of the logical queue associated with each CID. The maximum size is included for informative and potential future uses.

Modems provide an initial credit window size at the time of "Credit Window Initialization". Such initialization can take place during session initiation or any point thereafter. It can also take place when rate information changes. Additional "Credit Grants", i.e., increments to Credit Window size, are provided using a Destination Up or the new "Credit Control" Message. A router provides its view of the Credit Window, which is known as "Status", in Destination Up Response and the new "Credit Control Response" Messages. Routers can also request credits using the new "Credit Control" Message.

When modems provide credits to a router, they will need to take into account any overhead of their attached transmission technology and map it into the credit semantics defined in this document. In particular, the credit window is defined below to include per frame (packet) MAC headers and this may not match the actual overhead of the modem attached transmission technology. In that case a direct mapping or an approximation will need to be made by the modem to provide appropriate credit values.

As mentioned above, traffic classification supported by this document is performed on a per {destination, DSCP} tuple basis. (Per destination traffic classification is also supported.) This means that, routers need the combination of the DLEP identified destination and one or more DSCPs associated with a CID in order to match traffic they send to specific credit windows. Modems provide the mapping of DSCPs to CIDs in sets, each of which is identified via a "Traffic Classification Identifier" or "TID". When a destination becomes reachable, a modem "Associates" (identifies) the TID to be used for traffic sent by the router to that destination. This use of CIDs, TIDs and association of a TID to a DLEP destination enables a modem to share or dedicate resources as needed to match the specifics of its implementation and its attached transmission technology.

3. Extension Usage and Identification

The extension defined in this document is composed of the mechanisms and processing defined in Section 4 and Section 5. To indicate that the DiffServ Aware Credit Window Extension is to be used, an implementation MUST include the DiffServ Aware Credit Window Type Value in the Extensions Supported Data Item. The Extensions Supported Data Item is sent and processed according to [RFC8175].

The DiffServ Aware Credit Window Extension Type Value is TBA1, see Section 9.

4. Credit Window Control

This section defines additions to DLEP for the control of credit based flow control. As mentioned above, the definition is made in the context of credit windows which can be thought of as representing different logical queues. Two new messages and five data items are defined to support credit window control. Credit window control also impacts the data plane.

4.1. Data Plane Considerations

When the use of the extension defined in this document is agreed upon per standard DLEP processing, see Section 3, a router MUST NOT send data traffic to a modem for forwarding when there are no credits available in the associated Credit Window. This document defines credit windows in octets. A credit window value MUST be larger than the number of octets contained in a packet, including any MAC headers used between the router and the modem, in order for the router to send the packet to a modem for forwarding. The credit window is decremented by the number of sent octets.

A router MUST identify the credit window associated with traffic sent to a modem based on the traffic classification information provided in the data items defined in this document. Note that routers will typically view a DLEP destination as the next hop MAC address.

4.2. Extension Messages

Two new messages are defined by this extension: the Credit Control and the Credit Control Response Message. Sending and receiving both message types MUST be supported by any implementation that advertises use of this extension per Section 3.

4.2.1. Credit Control Message

Credit Control Messages are sent by modems and routers. Each sender is only permitted to have one message outstanding at one time. That is, a sender (modem or router) MUST NOT send a second (or any subsequent) Credit Control Message until a Credit Control Response Message is received from its peer (router or modem).

Credit Control Messages are sent by modems to provide credit window increases. Modems send credit increases when there is transmission or local queue availability that exceeds the credit window value previous provided to the router. Modems will need to balance the load generated by sending and processing frequent credit window increases against a router having data traffic available to send, but no credits available.

Credit Control Messages MAY be sent by routers to request credits and provide window status. Routers will need to balance the load generated by sending and processing frequent credit window requests against a having data traffic available to send, but no credits available.

The Message Type value in the DLEP Message Header is set to TBA2.

A message sent by a modem, MUST contain one or more Credit Window Grant Data Items as defined below in Section 4.3.3. A router receiving this message MUST respond with a Credit Control Response Message.

A message sent by a router, MUST contain one or more Credit Window Request Data Items defined below in Section 4.3.5 and SHOULD contain a Credit Window Status Data Item, defined in Section 4.3.4, corresponding to each credit window request. A modem receiving this message MUST respond with a Credit Control Response Message based on the received message and data item and the processing defined below, which will typically result in credit window increments being provided.

Specific processing associated with each Credit Data Item is provided below.

4.2.2. Credit Control Response Message

Credit Control Response Messages are sent by routers to report the current Credit Window for a destination. A message sent by a router, MUST contain one or more Credit Window Status Data Items as defined below in Section 4.3.4. Specific receive processing associated with the Credit Window Status Data Item is provided below.

Credit Control Response Messages sent by modems MUST contain one or more Credit Window Grant Data Items. A data item for every Credit Window Request data item contained in the corresponding Credit Control Response Message received by the modem MUST be included. Each Credit Grant Data Item MAY provide zero or more additional credits based on the modem’s transmission or local queue availability. Specific receive processing associated with each Grant Data Item is provided below.

The Message Type value in the DLEP Message Header is set to TBA3.

4.3. Credit Window Control Data Items

Five new data items are defined to support credit window control. The Credit Window Initialization Data Item is used by a modem to identify a credit window and set its size. The Credit Window Association Data Item is used by a modem to identify which traffic classification identifiers (flows) should be used when sending traffic to a particular DLEP identified destination. The Credit Window Grant is used by a modem to provide additional credits to a router. The Credit Request is used by a router to request additional credits. The Credit Window Status is used to advertise the sender’s view of number of available credits for state synchronization purposes.

Any errors or inconsistencies encountered in parsing data items are handled in the same fashion as any other data dtem parsing error encountered in DLEP, see [RFC8175]. In particular, the node parsing the data item MUST terminate the session with a Status Data Item indicating Invalid Data.

The defined data items and operations have similar objectives as those found in [I-D.ietf-manet-credit-window]. One notable difference from this extension is that in this document credits are never provided by the router to the modem.

4.3.1. Credit Window Initialization

The Credit Window Initialization Data Item is used by a modem to identify a credit window and set its size. This Data Item SHOULD be included in any Session Initialization Response Message that also contains the DiffServ Aware Credit Window Extension Type Value in the Extensions Supported Data Item. Updates to previously identified credit windows or new credit windows MAY be sent by a modem by including the data item in Session Update Messages. More than one data item MAY be included in a message to provide information on multiple credit windows.

The Credit Window Initialization Data Item identifies a credit window using a Credit Window Identifier, or CID. It also provides the size of the identified credit window. Finally, a queue size (in bytes) is provided for informational purposes. Note that to be used, a CID must be associated with in a Traffic Classification Identifier via a Credit Window Association Data Item.

The format of the Credit Window Initialization Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length (16)                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Credit Window Identifier (CID)|            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Credit Value                          :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                         Credit Value                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Scale      |         Credit Window Size                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA4

Length: 16

Per [RFC8175] Length is the number of octets in the data item. It MUST be equal to sixteen (16).

Credit Window Identifier (CID):

A 16-bit unsigned integer identifying a credit window. The value of 0xFFFF is reserved and MUST not be used in this data item. There is no other restriction on values used by a modem, and there is no requirement for sequential or ordered values.

Reserved:

MUST be set to zero by the sender (a modem) and ignored by the receiver (a router).

Credit Value:

A 64-bit unsigned integer representing the credits, in octets, to be applied to the Credit Window. This value includes MAC headers as seen on the link between the modem and router.

Scale:

An 8-bit unsigned integer indicating the scale used in the Credit Window Size fields. The valid values are:

```
Value  Scale
------------
    0   B - Bytes     (Octets)
    1  KB - Kilobytes (B/1024)
    2  MB - Megabytes (KB/1024)
    3  GB - Gigabytes (MB/1024)
```

Credit Window Size:

A 24-bit unsigned integer representing the maximum size, in the octet scale indicated by the Scale field, of the associated credit window.

A router that receives a Credit Window Initialization Data Item MUST locate the credit window that is associated with the CID indicated in each received data item. If no associated credit window is found, the router MUST initialize a new credit window using the values carried in the data item. When an associated credit window is found, the router MUST update the credit window using the values carried in the Data Item. It is worth noting, that such updates can result in a credit window size being reduced, for example, due to a transmission rate change on the modem.

4.3.2. Credit Window Associate

The Credit Window Associate Data Item is used by a modem to associate traffic classification information with a destination. The traffic classification information is identified using a TID value that has previously been sent by the modem or is listed in a Traffic Classification Data Item carried in the same message as the data item.

A single Credit Window Associate Data Item MUST be included in all Destination Up and Destination Update Messages sent by a modem when the use of the extension defined in this document is agreed upon, see Section 3. Note that a TID will not be used unless it is listed in a Credit Window Associate Data Item.

The format of the Credit Window Associate Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length (2)                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Traffic Class. Identifier (TID)|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA5

Length: 2

Per [RFC8175] Length is the number of octets in the data item. It MUST be equal to two (2).

Traffic Classification Identifier (TID):

A 16-bit unsigned integer identifying a traffic classification set that has been identified in a Credit Window Traffic Classification Data Item, see Section 5.1. Unknown TID values SHOULD be reported and result in associated traffic being dropped.

A router that receives the Credit Window Associate Data Item MUST locate the traffic classification information indicated by the received TID. If no corresponding information can be located, the data item MUST be treated as an error as described above. Once the traffic classification information is located, it MUST be associated with the destination and the router MUST ensure that any data plane state, see Section 4.1, that is associated with the TID is updated as needed.

4.3.3. Credit Window Grant

The Credit Window Grant data item is used by a modem to provide credits to a router. One or more Credit Window Grant Data Items MAY be carried in the DLEP Destination Up, Destination Announce Response, Destination Update, Credit Control Messages, and Credit Control Response Messages. Multiple Credit Window Grant Data Items in a single message are used to indicate different credit values for different credit windows. In all message types, this data item provides an additional number of octets to be added to the indicated credit window. Credit window are identified via using CID values that have been previously been sent by the modem or are listed in a Credit Window Initialization Data Item carried in the same messages as the data item.

The format of the Credit Window Grant Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length (12)                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Credit Window Identifier (CID)|            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Additional Credits                        :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                     Additional Credits                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA6

Length: 12

Per [RFC8175], Length is the number of octets in the data item. It MUST be equal to twelve (12).

Credit Window Identifier (CID):

A 16-bit unsigned integer identifying a credit window that has been identified in a Credit Window Initialization Data Item, see Section 4.3.1. Unknown CID values SHOULD be reported and ignored.

Additional Credit:

A 64-bit unsigned integer representing the credits, in octets, to be added to the Credit Window. This value includes MAC headers as seen on the link between the modem and router. A value of zero indicates that no additional credits are being provided.

When receiving this data item, a router MUST identify the credit window indicated by the CID. If the CID is not known to the router, it SHOULD report or log this information and discard the Data Item. It is important to note that while this data item can be received in a destination specific message, credit windows are managed independently from the destination identified in the message carrying this Data Item, and the indicated CID MAY even be disjoint from the identified destination.

Once the credit window is identified, the credit window size MUST be increased by the value contained in the Additional Credits field. If the increase results in a window overflow, i.e., the size of the credit window after the increase is smaller than the original credit window size, the Credit Window must be set to its maximum (0xFFFFFFFFFFFFFFFF).

No response is sent by the router to a modem after processing a Credit Window Grant Data Item received in a Credit Control Response Message. In other cases, the receiving router MUST send a Credit Window Status data item or items reflecting the resulting Credit Window value of the updated credit window. When the Credit Grant data item is received in a Destination Up Message, the Credit Window Status data item(s) MUST be sent in the corresponding Destination Up Response Message. Otherwise, a Credit Control Message MUST be sent.

4.3.4. Credit Window Status

The Credit Window Status data item is used by a router to report the current credit window size to its peer modem. One or more Credit Window Status data items MAY be carried in a Destination Up Response Message or a Credit Control Response Message. As discussed above, the Destination Up Response Message is used when the data item is sent in response to a Destination Up Message, and the Credit Control Response Message is sent in response to a Credit Control Message. Multiple Credit Window Status data items in a single message are used to indicate different sizes of different credit windows. Similar to the Credit Window Grant, credit windows are identified using CID values that have been previously been sent by the modem.

The format of the Credit Window Status Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length (12)                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Credit Window Identifier (CID)|           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Credit Window Size                       :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                      Credit Window Size                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA7

Length: 12

Per [RFC8175] Length is the number of octets in the data item. It MUST be equal to twelve (12).

Credit Window Identifier (CID):

A 16-bit unsigned integer identifying a credit window that has been identified in a Credit Window Initialization Data Item, see Section 4.3.1.

Credit Window Size:

A 64-bit unsigned integer, indicating the current number of credits, in octets, available for the router to send to the modem. This is referred to as the Modem Receive Window in [I-D.ietf-manet-credit-window].

When receiving this data item, a modem MUST identify the credit window indicated by the CID. If the CID is not known to the modem, it SHOULD report or log this information and discard the data item. As with the Credit Window Grant Data Item, the CID MAY be unrelated to the Destination indicated in the message carrying the data item.

Once the credit window is identified, the modem SHOULD check the received Credit Window Size field value against the outstanding credit window’s available credits at the time the most Credit Window Initialization or Grant data item associated with the indicated CID was sent. If the values significantly differ, i.e., greater than can be accounted for based on observed data frames, then the modem SHOULD send a Credit Window Initialization Data Item to reset the associated credit window size to the modem’s current view of the available credits. As defined above, Credit Window Initialization Data Items are sent in Session Update Messages. When multiple data items need to be sent, they SHOULD be combined into a single message when possible. Alternatively, and also in cases where there are small differences, the modem MAY adjust the values sent in Credit Window Grant data items to account for the reported Credit Window.

4.3.5. Credit Window Request

The Credit Window Request Data Item is used by a router to request additional credits for particular credit windows. Credit Window Request Data Items are carried in Credit Control Messages, and one or more Credit Window Request Data Items MAY be present in a message.

Credit windows identified using a CID as defined above in Section 4.3.1. Multiple CIDs MAY be present to allow for the case where the router identifies that credits are needed in multiple credit windows. The special CID value of 0xFFFF is used to indicate that a credit request is being made across all queues.

The format of the Credit Window Request Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Credit Window Identifier (CID)|              ...              :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:              ...              | Credit Window Identifier (CID)|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA8

Length: Variable

Per [RFC8175] Length is the number of octets in the data item, excluding the Type and Length fields. It will equal the number of CID fields carried in the data item times 2 and MUST be at least 2.

Credit Window Identifier (CID):

One or more 16-bit fields used to indicate a credit window that has been identified in a Credit Window Initialization Data Item, see Section 4.3.1. The special value of 0xFFFFFFFF indicates that the request applies to all CIDs.

A modem receiving this data item MUST provide a Credit Increment for the indicated credit windows via Credit Window Grant Data Items carried in a new Credit Control Message. Multiple values and queue indexes SHOULD be combined into a single Credit Control Message when possible. Unknown CID values SHOULD be reported or logged and then ignored by the modem.

5. Traffic Classification

Traffic classification is supported by the Traffic Classification Data Item defined below. The base data item and sub data item structure is intended to be independent of any specific usage of the flow identification provided within the data item. It is designed to be extensible for future traffic classification types. While the structure of the data items is extensible, actual flow information is expected to be used in an extension dependent manner.

In the context of the DiffServ Aware Credit Window Extension, the Traffic Classification Data Item is used by a modem to identify groups of DSCPs which are to be mapped to a credit window. A DLEP destination address is also needed to complete the traffic classification information. This address is provided by a modem when it identifies the traffic classification set in a Destination Up Message using the Credit Window Associate Data Item defined above.

5.1. Traffic Classification Data Item

This sections defines the Traffic Classification Data Item. This data item is used by a modem to provide a router with traffic classification information. When an extension requires use of this data item the Traffic Classification Data Item SHOULD be included by a modem in any Session Initialization Response Message that also contains the corresponding Extension Type Value in the Extensions Supported Data Item. Updates to previously provided traffic classifications or new traffic classifications MAY be sent by a modem by including the data item in Session Update Messages. More than one data item MAY be included in a message to provide information on multiple traffic classifiers.

The set of traffic classification information provided in the data item is identified using a Traffic Classification Identifier, or TID. Addition information, e.g., the list DSCPs associated with a credit window, is provided in a variable series of Queue Parameter sub-data items.

The format of the Traffic Classification Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Traffic Class. Identifier (TID)|   Num SDIs    |   Reserved    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Traffic Classification Sub Data Item 1              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                                ...                            :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Traffic Classification Sub Data Item n              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA9

Length: Variable

Per [RFC8175] Length is the number of octets in the data item, excluding the Type and Length fields.

Traffic Classification Identifier (TID):

A 16-bit unsigned integer identifying a traffic classification set. There is no restriction on values used by a modem, and there is no requirement for sequential or ordered values.

Num SDIs:

An 8-bit unsigned integer indicating the number of Traffic Classification Sub Data Items included in the data item. A value of zero (0) is allowed and indicates that no traffic should be matched against this TID.

Reserved:

MUST be set to zero by the sender (a modem) and ignored by the receiver (a router).

Traffic Classification Sub Data Item:

Zero or more Traffic Classification Sub Data Items of the format defined below MAY be included. The number MUST match the value carried in the Num SDIs field.

A router receiving the Traffic Classification Data Item MUST locate the traffic classification information that is associated with the TID indicated in each received data item. If no associated traffic classification information is found, the router MUST initialize a new information set using the values carried in the data item. When associated traffic classification information is found, the router MUST update the information using the values carried in the Data Item. In both cases, a router MUST also ensure that any data plane state, see Section 4.1, that is associated with the TID is updated as needed.

5.1.1. Traffic Classification Sub Data Item

All Traffic Classification Sub Data Items share a common format that is patterned after the standard DLEP data item format, see [RFC8175] Section 11.3. There is no requirement on, or meaning to sub data item ordering. Any errors or inconsistencies encountered in parsing sub data items are handled in the same fashion as any other data item parsing error encountered in DLEP.

The format of the Traffic Classification Sub Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Sub Data Item Type            | Length                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Value...                            :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Sub Data Item Type:

A 16-bit unsigned integer that indicates the type and corresponding format of the data item’s Value field. Sub Data Item Types are managed according to the IANA registry described in Section 9.4.

Length: Variable

Copying [RFC8175], Length a 16-bit unsigned integer that is the number of octets in the sub data item, excluding the Type and Length fields.

5.2. DiffServ Credit Window Traffic Classification Sub Data Item

The DiffServ Credit Window Traffic Classification Sub Data Item is used to identify the DSCPs associated with a specific credit window. Credit windows are identified using CID values that have been previously been sent by the modem or are listed in a Credit Window Initialization Data Item carried in the same messages as the sub data item. DSCPs are identified in a list of DiffServ fields. An implementation that does not support DSCPs, and wants to use credit window flow control for all traffic to a destination or destinations, would indicate with 0 DSCPs.

The format of the DiffServ Credit Window Traffic Classification Sub Data Item is:

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Must be two (2)               | Length                        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Credit Window Identifier (CID)|   Num DSCPs   |   DS Field 1  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |   DS Field 2  |      ...      |   DS Field n  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Length: Variable

Length is the number of octets in the sub data item. It is equal to three (3) plus the value of the Num DSCPs field.

Credit Window Identifier (CID):

A 16-bit unsigned integer identifying a credit window that has been identified in a Credit Window Initialization Data Item, see Section 4.3.1. Unknown CID values SHOULD be reported and result in associated traffic being dropped.

Num DSCPs:

An 8-bit unsigned integer indicating the number of DSCPs carried in the sub data item. A zero (0) indicates a (wildcard) match against any DSCP value.

DS Field:

Each DS Field is an 8-bit whose definition is the same as [RFC2474].

```
      0   1   2   3   4   5   6   7
    +---+---+---+---+---+---+---+---+
    |         DSCP          |  CU   |
    +---+---+---+---+---+---+---+---+

      DSCP: differentiated services codepoint
      CU:   currently unused, MUST be zero
```

A router receiving the DiffServ Traffic Classification Sub Data Item MUST validate the information on receipt prior to the information and data plane update described earlier in this section. The credit window associated with the CID indicated in each data item must be located. It is important to note that the CID value may be present in a Credit Window Initialization Data Item carried in the same message as the sub data item. If the CID is not located, then it MUST be treated as an error as described above.

When there are no unknown CIDs, the receiver MUST ensure that each DS Field value is listed only once across the whole Traffic Classification Data Item. Note, this check is across the data item and not the individual sub data item. If the same DS Field value is listed more than once within the same Traffic Classification Data Item, the data item MUST be treated as an error as described above.

In all cases, the router MUST use validated DSCPs in data plane credit window identification as described in Section 4.1.

6. Compatibility

Sessions established with both peers identified as supporting the DiffServ Aware Credit Window Extension Type, see Section 3, MUST NOT use the [I-D.ietf-manet-credit-window] defined Credit data items. If a node supporting the extension defined in this document, receives a [I-D.ietf-manet-credit-window] defined data item, the recipient MUST ignore the received information.

7. Management Considerations

This section provides several network management guidelines to implementations supporting the DiffServ Aware Credit Window Extension.

The use of the extension defined in this document SHOULD be configurable on both modems and routers.

Modems SHOULD support the configuration of DSCP to credit window (queue) mapping.

Modems MAY support the configuration of the number of credit windows (queues) to advertise to a router.

Routers may have limits on the number of queues that they can support and, perhaps, even limits in supported credit window combinations, e.g., if per destination queues can even be supported at all. When modem-provided credit window information exceeds the capabilities of a router, the router MAY use a subset of the provided credit windows.

Alternatively, a router MAY reset the session and indicate that the extension is not supported. In either case, the mismatch of capabilities SHOULD be reported to the user via normal network management mechanisms, e.g., user interface or error logging.

8. Security Considerations

The extension introduces a DiffServ awareness to the mechanisms defined in [I-D.ietf-manet-credit-window]. The extension does not inherently introduce any additional threats above those documented in [RFC8175]. The approach taken to Security in that document and [I-D.ietf-manet-credit-window] apply equally when running the extension defined in this document.

9. IANA Considerations

This document requests the assignment of 5 values by IANA. All assignments are to registries defined by [RFC8175].

9.1. Extension Type Value

This document requests 1 new assignment to the DLEP Extensions Registry named "Extension Type Values" in the range with the "Specification Required" policy. The requested value is as follows:

Code	Description
TBA1	DiffServ Aware Credit Window

Table 1: Requested Extension Type Value

9.2. Message Values

This document requests 2 new assignments to the DLEP Message Registry named "Message Values" in the range with the "Specification Required" policy. The requested values are as follows:

Type Code	Description
TBA2	Credit Control
TBA3	Credit Control Response

Table 2: Requested Message Values

9.3. Data Item Values

This document requests the following new assignments to the DLEP Data Item Registry named "Data Item Type Values" in the range with the "Specification Required" policy. The requested values are as follows:

Type Code	Description
TBA4	Credit Window Initialization
TBA5	Credit Window Association
TBA6	Credit Window Grant
TBA7	Credit Window Status
TBA8	Credit Window Request
TBA9	Traffic Classification

Table 3: Requested Data Item Values

9.4. DLEP Sub Data Item Registry

Upon approval of this document, IANA is requested to create a new DLEP registry, named "Sub Data Item Type Values". The registry shall identify the type code value, the Data Item which may use the value, and a description of the value. While the same value may be reused in different data items, this is not recommended at this time.

The following table provides initial registry values and the [RFC8126] defined policies that should apply to the registry:

Type Code	Valid Data Items	Description
0	N/A	Reserved
1	N/A	Reserved (for pause sub-DI)
2	DiffServ Credit Window Traffic Classification	DiffServ Traffic Classification
2-65407		Specification Required
65408-65534		Private Use
65535		Reserved

Table 4: Initial Registry Values

10. References

10.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8175] Ratliff, S., Jury, S., Satterwhite, D., Taylor, R., and B. Berry, "Dynamic Link Exchange Protocol (DLEP)", RFC 8175, DOI 10.17487/RFC8175, June 2017, <https://www.rfc-editor.org/info/rfc8175>.

10.2. Informative References

[I-D.ietf-manet-credit-window] Ratliff, S., "Credit Windowing extension for DLEP", draft-ietf-manet-credit-window-07 (work in progress), November 2016.

[I-D.ietf-manet-dlep-pause-extension]
Cheng, B., Wiggins, D., and L. Berger, "DLEP Control Plane Based Pause Extension", draft-ietf-manet-dlep-pause-extension-02 (work in progress), October 2017.

[IEEE.802.1Q_2014]
IEEE, "IEEE Standard for Local and metropolitan area networks--Bridges and Bridged Networks", IEEE 802.1Q-2014, DOI 10.1109/ieeestd.2014.6991462, December 2014, <http://ieeexplore.ieee.org/servlet/opac?punumber=6991460>.

[RFC2474] Nichols, K., Blake, S., Baker, F., and D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", RFC 2474, DOI 10.17487/RFC2474, December 1998, <https://www.rfc-editor.org/info/rfc2474>.

[RFC2475] Blake, S., Black, D., Carlson, M., Davies, E., Wang, Z., and W. Weiss, "An Architecture for Differentiated Services", RFC 2475, DOI 10.17487/RFC2475, December 1998, <https://www.rfc-editor.org/info/rfc2475>.

[RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 8126, DOI 10.17487/RFC8126, June 2017, <https://www.rfc-editor.org/info/rfc8126>.

Appendix A. Acknowledgments

The sub data item format was inspired by Rick Taylor’s "Data Item Containers". He also proposed the separation of credit windows from traffic classification at IETF98. Many useful comments were received from contributors to the MANET working group.

Appendix B. Notional Support for Ethernet Priority Code Points

This document is intended to allow for use of the credit control mechanisms defined in Section 4 with different flow identification techniques. This section explores the viability of this through the notional definition of credit control with Ethernet Priority Code Points. Ethernet Priority Code Point support is defined as part of the IEEE 802.1Q [IEEE.802.1Q_2014] tag format and includes a 3 bit "PCP" field. The tag format also includes a 12 bit VLAN identifier (VID) field.

In theory only one new Traffic Classification Sub Data Item is required to enable support for the traffic classification of a new flow type. This section defines such a sub data item. This definition is not a full Extension definition, but may serve as the foundation for such in the future; in a new document.

B.1. Notional Ethernet Credit Window Traffic Classification Sub Data Item

The Ethernet Credit Window Traffic Classification Sub Data Item is used to identify the VLAN and PCPs associated with a specific credit window. Credit windows are identified using CID values that have been previously been sent by the modem or are listed in a Credit Window Initialization Data Item carried in the same messages as the sub data item. PCPs are identified in a list of priority fields. An implementation that does not support PCPs, and wants to use credit window flow control for all traffic to a destination or destinations, would indicate with 0 PCPs. Such an implementation could identify a VLAN to use per destination.

The format of the Ethernet Credit Window Traffic Classification Sub Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| TBD                           | Length (8)                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Credit Window Identifier (CID)|NumPCPs| VLAN Identifier (VID) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Pri. 1| Pri. 2| Pri. 3| Pri. 4| Pri. 5| Pri. 6| Pri. 7| Pri. 8|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Length: Variable

Length is the number of octets in the sub data item. It is equal to eight (8).

Credit Window Identifier (CID):

A 16-bit unsigned integer identifying a credit window that has been identified in a Credit Window Initialization Data Item, see Section 4.3.1. Unknown CID values SHOULD be reported and result in associated traffic being dropped.

Num PCPs:

A 4-bit unsigned integer indicating the number of PCPs carried in the sub data item. A zero (0) indicates a (wildcard) match against any PCP value.

VLAN identifier (VID):

A 12-bit unsigned integer field indicating the VLAN to be used in traffic classification. A value of all ones (0xFFF) indicates a wild card and any VID is to be accepted during traffic classification. Zero (0) and any other value are valid values.

Priority:

Each Priority Field is an 4-bit whose definition includes the PCP field defined in [IEEE.802.1Q_2014]

```
 0   1   2   3
+---+---+---+---+
|    PCP    |DEI|
+---+---+---+---+

PCP: Priority code point
DEI: currently unused, MUST be zero
```

A router receiving the Ethernet Traffic Classification Sub Data Item MUST validate the information on receipt prior to the information and data plane update described earlier in this section. The credit window associated with the CID indicated in each data item must be located. It is important to note that the CID value may be present in a Credit Window Initialization Data Item carried in the same message as the sub data item. If the CID is not located, the it MUST be treated as an error as described above.

When there are no unknown CIDs, the receiver MUST ensure that each Priority Field value is listed only once across the whole Traffic Classification Data Item. Note, this check is across the data item and not the individual sub data item. If the same Priority Field value is listed more than once within the same Traffic Classification Data Item, the data item MUST be treated as an error as described above.

In all cases, the router MUST use validated PCPs in data plane credit window identification as described in Section 4.1.

B.2. Other Considerations

A full definition for the support of an Ethernet Credit Window Extensions would need to assign a new Extension Type Value as well as the Ethernet Credit Window Traffic Classification Sub Data Item Value. It would also need to fully document the implications of multiple VLAN support, including configuration implications, e.g., limiting value to 0 to indicate PCP-only usage.

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DLEP Control Plane Based Pause Extension
draft-ietf-manet-dlep-pause-extension-03

Abstract

This document defines an extension to the DLEP protocol that enables a modem to use DLEP messages to pause and resume data traffic coming from its peer router.

Status of This Memo

Copyright Notice

Table of Contents

1. Introduction

The Dynamic Link Exchange Protocol (DLEP) is defined in [RFC8175]. It provides the exchange of link related control information between DLEP peers. DLEP peers are comprised of a modem and a router. DLEP defines a base set of mechanisms as well as support for possible extensions. This document defines one such extension.

The base DLEP specification does not include any data plane flow control capability. Various flow control methods are possible, e.g., see [I-D.ietf-manet-credit-window]. The extension defined in this document supports flow control of data traffic based on explicit messages sent via DLEP by a modem to indicate when a router should hold off sending traffic, and when it should resume. The extension also optionally supports DSCP (differentiated services codepoint) aware, see [RFC2475], flow control. The extension defined in this document is referred to as "Control Plane Based Pause". Note that this mechanism only controls traffic that is to be transmitted on the modem’s attached data channel and not to DLEP control messages themselves.

This document defines a new DLEP Extension Type Value in Section 2 which is used to indicate the use of the extension, and three new DLEP Data Items in Section 3.

1.1. Key Words

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.

2. Extension Usage and Identification

The use of the Control Plane Based Pause Extension SHOULD be configurable. To indicate that the Control Plane Based Pause Extension is to be used, an implementation MUST include the Control Plane Based Pause Extension Type Value in the Extensions Supported Data Item. The Extensions Supported Data Item is sent and processed according to [RFC8175].

The Control Plane Based Pause Extension Type Value is TBA1, see Section 5.

3. Extension Data Items

Three data items are defined by this extension. The Queue Parameters Data Item is used by a modem to provide information on the DSCPs it uses in forwarding. The Pause Data Item is used by a modem to indicate when a router should cease sending packets and the Restart Data Item is used by a modem to indicate when a router can resume sending packets.

3.1. Queue Parameters

The Queue Parameters Data Item is used by a modem to indicate DSCP values that may be independently paused. This data item MUST be included in a Session Initialization Response Message that also contains the Control Plane Based Pause Extension Type Value in the Extensions Supported Data Item. Updates to these parameters MAY be sent by a modem by including the data item in Session Update Messages.

The Queue Parameters Data Item identifies DSCPs based on groups of logical queues, each of which is referred to via a "Queue Index". The number of logical queues, or queue indexes, is variable as is the number of DSCPs associated with each queue. A queue size (in bytes) is provided for informational purposes. Queue Indexes are numbered sequentially from zero, where queue index zero is a special case covering DSCPs which are not otherwise associated with Queue Index.

An implementation that does not support DSCPs would indicate 1 queue with 0 DSCPs, and the number of bytes that may be in its associated link transmit queue. Additional logical queues are represented in a variable series of Queue Parameter sub-data items.

The format of the Queue Parameters Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Num Queues  | Scale |              Reserved                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Reserved     |              Queue Size Q0                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Queue Parameter Sub Data Item 1                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                                ...                            :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Queue Parameter Sub Data Item n                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA2

Length: Variable

Per [RFC8175] Length is the number of octets in the data item, excluding the Type and Length fields.

Num Queues:

An 8-bit unsigned integer indicating the number of queues represented in the data item. This field MUST contain a value of at least one (1), and is equal to one greater than the number of included Queue Parameter Sub Data Items.

Scale:

An 4-bit unsigned integer indicating the scale used in the Queue Size fields. The valid values are:

```
Value  Scale
------------
    0   B - Bytes     (Octets)
    1  KB - Kilobytes (B/1024)
    2  MB - Megabytes (KB/1024)
    3  GB - Gigabytes (MB/1024)
```

Reserved:

MUST be set to zero by the sender (a modem) and ignored by the receiver (a router).

Queue Size Q0:

A 24-bit unsigned integer representing the size, in the octet scale indicated by the Scale field, of queue index zero.

3.1.1. Queue Parameter Sub Data Item

Queue Parameter Sub Data Items are an ordered list composed of sub data items with a common format. The first sub data item is assigned a Queue Index value of 1, and subsequent data items are numbered incrementally. The format of the Queue Parameter Sub Data Item is patterned after the standard DLEP data item format, see [RFC8175] Section 11.3. Any errors or inconsistencies encountered in parsing Sub Data Items are handled in the same fashion as any other Data Item parsing error encountered in DLEP.

The format of the Queue Parameter Sub Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Must be one (1)               | Length                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Value...                             :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

and Value has the format:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Num DSCPs Qn  |             Queue Size Qn                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  DS Field Qn  |  DS Field Qn  |              ...              :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                         ...                   |  DS Field Qn  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Length: Variable

Copying [RFC8175], Length is the number of octets in the sub data item, excluding the Type and Length fields.

Num DSCPs Qn:

An 8-bit unsigned integer indicating the number of DSCPs associated with the queue index associated with the sub data item. This field MUST contain a value of at least one (1).

Queue Size Qn:

A 24-bit unsigned integer representing the size, in the octet scale indicated by the Scale field, of the queue supporting traffic with the DSCPs associated with the queue index.

DS Field Qn:

The data item contains a sequence of 8 bit DS Fields. The position in the sequence identifies the associated queue index. The number of DS Fields present should equal the sum of all Num DSCPs field values.

The DS Field structure is the same as [RFC2474].

```
  0   1   2   3   4   5   6   7
+---+---+---+---+---+---+---+---+
|         DSCP          |  CU   |
+---+---+---+---+---+---+---+---+

  DSCP: differentiated services codepoint
  CU:   currently unused, MUST be zero
```

3.2. Pause

The Pause Data Item is used by a modem to indicate to its peer that traffic is to be suppressed. An example of when a modem might send this data item is when an internal queue length exceeds a particular threshold.

A modem may indicate that traffic is to be suppressed on a device wide or destination specific basis. An example of when a modem might use device wide indications is when output queues are shared across all destinations, and destination specific might be used when per destination queuing is used. To indicate that suppression applies to all destinations, a modem MAY send the Pause Data Item in a Session Update Message. To indicate that suppression applies to a particular destination a modem MAY send the Pause Data Item in a Destination Update Message.

Each Pause Data Item identifies the traffic to be suppressed by the Queue Index defined by Section 3.1, which in turn indicates a set of traffic identified by DSCPs. The special value of 255 is used to indicate that all traffic is to be suppressed.

While there is no restriction on the number of Messages containing Pause Data Item that may be sent by a modem, a modem SHOULD include multiple queue indexes in the same message when possible.

A router which receives the Pause Data Item MUST cease sending the identified traffic to the modem. This may of course translate into the router’s queues exceeding their own thresholds. If a received Pause Data Item contains a Queue Index value other than 0, 255, or a queue index established by a Session Initialization or Session Update Message, the router MUST terminate the session with a Status Data Item indicating Invalid Data.

The format of the Pause Data Item is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Queue Index  |               ...                             :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                                ...            |  Queue Index  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA3

Length: Variable

Per [RFC8175] Length is the number of octets in the data item, excluding the Type and Length fields. It will equal the number of Queue Index fields carried in the data item.

Queue Index:

One or more 8-bit fields used to indicate a queue index defined by a Queue Parameters Data Item. The special value of 255 indicates all traffic is to be suppressed to the modem, when the data item is carried in a Session Update Message, or a destination, when the data item is carried in Destination Update Message.

3.3. Restart

The Restart Data Item is used by a modem to indicate to its peer that transmission of previously suppressed traffic may be resumed. An example of when a modem might send this data item is when an internal queue length drops below a particular threshold.

The sending of this data item parallels the Pause Data Item, see the previous section, and follows the same rules. This includes that to indicate that transmission can resume to all destinations, a modem MAY send the Restart Data Item in a Session Update Message. It also includes that to indicate that transmission can resume to a particular destination a modem MAY send the Pause Restart Item in a Destination Update Message. Finally, the same rules apply to queue indexes.

A router which receives the Restart Data Item SHOULD resume transmission of the identified traffic to the modem.

The format of the Restart Data Item matches the Pause Data Item and is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Data Item Type                | Length                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Queue Index  |               ...                             :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                                ...            |  Queue Index  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Data Item Type: TBA4

Length: See Section 3.2.

Queue Index: See Section 3.2.

4. Security Considerations

The extension introduces a new mechanism for flow control between a router and modem using the DLEP protocol. The extension does not inherently introduce any additional threats above those documented in [RFC8175]. The approach taken to Security in that document applies equally when running the extension defined in this document.

5. IANA Considerations

This document requests the assignment of 4 values by IANA. All assignments are to registries defined by [RFC8175].

5.1. Extension Type Value

This document requests 1 new assignment to the DLEP Extensions Registry named "Extension Type Values" in the range with the "Specification Required" policy. The requested value is as follows:

Code	Description
TBA1	Control Plane Based Pause

Table 1: Requested Extension Type Value

5.2. Data Item Values

This document requests 3 new assignments to the DLEP Data Item Registry named "Data Item Type Values" in the range with the "Specification Required" policy. The requested values are as follows:

Type Code	Description
TBA2	Queue Parameters
TBA3	Pause
TBA4	Restart

Table 2: Requested Data Item Values

6. References

6.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8175] Ratliff, S., Jury, S., Satterwhite, D., Taylor, R., and B. Berry, "Dynamic Link Exchange Protocol (DLEP)", RFC 8175, DOI 10.17487/RFC8175, June 2017, <https://www.rfc-editor.org/info/rfc8175>.

6.2. Informative References

[I-D.ietf-manet-credit-window] Ratliff, S., "Credit Windowing extension for DLEP", draft-ietf-manet-credit-window-07 (work in progress), November 2016.

[RFC2474] Nichols, K., Blake, S., Baker, F., and D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", RFC 2474, DOI 10.17487/RFC2474, December 1998, <https://www.rfc-editor.org/info/rfc2474>.

[RFC2475] Blake, S., Black, D., Carlson, M., Davies, E., Wang, Z., and W. Weiss, "An Architecture for Differentiated Services", RFC 2475, DOI 10.17487/RFC2475, December 1998, <https://www.rfc-editor.org/info/rfc2475>.

Appendix A. Acknowledgments

The sub data item format was inspired by Rick Taylor's "Data Item Containers".

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GMPLS Routing and Signaling Framework for Flexible Ethernet (FlexE)
draft-izh-ccamp-flexe-fwk-05

Abstract

This document specifies GMPLS control plane requirements, framework, and architecture for FlexE technology.

As different from earlier Ethernet data planes FlexE allows for decoupling of the Ethernet Physical layer (PHY) and Media Access Control layer (MAC) rates.

Study Group 15 (SG15) of the ITU-T has endorsed the FlexE Implementation Agreement from Optical Internetworking Forum (OIF) and included it, by reference, in some of their Recommendations.

Status of This Memo

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1. Introduction

Ethernet MAC rates were until recently constrained to match the rates of the Ethernet PHY(s). Work within the OIF allows MAC rates to be different from PHY rates. An OIF implementation agreement [OIFFLEXE1] allows for complete decoupling of the MAC and PHY rates.

SG15 in ITU-T has endorsed the OIF FlexE data plane and parts of [G.872], [G.709], [G.798] and [G.8021] depends on or are based on the FlexE data plane.

This includes support for:

a. MAC rates which are greater than the rate of a single PHY; multiple PHYs are bonded to achieve this

b. MAC rates which are less than the rate of a PHY (sub-rate)

c. support for channelization within a single PHY, or over a group of bonded PHYs.

The capabilities supported by the first version of the FlexE data plane are:

a. Support a large rate Ethernet MAC over bonded Ethernet PHYs, e.g. supporting a 200G MAC over 2 bonded 100GBASE-R PHY(s)

b. Support a sub-rate Ethernet MAC over a single Ethernet PHY, e.g. supporting a 50G MAC over a 100GBASE-R PHY

c. Support a collection of flexible Ethernet clients over a single Ethernet PHY, e.g. supporting two MACs with the rates 25G, and one with rate 50G over a single 100GBASE-R PHY

d. Support a sub-rate Ethernet MAC over bonded PHYs, e.g. supporting a 150G Ethernet client over 2 bonded 100GBASE-R PHY(s)

e. Support a collection of Ethernet MAC clients over bonded Ethernet PHYs, e.g. supporting a 50G, and 150G MAC over 2 bonded Ethernet PHY(s)

Networks which support FlexE Ethernet interfaces include a basic building block, this is true also when the interfaces are bonded. This building block consists of two FlexE Shim functions, located at opposite ends of a link, and the logical point to point links that carry the Ethernet PHY signals between the two FlexE Shim Functions.

These logical point-to-point links may be realized in a variety of ways:

a. direct point-to-point links with no intervening transport network.

b. Ethernet PHY(s) may be transparently transported via an Optical Transport Network (OTN), as defined by ITU-T in [G.709] and [G.798]. The OTN set of client mappings has been extended to support the use cases identified in the OIF FlexE implementation agreement.

This draft considers the variants in which the two peer FlexE devices are both customer-edge devices, or when one is a customer-edge and the other is provider edge devices. This list of use cases will help identify the Control Plane (i.e. Routing and Signaling) extensions that may be required.

1.1. 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. Terminology

a. CE (Customer Edge) - the group of functions that support the termination/origination of data received from or sent to the network

b. Ethernet PHY: an entity representing Physical Coding Sublayer (PCS), Physical Media Attachment (PMA), and Physical Media Dependent (PMD) layers.

c. FlexE Calendar: 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).

d. FlexE Client: An Ethernet flow based on a MAC data rate that may or may not correspond to any Ethernet PHY rate.

e. FlexE Group: A FlexE Group is composed of from 1 to n Ethernet PHYs. In the first version of FlexE each PHY is identified by a number in the range {1-254}.

f. FlexE Shim: the layer that maps or demaps the FlexE client flows carried over a FlexE Group.

g. LMP: Link Management Protocol

h. LSP: Label Switched Path

i. OTN: Optical Transport Network

j. SG15: ITU-T Study Group 15 (Transport, Access and Home).

k. TE: Traffic Engineering

l. TED: Traffic Engineering Database

3. FlexE Reference Model

The figure below gives a simplified FlexE reference model.

```
                           ....................................
                  n x PHY  .         n x crunched PHYs        .
                           .                                  .
         +----+            . +-----+    +-----+    +-----+    .   +----+
         | CE +--------------+ PE1 +----+  P  +----+ PE2 +--------+ CE |
         +----+            . +-----+    +-----+    +-----+    .   +----+
                           .                                  .
         +----+   m x PHY  .                                  .   +----+
         | CE +---------------------------------------------------+ CE |
         +----+            .                                  .   +----+
                           .         OTN Network              .
                           .                                  .
                           .....................................

         +----+   p x PHY                                         +----+
         | CE +---------------------------------------------------+ CE |
         +----+                                                   +----+
```

Figure 1: FlexE Reference Model

The services offered by Flexible Ethernet are essentially the same as for traditional Ethernet, connection less Ethernet transport. However, when the relationship between the PHY and MAC layer are setup by a GMPLS control plane there is a strong connection oriented aspect.

4. Requirements

This section summarizes the control plane requirements for FlexE Group and FlexE Client signaling and routing.

Req-1 The solution SHALL support the creation of a FlexE Group, consisting of one or more (i.e., in the 1 to 254 range) 100GE Ethernet PHY(s).

There are several alternatives that can meet this requirement, e.g. routing and signaling protocols, or a centralized controller/management system with network access to the FlexE mux/demux at each FlexE Group termination point.

Req-2 The solution 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 peer FlexE shims.

Req-3 The solution SHALL support the ability to delete a FlexE Group.

Req-4 The solution SHALL support the ability to administratively lock/unlock a FlexE Group.

Req-5 It SHALL be possible to add/remove PHY(s) to/from an operational FlexE group while the group has been administratively locked.

Req-6 The solution SHALL support the ability to advertise and discover information about FlexE capable nodes, and the FlexE Groups and FlexE Clients they support.

Req-7 The system SHALL allow the addition (or removal) of one or more FlexE clients on aFlexE Group. The addition (or removal) of a FlexE client flow SHALL NOT affect the services for the other FlexE client signals.

Req-8 The system SHALL allow the FlexE client signals to flexibly span the set of Ethernet PHY(s) which comprise the FlexE Group.

Req-9 The solution SHALL support FlexE client flow resizing without affecting any existing FlexE clients within the same FlexE Group.

Req-10 The solution SHALL support establishment of MPLS LSPs that requires the support of a FlexE infrastructure.

5. GMPLS Controlled FlexE

The high level goals for using a GMPLS control plane for FlexE can be summarized as:

- Set up a FlexE Group
- Set up a FlexE Client
- Advertise FlexE Groups and FlexE Clients
- Set up of a higher layer LSP that requires to be run over a FlexE infrastructure.

5.1. Types of LSPs in a FlexE capable network

The FlexE infrastructure may be established in three different ways

- o The FlexE Groups and FlexE Client may be pre-configured
- o Only the FlexE groups may be pre-configured, while the setup of the FlexE client is triggered by the request to setup a MPLS LSP
- o The setup of both FlexE Group and FlexE Client may be triggered by the request to setup an MPLS LSP.

5.2. Signaling Channel

In the type of equipment for which FlexE was first specified an out of band signaling channel is not commonly available. If that is the case, and the GMPLS FlexE control plane will be used, the FlexE Group will have to setup by e.g. a management system and a FlexE Client on that FlexE Group (also configured) will have to allocated as a signaling channel.

Further details of the setup of the FlexE Groups, FlexE Clients and MPLS LSPs over a FlexE infrastructure will be found in Section 7.2.

5.3. MPLS LSP in the FlexE Data Plane

FlexE is a true link layer technology, i.e. it is not switched, this means that the FlexE Groups and FlexE Clients are terminated on the next-hop node, and that the switching needs to take place on a higher layer.

The FlexE technology can be used to establish link layer connectivity with high and deterministic bandwidth. However, there is no way to, in a deterministic way, allocate certain traffic to a specific FlexE Client. A GMPLS control plane can do this.

A GMPLS controlled FlexE capable node may be thought of using the traditional model of a node with a separation between control and data plane.

```
                        +------------------+
                        |  +------------+  |
                        |  |   GMPLS    |  |
                        |  |  Control   |  |
                        |  |   Plane    |  |
                        |  +------------+  |
                        |         ^        |
                        |         |        |
                        |         v        |
                        |  +------------+  |
                        |  |   FlexE    |  |
                        |  |    Data    |  |   ^
                        |  |   Plane    |  |
                        |  +------------+  |
                        +------------------+
```

Figure 2: GMPLS controlled FlexE Node

The GMPLS control plane will speak extended standard GMPLS protocols with its neighbours and peers.

```
               Node A                  Node B                 Node Z
             +--CP
           +-|-----------+        |------------------+  ~   +---------+
           | |           |        |                  |      |         |
           | |  +------+ |        | +--------------+ |      | +-----+ |
     LSP   | +->|  v   | |        | |  ....x.....  | |      | |  ^  | |
           | |  |  .   | |        | |  .        .  | |      | |  .  | |
           | |  +--.---+ |        | +--.--------.--+ |      | +--.--+ |
    FlexE  | +->|  o   | |        | |  o  |  |  o  | |      | |  o  | |
    Client | |  |  o   | |        | |  o  |  |  o  | |      | |  o  | |
           | |  +--o---| |        | +--o--+  +--o--+ |      | +--o--| |
    FlexE  | +->|  U   | |        | |  U  |  |  U  | |      | |  U  | |
    Group  |    |  U   | |        | |  U  |  |  U  | |      | |  U  | |
           |    +--U---| |        | +--U--+  +--U--+ |      | +--U--+ |
           |-------U-----+       +----U--------U----+      +----U----+
                   U                  U        U                U
                   UUUUUUUUUUUUUUUUUUUUU        UUUUUUU ~ UUUUUUUU

                   Legend ... = LSP
                          ooo = FlexE Client
                          UUU = FlexE Group
```

Figure 3: GMPLS controlled network with FlexE infrastructure

Figure 3 describes how an MPLS LSP is mapped over a FlexE Client and FlexE Group.

5.4. Configuring the data plane in FlexE capable nodes

In Figure 3 we show an LSP, a FlexE Client and a FlexE Group, the LSP is there because while the FlexE Channel and Group are not switched, switching in our example takes place on the LSP level. This section will discuss establishment of FlexE Clients and Groups, and mapping of the LSP onto a FlexE Client.

The establishment of a LSP over a FlexE system is very similar to how this is done in any other system. Building on information gathered through the routing system and using the GMPLS signaling to establish the LSP.

5.4.1. Configure/Establish a FlexE Group/Link

Consider the setup of a FlexE Group between node A and B, corresponding to the row of U’s from node A to B in Figure 3. The FlexE group is considered to consist of n PHYs, but does not have any FlexE Clients defined from start.

When this is done by the GMPLS control plane, two conditions need to be fulfilled (1) there need to be a data channel defined between node A and B; and (2) a FlexE capable IGP-TE protocol needs to be running in the network.

Node A will send an RSVP-TE message to node be with the information describing the FlexE Group to be setup. This information might be thought of as the "FlexE Group Label" (or part of the FlexE label). It will contain at least the following information:

- o A FlexE Group Identifier (FGid).
- o The number of active FlexE Channels (numFC), where 0 indicates that zero clients are active.
- o Number of PHYs that the FlexE Group is composed of, for each PHY
  - * PHY identifier
  - * PHY bandwidth
  - * slot granularity/number of slots
  - * available and unavailable slots

When node B receives the RSVP-TE message it checks that it can setup the requested FlexE Group. If the check turns positive, node send an acknowledgment to node A and the FlexE Group is setup.

A more detailed description of how to setup a FlexE Group, will be included in the draft dealing with signaling in detail.

5.4.2. Configure/Establish a FlexE Client

Consider the situation where a FlexE Group is already established (as described in Section 5.4.1) and an m G FlexE Client is needed. Similar to the establishment of the FlexE Group, node A will send a RSV-TE message to node B.

This RSVP-TE message include at least the following information:

- o FlexE Group Identifier
- o FlexE Client Identifier
- o from which PHYs the slots will allocated, i.e. slots might come from more than one PHY.
- o Information per PHY
  - * PHY bandwidth
  - * slot granularity
  - * available/unavailable slots
  - * allocated slots

A more detailed description of how to setup a FlexE Channel, will be included in the draft dealing with signaling in detail.

5.4.3. Advertise FlexE Groups and FlexE lts

Once the FlexE Group and FlexE CLielts are configured they can be advertised into the routing system as normal routing adjacencies, including the FlexE specific TE information.

5.5. Open Issues

Note: This section is intended to be removed and the results of the discussion are supposed to brought into the relevant sections of this document.
The intention is to trigger this discussion.

While working on the FlexE Control Plane, questions around the relationship of entities as "control plane / multi-layer control plane", RSVP-TE session and the information relating to a layer network. The table below summarizxes the possibilities we see.

Control Plane	Session	Network layer info
MLCP-1	One session	Info for all network layers
MLCP-2	Sesion for each network layer	Each session have info for one network layer
MLCP-12	More than one sesion	info for each network layer included in the session
MLCP-3	One sesion	info for a single network layer

Table 1: Multi-layer CP types

Sections Section 5.5.1 to Section 5.5.4 shortly describes the different types of control plane identified.

5.5.1. Multi Layer Control Plane Typ-1 (MLCP-1)

A multi layer control plane type 1 (MLCP-1) has one single control plane that that controls all layer networks that two nodes interact over. The control plane sets up one single RSVP-TE session and all layer networks are controlled over that single session. For each layer network there is a set of information that the control plane manages over that session.

5.5.2. Multi Layer Control Plane Typ-2 (MLCP-2)

A multi layer control plane type 2 (MLCP-2) has one single control plane that that controls all layer networks that two nodes interact over. The control plane sets up one RSVP-TE session for each layer network and the layer networks are controlled over a dedicated session. For each layer network there is a set of information that the control plane manages over the dedicated session.

5.5.3. Multi Layer Control Plane Typ-12 (MLCP-12)

A multi layer control plane type 12 (MLCP-12) is a mix between MLCP-1 and MLCP-2, the control plane still controls all layer networks that two nodes interact over. However, for some layer networks it set up a RSVP-TE session the may control more than one layer network. For other layer network an RSCP-TE session is used to control a single layer network. For each layer network there is a set of information that the control plane manages over dedicated sessions.

5.5.4. Multi Layer Control Plane Typ-3 (MLCP-3)

A multi layer control plane type 3 (MLCP-3) may be viewed as a set of confederated control plsnes, where each control plane controls one layer network, via a RSVP-TE session. For each layer network there is a set of information that the control plane manages over the dedicated session. For the case that there are more than one layer network between two nodes that needs to controlled, there is one dedicated control plane for each layer network.

6. Framework and Architecture

This section discusses FlexE framework and architecture. Framework is taken to mean how FlexE interoperates with other parts of the data communication system. Architecture is taken to mean how functional groups and elements within FlexE work together to deliver the expected FlexE services. Framework is taken to mean how FlexE interacts with it environment.

6.1. FlexE Framework

The service offered by Flexible Ethernet is a transport service very similar (or even identical) to the service offered by Ethernet.

There are two major additions supported by FlexE:

- o FlexE is intended to support high bandwidth and FlexE can offer granular bandwidth from 5Gbits/s and a bandwidth as high as the FlexE Group allows.

- o As FlexE groups and clients are setup as a configuration activity, by a centralized controller or by a GMPLS control plane the service is connection oriented.

6.2. FlexE Architecture

6.2.1. Architecture Components

This section discusses the different parts of FlexE signaling and routing and how these parts interoperate.

The FlexE routing mechanism is used to provide resource available information for setup of higher layer LSPs, like Ethernet PHYs' information, partial-rate support information. Based on the resource available information advertised by routing protocol, an end-to-end

FlexE connection is computed, and then the signaling protocol is used to set up the end-to-end connection.

FlexE signaling mechanism is used to setup LSPs.

MPLS forwarding over a FlexE infrastructure is different from forwarding over other infrastructures. When MPLS runs over a FlexE infrastructure it is possible that there are more than FlexE Client that meet the next-hop requirements, often it is possible to use any suitable FlexE Clientfor a hop between two nodes. If the mapping between a MPLS encapsulated packet and the FlexE Client, this mapping need to be explicit when the LSP is set up, and the MPLS label will be used to find the correct FlexE Client.

6.2.2. FlexE Layer Model

The FLexE layer model is similar Ethernet model, the Ethernet PHY layer corresponds to the "FlexE Group", and the MAC layer corresponds to the "FlexE Client".

As different from earlier Ethernet the combination of Flexe Group and Client allows for a huge freedom when it comes to define the bandwidth of an Ethernet connectivity.

6.2.2.1. FlexE Group structure

The FlexE Group might be supported by virtually any transport network, including the Ethernet PHY. While the Ethernet PHY offers a fixed bandwidth the FlexE Group has been structured into 5 Gbit/s slots. This means that the FlexE Group can support FlexE clients of a variety of bandwidths.

The first version is defined for 20 slots of 5 Git/s over a 100 Gbit/s PHY. The 100 Gbit/s PHYs can be bonded to give higher bandwidth.

6.2.2.2. FlexE Client mapping

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 Shim is the layer that maps or demaps the FlexE client flows carried over a FlexE group. As defined in [OIFFLEXE1], MAC rates of 10, 40, and any multiple of 25 Gbit/s are supported. This means that if there is a 100 Gbit/s FlexE Group between A and B, a FlexE client of 10, 25, 40, 50, 75 and 100 Gbit/s can be created.

However, by bonding, for example 5 PHYs of 100 Git/s to a single FlexE group, FlexE clients of 500 Gbit/s can be supported.

7. Control Plane

This section discusses the procedures and extensions needed to the GMPLS Control Plane to establish FlexE LSPs.

There are several ways to establish FlexE groups, allocate slots for FlexE clients, and setup higher layer LSPs. A configuration tool, a centralized controller or the GMPLS control plane can all be used.

To create the FlexE GMPLS control plane Groups, FlexE Clients and higher layer LSPs, extensions to the following protocols may be needed:

- o "RSVP-TE: Extensions to RSVP for LSP Tunnels" (RSVP-TE) [RFC3209]
- o "Link Management Protocol" (LMP) [RFC4204]
- o "Path Computation Element (PCE) Communication Protocol" (PCEP) [RFC5440]
- o IS-IS Extensions for Traffic Engineering (ISIS-TE) [RFC5305]
- o "OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)" (OSPF-TE) [RFC4203]
- o "North-Bound Distribution of Link-State and Traffic Engineering (TE) Information Using BGP" (BGP-LS) [RFC7752]

A FlexE control plane YANG model will also be needed.

Section 7.2 and Section 7.1 discusses the role of the GMPLS control plane when primarily setting up LSPs.

When discussing the signaling and routing procedures we assume that the FlexE group has been established prior to executing the procedures needed to establish an LSP. Technically it is possible to establish FlexE group, allocate FlexE client slots and LSP with a single exchange of GMPLS signaling messages.

7.1. GMPLS Routing

To establish an LSP the Traffic Engineering (TE) information is the most critical information, e.g. resource utilization on interfaces and link, including the availability of slots on the FlexE groups. The GPMPLS routing protocols needs to be extended to handle this information. The Traffic Engineering Database (TED) will keep an updated version of this information.

The FlexE capable nodes will be identified by IP-addresses, and the routing and traffic engineering information will be flooded to all nodes within the routing domain using TCP/IP.

When an LSP over the FlexE infrastructure is about to be setup, e.g. R1 - R4 - R5 in Figure 4 the information in the TED is used verify that resources are available. When it is conformed that the LSP is established the TED is updated, marking the resources used for the new LSP as used. Similarly when a LSP is taken down the resources are marked as free.

7.2. GMPLS Signaling

As described in Section 5 the state of the FlexE infrastructure may effect the actions needed to setup an LSPin a FlexE capable network. The FlexE infrastructure maybe be:

1. fully pre-configured

2. partially pre-configured, i.e. the FlexE Group may be pre-configured, but not the FlexE Clients

3. not pre-configured, i.e. the setup of FlexE Group and FlexE Client will be triggered because of the request to setup an LSP.

Figure 4 will be used to illustrate the different cases.

```
+----+
| R1 +---------------------+
+----+                     |
                           |
+----+                  +--+--+                     +----+
| R2 +------------------+  R4 +-------------------------+ R5 |
+----+                  +--+--+                     +----+
                           |
+----+                     |
| R3 +---------------------+   PHY R1 to R4 100 Gbit(s
+----+                         PHY R2 to R4 100 Gbit(s
                               PHY R3 to R4 100 Gbit(s
                               PHY R4 to R5 200 Gbit(s
```

Figure 4: FlexE LSP Example

The text in Section 7.2 is not a specification of the GMPLS signaling extensions for FlexE capable network, it is a description to illustrate the expected features of such a protocol. Nor do we discuss failure scenarios.

7.2.1. LSP setup with pre-configured FlexE infrastructure

In this first example, referencing Figure 4, one 100 Gbit/s FlexE group is configured between R1 and R4, between R2 and R4, and between R3 and R4. Between R4 and R5 there is a 200 Gbit/s FlexE Group.

Over each 100 Gbit/s FlexE Group there are four 5 Gbit/s, two 20 Gbit/s and one 40 Gbit/s FlrxE Clients configured. Over the 200 Git/s FlexE Group there are eoght 5 Gbit/s, four 20 Gbit/s and tow 40 Gbit/s FlrxE Clients configured.

One of the 5 Gbit/s FlexE Clients on each FlexE Groups are used as signaling channel.

To establish the for example a 200 Mbit/s MPLS LSP the normal GMPLS request/response procedures are followed. R1 sends the request to R4, R4 allocate resources on one of the FlexE Ckients, forward the request to R5. R5 responds to R4 indicating the label and the FlexE Client the traffic should be sent over, R4 does the same for R1.

The only difference between the standard signaling and what happens here is that there the assigned label will be used to find the right FlexE Client.

7.2.2. LSP setup with partially configured FlexE infrastructure

In the second example, also referencing Figure 4, the FlexE Groups are set up in the same way as in the first example, however only one 5 Gbit/s FlexE Client per FlexE Group are established by configuration. This FlexE Client will be used for signaling.

When preparing to send the request that a 5 Gbit/s MPLS LSP shall be set up R1 discovers that there are no feasible FlexE Client between R1 aand R4. R1 therefore sends the request to establish such a FlexE Client, when receiving the request R4 allocates resources for the FlexE Client on the FlexE Group. There may be different strategies for allocating the bandwidth for this FlexE client. Such strategies are out of scope for this document. R1 then sends the information about the FlexE Client to R1, and both ends establish the FlexE Client.

When the FlexE Client between R1 and R4 is established, R1 proceeds to send the request for an MPLS LSP to R4. R4 will discover that a feasible FlexE Client is missing between R4 and R5. The same procedure s for setting up the FlexE Client between R1 and R4 is repeated for R4 and R5. When there is a feasible FlexE Client available the signaling to set up the MPLS LSP continues as normal.

The label allocated for the MPLS LSP will be used to find the correct FlexE Client.

When a FlexE Clients is set up in this way they can be announced into the routing system in two different ways. First, they can be made generally available, i.e. it will be free to use for anyone that want to set up LSPs over the FlexE Group between R1 and R4 and between R4 and R5. Second, the use of the FlexE Clients may be restricted to the application that initially did set up the FlexE Client.

7.2.3. LSP setup with non-configured FlexE infrastructure

This example also refers to Figure 4 as different from the earlier example no FlexE Group or FlexE Client configuration is done prior to the first request for an MPLS LSP over the FlexE infrastructure.

To make the set up of LSPs in a FlexE network where no FlexE Groups or FlexE Clients have been configured two conditions need to be fulfilled. First an out of band signaling channel must be available. Second the FlexE Capabilities must be announced in to the IGP and/or centralized controller.

If these two conditions are fulfilled, the set up of an MPLS LSP progress pretty much as in the partially configured network. The difference is that the set up of both the FlexE Group and FlexE Client are triggered by the request to set up an MPLS LSP.

As in the partially configured case FlexE Clients can be announced into the routing system in two different modes, either they are generally availble. It or they are reserved for the applications that first established them.

7.2.4. Packet Label Switching Data Plane

This section discusses how the FlexE LSP data plane works. In general it can be said that the interface offered by the FlexE Shim and the FlexE client is equivalent to the interface offered by the Ethernet MAC.

Figure 5 below illustrates the FlexE packet switching data plane procedures.

```
            R1                         R3                        R4
       .............         ......................          ...........
       . +-------+ .         . +----------------+ .          . +-----+ .
       . |  LSP  | .         . | LSP  \  / LSP  | .          . | LSP | .
       . |   a   | .         . | a    \/   b    | .          . |  b  | .
       . +-------+ .         . +----------------+ .          . +-----+ .
       . |  ETH  | .         . | ETH |    | ETH | .          . | ETH | .
       . |  i/f  | .         . | i/f |    | i/f | .          . | i/f | .
       . +-------+ .         . +-----+    +-----+ .          . +-----+ .
       . | FlexE | .         . |FlexE|    |FlexE| .          . |FlexE| .
       . | trsp  | .         . |trsp |    |trsp | .          . |trsp | .
       . +---+---+ .         . +--+--+    +--+--+ .          . +--+--+ .
       ......|......         .....^..........|.....          .....^.....
             |                    |          |                    |
             +--------------------+          +--------------------+
```

Figure 5: LSP over FlexE Data Plane

The data plane processes packets like this:

- o The LSP encapsulating and forawrding function in node R1 receives a packet that needs to be encapsulated as an MPLS packet with the label "a". The label "a" is used to figure out which FlexE emulated Ethernet interfaces the label encapsulated packet need to be forwarded over.

- o The Ethernet interfaces, by means of FlexE transport, forwards the packet to node R3. Node R3 swaps the label "a" to label "b" and uses "b" to decide over which interface to send the packet.

- o Node R3 forwards the packet to node R, which terminates the LSP.

Sending MPLS encapsulated packets over a FlexE Client is similar to send them over an Ethernet 802.1 interface. The critical differences are:

- o FlexE channelized sub-interfaces guarantee a deterministic bandwidth for an LSP.

- o When a application that originally establish a FlexE Client reserve it for use by that application only, it is possible to create uninfringeable bandwidth end-to-end for an MPLS LSP.

- o FlexE infrastructure allows for creating very large end to end bandwidth

8. Operations, Administration, and Maintenance (OAM)

To be added in a later version.

9. Acknowledgements

10. IANA Considerations

This memo includes no request to IANA.

Note to the RFC Editor: This section should be removed before publishing.

11. Security Considerations

To be added in a later version.

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13. References

13.1. Normative References

[G.709] ITU, "Optical Transport Network Interfaces (http://www.itu.int/rec/T-REC-G.709-201606-P/en)", July 2016.

[G.798] ITU, "Characteristics of optical transport network hierarchy equipment functional blocks (http://www.itu.int/rec/T-REC-G.798-201212-I/en)", February 2014.

[G.8021] ITU, "Characteristics of Ethernet transport network equipment functional blocks", November 2016.

[G.872] ITU, "Architecture of optical transport networks", January 2017.

[OIFFLEXE1] OIF, "FLex Ethernet Implementation Agreement Version 1.0 (OIF-FLEXE-01.0)", March 2016.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

13.2. Informative References

[RFC3209] Awduche, D., Berger, L., Gan, D., Li, T., Srinivasan, V., and G. Swallow, "RSVP-TE: Extensions to RSVP for LSP Tunnels", RFC 3209, DOI 10.17487/RFC3209, December 2001, <https://www.rfc-editor.org/info/rfc3209>.

[RFC4203] Kompella, K., Ed. and Y. Rekhter, Ed., "OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4203, DOI 10.17487/RFC4203, October 2005, <https://www.rfc-editor.org/info/rfc4203>.

[RFC4204] Lang, J., Ed., "Link Management Protocol (LMP)", RFC 4204, DOI 10.17487/RFC4204, October 2005, <https://www.rfc-editor.org/info/rfc4204>.

[RFC5305] Li, T. and H. Smit, "IS-IS Extensions for Traffic Engineering", RFC 5305, DOI 10.17487/RFC5305, October 2008, <https://www.rfc-editor.org/info/rfc5305>.

[RFC5440] Vasseur, JP., Ed. and JL. Le Roux, Ed., "Path Computation Element (PCE) Communication Protocol (PCEP)", RFC 5440, DOI 10.17487/RFC5440, March 2009, <https://www.rfc-editor.org/info/rfc5440>.

[RFC7752] Gredler, H., Ed., Medved, J., Previdi, S., Farrel, A., and S. Ray, "North-Bound Distribution of Link-State and Traffic Engineering (TE) Information Using BGP", RFC 7752, DOI 10.17487/RFC7752, March 2016, <https://www.rfc-editor.org/info/rfc7752>.

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GMPLS Routing and Signaling Framework for B100G
draft-merge-ccamp-otn-b100g-fwk-03

Abstract

This document provides a framework to describe how to use current existing GMPLS routing and signaling to set up ODUk/ODUflex over ODUCn link, as a result of the support of OTU/ODU links with rates larger than 100G in the 2016 version of G.709.

Status of This Memo

Copyright Notice

Table of Contents

1. Introduction

The current GMPLS routing [RFC7138] and signaling extensions [RFC7139] includes coverage for all the OTN capabilities that were defined in the 2012 version of G.709 [ITU-T_G709_2012].

The 2016 version of G.709 [ITU-T_G709_2016] introduces support for higher rate OTU signals, termed OTUCn (which have a nominal rate of n x 100 Gbps). How to set up ODUk/ODUflex over ODUCn link is still an unresolved issue, which is not covered in any draft in IETF. This document presents an overview of the changes introduced in

[ITU-T_G709_2016] that bring impact to this topic and analyzes them to identify the extensions that would be required in GMPLS routing and signaling to enable the setup of ODUk/ODUflex over ODUCn.

1.1. Scope

For the purposes of the B100G control plane discussion, the OTN should be considered as a combination of ODU and OTSi layers. Note that [ITU-T_G709_2016] is deprecating the use of the term "OCh" for B100G entities, and leaving it intact only for maintaining continuity in the description of the signals with bandwidth upto 100G. This document focuses on only the control of the ODU layer. The control of the OTSi layer is out of scope of this document. But in order to facilitate the description of the challenges brought by [ITU-T_G709_2016] to B100G GMPLS routing and signalling, some general description about OTSi will be discussed in this draft.

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].

2.2. OTN terminology used in this document

a. OPUCn: Optical Payload Unit -Cn.

b. ODUCn: Optical Data Unit - Cn.

c. OTUCn: Fully standardized Optical Transport Unit - Cn.

d. OTUCn-M: This signal is an extension of the OTUCn signal introduced above. This signal contains the same amount of overhead as the OTUCn signal, but contains a reduced amount of payload area. Specifically the payload area consists of M 5G tributary slots (where M is strictly less than 20*n).

e. PSI: OPU Payload structure Indicator. This is a multi-frame message and describes the composition of the OPU signal. This field is a concatenation of the Payload type (PT) and the Multiplex Structrure Indicator (MSI) defined below.

f. MSI: Multiplex Structure Indicator. This structure indicates the grouping of the tributary slots in an OPU payload area to realize a client signal that is multiplexed into an OPU. The individual clients multiplexed into the OPU payload area are distinguished by the Tributary Port number (TPN).

g. GMP: Generic Mapping Procedure.

h. OTSiG: see [ITU-T_G872]

i. OTSiA: see [ITU-T_G872]

Detailed description of these terms can be found in [ITU-T_G709_2016].

3. Overview of B100G in G.709

This section provides an overview of new features in [ITU-T_G709_2016].

3.1. OTUCn

In order to carry client signals with rates greater than 100Gbps, [ITU-T_G709_2016] takes a general and scalable approach that decouples the rates of OTU signals from the client rate evolution. The new OTU signal is called OTUCn; this signal is defined to have a rate of (approximately) n*100G. The following are the key characteristics of the OTUCn signal:

a. The OTUCn signal contains one ODUCn. The OTUCn and ODUCn signals perform digital section roles only (see [ITU-T_G709_2016]:Section 6.1.1)

b. The OTUCn signals can be viewed as being formed by interleaving n OTUC signals (where are labeled 1, 2, ..., n), each of which has the format of a standard OTUk signal without the FEC columns (per [ITU-T_G709_2016]Figure 7-1). The ODUCn have a similar structure, i.e. they can be seen as being formed by interleaving n instances of ODUC signals (respectively). The OTUC signal contains the ODUC signals, just as in the case of fixed rate OTUs defined in G.709 [ITU-T_G709_2016].

c. Each of the OTUC "slices" have the same overhead (OH) as the standard OTUk signal in G.709 [ITU-T_G709_2016]. The combined signal OTUCn has n instances of OTUC OH, ODUC OH.

d. The OTUC signal has a slightly higher rate compared to the OTU4 signal (without FEC); this is to ensure that the OPUC payload area can carry an ODU4 signal.

3.1.1. Carrying OTUCn between 3R points

As explained above, within G.709 [ITU-T_G709_2016], the OTUCn, ODUCn and OPUCn signal structures are presented in a (physical) interface independent manner, by means of n OTUC, ODUC and OPUC instances that are marked #1 to #n. Specifically, the definition of the OTUCn signal does not cover aspects such as FEC, modulation formats, etc. These details are defined as part of the adaptation of the OTUCn layer to the optical layer(s). The specific interleaving of OTUC/ODUC/OPUC signals onto the optical signals is interface specific and specified for OTN interfaces with standardized application codes in the interface specific recommendations (G.709.x).

The following scenarios of OTUCn transport need to be considered (see Figure 1):

a. inter-domain interfaces: These types of interfaces are used for connecting OTN edge nodes to (a) client equipment (e.g. routers) or (b) hand-off points from other OTN networks. ITU-T has standardized the Flexible OTN (FlexO) interfaces to support these functions. Recommendation [ITU-T_G709.1] specifies a flexible interoperable short-reach OTN interface over which an OTUCn (n >=1) is transferred, using bonded FlexO interfaces which belong to a FlexO group. The FlexO group supports physical interface bonding, management of the group members, overhead for communication between FlexO peers etc. (these overheads are separate from the GCC0 channel defined over OTUCn). In its current form, Recommendation [ITU-T_G709.1] is limited to the case of transporting OTUCn signals using n 100G Ethernet PHY(s). The mechanisms for transporting the OTUCn signals over 100G optical interfaces are specified in [ITU-T_G709.1] and are not repeated here. When the PHY(s) for the emerging set of Ethernet signals, e.g. 200GbE and 400GbE, become available, new recommendations can define the required adaptations.

b. intra-domain interfaces: In these cases, the OTUCn is transported using a proprietary (vendor specific) encapsulation, FEC etc. In future, it may be possible to transport OTUCn for intra-domain links using future variants of FlexO.

```
=================================================================

      +---------------------------------------------------------+
      |                 OTUCn signal                            |
      +---------------------------------------------------------+
      |  Inter+Domain     |  Intra+Domain     |  Intra+Domain   |
      |  Interface (IrDI)|  Interface (IaDI)|  Interface       |
      |  FlexO (G.709.1) |  FlexO (G.709.x) |  Proprietary     |
      |                  |  (Future)        |  Encap, FEC etc. |
      +---------------------------------------------------------+

=================================================================
```

Figure 1: OTUCn transport possibilities

3.2. ODUCn

The ODUCn signal [ITU-T_G709_2016] can be viewed as being formed by the appropriate interleaving of content from n ODUC signal instances. The ODUC frames have the same structure as a standard ODU -- in the sense that it has the same Overhead (OH) area, and the payload area -- but has a higher rate since its payload area can embed an ODU4 signal.

The ODUCn signals have a rate that is captured in Table 1.

ODU Type	ODU Bit Rate
ODUCn	n x 239/226 x 99,532,800 kbit/s = n x 105,258,138.053 kbit/s

Table 1: ODUCn rates

The ODUCn is a multiplex section ODU signal, and is mapped into an OTUCn signal which provides the regenerator section layer. In some scenarios, the ODUCn, and OTUCn signals will be co-terminous, i.e. they will have identical source/sink locations. [ITU-T_G709_2016] and [ITU-T_G872] allow for the ODUCn signal to pass through a digital regenerator node which will terminate the OTUCn layer, but will pass the regenerated (but otherwise untouched) ODUCn towards a different OTUCn interface where a fresh OTUCn layer will be initiated (see Figure 2). In this case, the ODUCn is carried by 3 OTUCn segments.

Specifically, the OPUCn signal flows through these regenerators unchanged. That is, the set of client signals, their TPNs, trib-slot allocation remains unchanged. Note however that the ODUCn Overhead (OH) might be modified if TCM sub-layers are instantiated in order to monitor the performance of the repeater hops. In this sense, the ODUCn should not be seen as a general ODU which can be switched via an ODUk cross-connect.

```
   ==================================================================

+--------+           +--------+                +--------+           +--------+
|        +-----------+        |                |        +----------+        |
| OTN    |-----------| OTN    |                | OTN    |----------| OTN    |
| DXC    +-----------+ WXC    +----------------+ WXC    +----------+ DXC    |
|        |           | 3R     |                | 3R     |          |        |
+--------+           +--------+                +--------+          +--------+
    <--------------------------------ODUCn------------------------------>
     <------------------>  <---------------------> <------------------>
             OTUCn                    OTUCn                  OTUCn

   ==================================================================
```

Figure 2: ODUCn signal

3.3. OTUCn-M

The standard OTUCn signal has the same rate as that of the ODUCn signal as captured in Table 1. This implies that the OTUCn signal can only be transported over wavelength groups which have a total capacity of multiples of (approximately) 100G. Modern DSPs support a variety of bit rates per wavelength, depending on the reach requirements for the optical link. With this in mind, ITU-T supports the notion of a reduced rate OTUCn signal, termed the OTUCn-M. The OTUCn-M signal is derived from the OTUCn signal by retaining all the n instances of overhead (one per OTUC slice) but only M tributary slots of capacity.

3.4. Time Slot Granularity

[ITU-T_G709_2012] introduced the support for 1.25G granular tributary slots in OPU2, OPU3, and OPU4 signals. With the introduction of higher rate signals, it is no longer practical for the optical networks (and the datapath hardware) to support a very large number of flows at such a fine granularity. ITU-T has defined the OPUC with a tributary slot granularity of 5G. This means that the ODUCn signal has 20*n tributary slots (of 5Gbps capacity).

3.5. Structure of OPUCn MSI with Payload type 0x22

As mentioned above, the OPUCn signal has 20*n 5G tributary slots. The OPUCn contains n PSI structures, one per OPUC instance. The PSI structure consists of the Payload Type (of 0x22), followed by a Reserved Field (1 byte), followed by the MSI. The OPUCn MSI field has a fixed length of 40*n bytes and indicates the availability of each TS. Two bytes are used for each of the 20*n tributary slots, and each such information structure has the following format ([ITU-T_G709_2016] G.709:Section 20.4.1):

a. The TS availability bit 1 indicates if the tributary slot is available or unavailable

b. The TS occupation bit 9 indicates if the tributary slot is allocated or unallocated

c. b.c. The tributary port # in bits 2 to 8 and 10 to 16 indicates the port number of a specific TS that is allocated to the client; a flexible assignment of tributary port to tributary slots is possible. Numbering of tributary ports are is from 1 to 10n.

3.6. Client Signal Mappings

The approach taken by the ITU-T to map non-OTN client signals to the appropriate ODU containers is as follows:

a. All client signals with rates less than 100G are mapped as specified in [ITU-T_G709_2016]:Clause 17. These mappings are identical to those specified in the earlier revision of G.709 [ITU-T_G709_2012]. Thus, for example, the 1000BASE-X/10GBASE-R signals are mapped to ODU0/ODU2e respectively (see Table 2 -- based on Table 7-2 in [ITU-T_G709_2016])

b. Always map the new and emerging client signals to ODUflex signals of the appropriate rates (see Table 2 -- based on Table 7-2 in [ITU-T_G709_2016])

c. Drop support for ODU Virtual Concatenation. This simplifies the network, and the supporting hardware since multiple different mappings for the same client are no longer necessary. Note that legacy implementations that transported sub-100G clients using ODU VCAT shall continue to be supported.

d. ODUflex signals are low-order signals only. If the ODUflex entities have rates of 100G or less, they can be transported using either an ODUk (k=1..4) or an ODUCn server layer. On the other hand, ODUflex connections with rates greater than 100G will require the server layer to be ODUCn. The ODUCn signals must be adapted to an OTUCn signal. Figure 3 illstrates the hierarchy of the digital signals defined in [ITU-T_G709_2016].

ODU Type	ODU Bit Rate
ODU0	1,244,160 Kbps
ODU1	239/238 x 2,488,320 Kbps
ODU2	239/237 x 9,953,280 Kbps
ODU2e	239/237 x 10,312,500 Kbps
ODU3	239/236 x 39,813,120 Kbps
ODU4	239/227 x 99,532,800 Kbps
ODUflex for CBR client signals	239/238 x Client signal Bit rate
ODUflex for GFP-F mapped packet traffic	Configured bit rate
ODUflex for IMP mapped packet traffic	s x 239/238 x 5 156 250 kbit/s: s=2,8,5*n, n >= 1
ODUflex for FlexE aware transport	103 125 000 x 240/238 x n/20 kbit/s, where n is total number of available tributary slots among all PHYs which have been crunched and combined.

Note that this table doesn't include ODUCn -- since it cannot be generated by mapping a non-OTN signal. An ODUCn is always formed by multiplexing multiple LO-ODUs.

Table 2: Types and rates of ODUs usable for client mappings

```
    ==================================================================

                    Clients (e.g. SONET/SDH, Ethernet)
                         +       +      +
                         |       |      |
      +------------------+-------+------+-----------------------+
      |                    OPUk                                 |
      +---------------------------------------------------------+
      |                    ODUk                                 |
      +-----------------------+---------------------------+-------+
      | OTUk, OTUk.V, OTUkV   |          OPUk             |       |
      +----------+----------------------------------------+       |
      | OTLk.n   |            |          ODUk             |       |
      +----------+            +---------------------+-----+       |
                              | OTUk, OTUk.V, OTUkV |   OPUCn     |
                              +----------+----------------------+
                              | OTLk.n   |          |   ODUCn     |
                              +----------+          +------------+
                                                    |   OTUCn    |
                                                    +------------+

    ==================================================================
```

Figure 3: Digital Structure of OTN interfaces (from G.709:Figure 6-1)

4. Applications and GMPLS Implications

4.1. Applications and Challenges

Two typical scenarios are depicted in Appendix XIII of [ITU-T_G709_2016], which are also introduced into this document to help analyze the potential extension to GMPLS needed. Though these two scenarios are mainly introduced in G.709 to describe OTUCn sub rates application, they can also be used to describe general OTUCn application. One thing that should be note is these two scenarios are a little different from those described in [ITU-T_G709_2016], as the figure in this section include the OTSi(G) in to facilitate the description of the challenge brought by [ITU-T_G709_2016].

The first scenarios is depicted in Figure 4. This scenario deploys OTUCn/OTUCn-M between two line ports connecting two L1/L0 ODU cross connects (XC) within one optical transport network. One OTUCn is actually carried by one OTSi(G) or OTSiA.

As defined in [ITU-T_G872], OTSiG is used to represent one or more OTSi as a group to carry a single client signal (e.g., OTUCn). The

OTSiG may have non-associated overhead, the combination of the OTSiG and OTSiG-O is represented by the OTSiA management/control abstraction.

In this scenario, it is clear that the OTUCn and ODUCn link can be automatically established, after/together with the setup of OTSi(G) or OTSiA, as both OTUCn and ODUCn perform section layer only. One client OTUCn signal is carried by one single huge OTSi signal or a group of OTSi. There is a 1:1 mapping relationship between OTUCn and OTSi(G) or OTSiA.

For example, one 400G OTUCn signal can be carried by one single 400G OTSi signal or one 400G OTUCn signal can be split into 4 different OTUC instances, with each instances carried by one OTSi. Those four OTSi function as a group to carry a single 400G OTUCn signal.

```
==================================================================


              +--------+                     +--------+
              |        +---------------------+        |
              | OTN    |---------------------| OTN    |
              |  XC    +---------------------+  XC    |
              |        |                     |        |
              +--------+                     +--------+
                <---------- ODUk/ODUflex ----------->
                 <------------ ODUCn -------------->
                  <------- OTUCn/OTUCn-M --------->
                   <--------OTSi(G)/OTSiA--------->


==================================================================
```

Figure 4: Scenario A

The second scenarios is depicted in Figure 4. This scenario deploys OTUCn/OTUCn-M between transponders which are in a different domain B, which are separated from the L1 ODU XCs in domain A and/or C. one end-to-end ODUCn is actually supported by three different OTUCn or OTUCn-M segments, which are in turn carried by OTSi(G) or OTSiA.

In the second scenario, OTUCn links will be established automatically after/together with the setup of OTSi(G) or OTSiA, while there are still some doubts about how the ODUCn link is established. In principle, it could/should be possible but it is not yet clear in details how the ODUCn link can be automatically setup.

```
   ==================================================================


                    +--------------------------------------+
     A              |                B                     |          A or C
     |              |                                      |             |
+--------+          | +--------+                +--------+ |        +--------+
|        +----------|-+        |                |        +-|--------+        |
| OTN    |----------|-| Transp |                | Transp |-|--------| OTN    |
|  XC    +----------|-+ onder  +----------------+ onder  +-|--------+  XC    |
|        |          | |        |                |        | |        |        |
+--------+          | +--------+                +--------+ |        +--------+
                    |                                      |
                    +--------------------------------------+

     <-----------------------------ODUk/ODUflex---------------------------->
      <----------------------------- ODUCn ------------------------------->
       <-------OTUCn-------><-----OTUCn/OTUCn-M-----><-------OTUCn------->
        <--OTSi(G)/OTSiA-->  <----OTSi(G)/OTSiA---->  <--OTSi(G)/OTSiA-->


   ==================================================================
```

Figure 5: Scenario B

According to the above description, it can be concluded that some uncertainty about setup of ODUCn link still exist, and this uncertainty may have relationship with the progress in ITU-T. Based on the analysis, it is suggested that the scope of this draft should mainly focus on how to set up ODUk/ODUflex LSPs over ODUCn links, as also indicated in the figure above.

4.2. GMPLS Implications and Applicability

4.2.1. Implications and Applicability for GMPLS Signalling

Once the ODUCn link is configured, the GMPLS mechanisms defined in RFC7139 can be reused to set up ODUk/ODUflex LSP with no/few changes. As the resource on the ODUCn link which can be seen by the client ODUk/ODUflex is a serial of 5G slots, the label defined in RFC7139 is able to accommodate the requirement of the setup of ODUk/ODUflex over ODUCn link.

One thing should be note is the TPN used in RFC7139 and defined in G.709-2016 for ODUCn link. Since the TPN currently defined in G.709 for ODUCn link has 14 bits, while this field in RFC7139 only has 12 bits, some extension work is needed, but this is not so urgent since for today networks scenarios 12 bits are enough, as it can support a single ODUCn link up to n=400, namely 40Tbit.

An example is given below to illustrate the label format defined in RFC7139 for multiplexing ODU4 onto ODUC10. One ODUC10 has 200 5G slots, and twenty of them are allocated to the ODU4. Along with the increase of "n", the label may become lengthy, an optimized label format may be needed.

```
==================================================================


  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |       TPN = 3         |   Reserved    |     Length = 200      |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |0 0 0 0 0 0 0 0|              Padding Bits(0)                  |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+


==================================================================
```

Figure 6: Label format

4.2.2. Implications and Applicability for GMPLS Routing

For routing, we think that no extension to current mechanisms defined in RFC7138 are needed. Because, once one ODUCn link is up, we need to advertise only the resources that can be used on this ODUCn link and the multiplexing hierarchy on this link. Considering ODUCn link is already configured, it’s the ultimate hierarchy of this multiplexing, there is no need to explicitly extent the ODUCn signal type in the routing.

The OSPF-TE extension defined in section 4 of RFC7138 can be used to advertise the resource information on the ODUCn link to direct the setup of ODUk/ODUflex.

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8. IANA Considerations

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9. Security Considerations

None.

10. References

10.1. Normative References

[ITU-T_G709.1]
ITU-T, "ITU-T G.709.1: Flexible OTN short-reach interface; 2016", , 2016.

[ITU-T_G709_2012]
ITU-T, "ITU-T G.709: Optical Transport Network Interfaces; 02/2012", http://www.itu.int/rec/T-REC-G..709-201202-S/en, February 2012.

[ITU-T_G709_2016]
ITU-T, "ITU-T G.709: Optical Transport Network Interfaces; 07/2016", http://www.itu.int/rec/T-REC-G..709-201606-P/en, July 2016.

[ITU-T_G872]
ITU-T, "ITU-T G.872: The Architecture of Optical Transport Networks; 2017", http://www.itu.int/rec/T-REC-G.872/en, January 2017.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC4328] Papadimitriou, D., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Extensions for G.709 Optical Transport Networks Control", RFC 4328, DOI 10.17487/RFC4328, January 2006, <https://www.rfc-editor.org/info/rfc4328>.

[RFC7138] Ceccarelli, D., Ed., Zhang, F., Belotti, S., Rao, R., and J. Drake, "Traffic Engineering Extensions to OSPF for GMPLS Control of Evolving G.709 Optical Transport Networks", RFC 7138, DOI 10.17487/RFC7138, March 2014, <https://www.rfc-editor.org/info/rfc7138>.

[RFC7139] Zhang, F., Ed., Zhang, G., Belotti, S., Ceccarelli, D., and K. Pithewan, "GMPLS Signaling Extensions for Control of Evolving G.709 Optical Transport Networks", RFC 7139, DOI 10.17487/RFC7139, March 2014, <https://www.rfc-editor.org/info/rfc7139>.

10.2. Informative References

[I-D.izh-ccamp-flexe-fwk] Hussain, I., Valiveti, R., Pithewan, K., Wang, Q., Andersson, L., Zhang, F., Chen, M., Dong, J., Du, Z., zhenghaomian@huawei.com, z., Zhang, X., Huang, J., and Q. Zhong, "GMPLS Routing and Signaling Framework for Flexible Ethernet (FlexE)", draft-izh-ccamp-flexe-fwk-00 (work in progress), October 2016.

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Finite state machine YANG model augmentation for Transponder Reconfiguration
draft-sambo-ccamp-yang-fsm-transponder-reconf-00

Abstract

YANG enables to compile a set of consistent vendor-neutral data models for optical networks and components based on actual operational needs emerging from heterogeneous use cases. A YANG model has been also proposed to describe finite state machine to program network elements that are modeled with YANG. This document augments the more generic YANG model for finite state machine [I-D.sambo-netmod-yang-fsm], in order to pre-instruct an optical transponder on the actions to be performed (e.g., code adaptation) in case some events, such as physical layer degradations, occur.

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Table of Contents

1. Introduction

Networks are evolving toward more programmability, flexibility, and multi-vendor interoperability. Multi-vendor interoperability can be applied in the context of nodes, i.e. a node composed of components provided by different vendors (named fully disaggregated white box) is assembled under the same control system. This way, operators can optimize costs and network performance without the need of being tied to single vendor equipment. NETCONF protocol RFC6241 [RFC6241] based on YANG data modeling language RFC6020 [RFC6020] is emerging as a candidate Software Defined Networking (SDN) enabled protocol. First, NETCONF supports both control and management functionalities, thus permits high programmability. Then, YANG enables data modeling in a vendor-neutral way. Some recent works have provided YANG models to describe attributes of links (e.g., identification), nodes (e.g., connectivity matrix), media channels, and transponders (e.g., supported forward error correction - FEC) of networks

([I-D.ietf-i2rs-yang-network-topo] [I-D.vergara-ccamp-flexigrid-yang] [I-D.zhang-ccamp-l1-topo-yang]), also including optical technologies. A YANG model [I-D.sambo-netmod-yang-fsm] has been also proposed to describe finite state machines (FSMs) in order to program actions based on conditions and events in YANG-described devices. Such draft mainly refers to elastic optical networks (EONs), i.e. optical networks based on flexible grid where circuits with different bandwidth requirements are switched. EONs are expected to employ flexible transponders, i.e. transponders supporting multiple bit rates, multiple modulation formats, and multiple codes. Such transponders permits the (re-) configuration of the bit rate value based on traffic requirements, as well as the configuration of the modulation format and code based on the physical characteristics of a path (e.g., quadrature phase shift keying is more robust than 16 quadrature amplitude modulation). This document augments the YANG model for FSM [I-D.sambo-netmod-yang-fsm] to be applied in programming reconfiguration of transponders in EONs based on physical layer conditions. In particular, the model enables a centralized remote network controller (managed by a network operator) to instruct a transponder controller about the actions to perform when certain events (e.g., failures) occur. The actions to be taken and the events can be re-programmed on the device.

2. Conventions used in this document

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 [RFC2119].

3. Terminology

ABNO: Application-Based Network Operations

BER: Bit Error Rate

EON: Elastic Optical Network

FEC: Forward Error Correction

FSM: Finite State Machine

NETCONF: Network Configuration Protocol

OAM: Operation Administration and Maintenance

SDN: Software Defined Network

YANG: Yet Another Network Generator

4. Flexible Transponders

Flexible transponders enable several parameters’ configurations, through the support of multiple modulation formats, baud rate, and forward error correction (FEC) schemes. This way, transmission parameters can be (re-)configured based on the physical layer conditions. The YANG model presented in this draft enables to pre-program reconfiguration settings of data plane devices in case of changes in the physical layer conditions. In particular, soft failures can be assumed. Soft failures imply transmission performance degradation, in turns a bit error rate (BER) increase, e.g. due to the ageing of some network devices. Without loosing generality, the ABNO architecture is assumed for the control and management of EONs (RFC7491 [RFC7491]). Considering the state of the art, when pre-FEC BER passes above a predefined threshold, it is expected that an alarm is sent to the OAM Handler, which communicates with the ABNO controller that may trigger an SDN controller (that could be the Provisioning Manager of ABNO RFC7491 [RFC7491]) for computing new transmission parameters. The involved ABNO modules are shown in the simplified ABNO architecture of Fig. 1. Then, transponders are reconfigured. When alarms related to several connections impacted by the soft failure are generated, this procedure may be particularly time consuming. The related workflow for transponder reconfiguration is shown in Fig. 2. The proposed model enables an SDN controller to instruct the transponder about reconfiguration of new transmission parameters values if a soft failure occurs. This can be done before the failure occurs (e.g., during the connection instantiation phase or during the connection service), so that data plane devices can promptly reconfigure themselves without querying the SDN controller to trigger an on-demand recovery. This is expected to speed up the recovery process from soft failures. The related flow chart is shown in Fig. 3.

```
          ___________            ___________
         |  ABNO     |          |   OAM     |
         |controller |  ------  |  Handler  |
         |___________|          |___________|

           |                         |
           |                         |
           |                         |
        ____________                 |
       |    SDN     |                |
       | controller |                |
       |____________|                |
                                     |
            |                        |
            |                        |
            |                        |
          _____________________________
         |            Client           |
         |            network          |
         |_____________________________|
```

Figure 1: Assumed ABNO functional modules

```
              _____________________
             |         1           |
             |Sending alarm to the |
             |        OAM Handler  |
             |                     |
             |_____________________|
                       |
                       |
                       |
             _____________________
            |         2           |
            |      Trigger        |
            |  SDN Controller     |
            |                     |
            |_____________________|
                       |
                       |
                       |
             _____________________
            |         3           |
            |   Computation of    |
            |  new transmission   |
            |    parameters       |
            |_____________________|
                      |
                      |
                      |
             _____________________
            |        4            |
            |    Data plane       |
            |    reconfiguration  |
            |                     |
            |_____________________|
```

Figure 2: Flow chart of the expected state-of-the-art approach

```
             ________________________
            |           1            |
            | Instructing the local  |
            |   controller of        |
            |  data plane devices    |
            |________________________|
                        |
                        |
                        |
             ________________________
            |           2            |
            | Local reconfiguration  |
            |     upon failure       |
            |       detection        |
            |________________________|
                        |
                        |
                        |
             ________________________
            |           3            |
            |                        |
            |     notification       |
            |                        |
            |________________________|
```

Figure 3: Flow chart of the approach exploiting YANG models in this draft

5. Augmenting the FSM YANG model for transponder reconfiguration

This section augments the FSM YANG model presented in [I-D.sambo-netmod-yang-fsm] to address the specific use case of transponder reconfiguration triggered by physical layer changes. The FSM model is based on the following main attributes: states, transitions (corresponding to some specific event), and actions. In particular, more specifically with respect to [I-D.sambo-netmod-yang-fsm], in such a use case, a state corresponds to a specific configuration of transponder transmission parameters: e.g., given by the modulation format and the FEC. A transition is triggered when the pre-FEC BER (or another parameter such as the OSNR) is below or above a threshold. To this purpose, with respect to [I-D.sambo-netmod-yang-fsm], the attribute <filter> is expressed by the definition of thresholds and operators. The action mainly consists of the change of modulation format and/or FEC.

The Tree of the YANG model for transponder reconfiguration (augmentation of the YANG model for FSM) is reported below.

```
module: ietf-treconf
   +--rw current-state?   leafref
   +--rw states
      +--rw state [id]
         +--rw id             state-id-type
         +--rw description?   string
         +--rw transitions
            +--rw transition [name]
               +--rw name                   string
               +--rw description?           string
               +--rw threshold-parameter?   decimal64
               +--rw threshold-operator?    string
               +--rw transition-action
                  +--rw action [id]
                     +--rw id        transition-id-type
                     +--rw type      enumeration
                     +--rw simple
                        +--rw execute
                        +--rw next-action?   transition-id-type
                        +--rw next-state?    Leafref
```

More specifically, the attribute <state> is a list defining all the transponder states. <transitions> is an attribute defining a list of events that may trigger the change of transponder state (e.g., BER change). <threshold-parameter> defines a threshold value, while <threshold-operator> defines the operator <,>,<=,>=. Thus, if the event BER>TH has to be modeled, the attribute <threshold-parameter> has to be set to "TH" while <threshold-operator> to ">". <actions> defines a list of actions to take during the transition (e.g. change of modulation format) <next-state> defines the next transponder state when an action is executed (e.g., new modulation format and FEC).

For more details about the other model attributes, the reader can refer to [I-D.sambo-netmod-yang-fsm].

In such a use case, we assume that an event (e.g., BER>TH) is revealed by the digital signal processing (DSP) of the receiver. Once the event is recognized, the modulation format and/or the FEC have to be changed, both at the receiver and the transmitter. Thus, the list of actions to be executed includes the change of transmission parameters at the receiver side, as well as the generation of a message sent by the receiver controller to the transmitter controller to synchronize about the transmission parameters to be adopted. This message can be sent over a control channel between transmitter and receiver. Such transponder reconfiguration based on FSM has been successfully demonstrated by integrating control and data planes in a lab and field trials.

6. Code of the YANG model for transponder reconfiguration

The related code is reported below.

```
<CODE BEGINS> file "ietf-treconf@2016-03-15.yang"


 module ietf-treconf {
  namespace "http://sssup.it/fsm";
  prefix fsm;


  organization
    "Scuola Superiore Sant'Anna Network and Services Laboratory";

  contact
    " Editor: Matteo Dallaglio
              <mailto:m.dallaglio@sssup.it>
    ";

  description
    "This module contains a YANG definitions of a generic finite state machine."
;

  revision 2016-03-15 {
    description "Initial Revision.";
    reference
      "RFC xxxx:";
  }


  identity TRANSITION {
      description "Base for all types of event";
  }

  identity ON_CHANGE {
      base TRANSITION;
      description
        "The event when the database changes.";
  }


  // typedef statements

  typedef transition-type {
        description "it defines the transition type";
    type identityref {
      base TRANSITION;
    }
```

```
  }

  typedef transition-id-type {
        description "it defines the transition id type";
    type uint32;
  }


  // grouping statements
  grouping action-block {
        description "it defines the grouping action";
    leaf id {
        description "it defines the id of the transition";
      type transition-id-type;
    }
    leaf type {
        description "it defines if the action has to be simply executed or if a
conditional statement has to be checked before execution";

      type enumeration {
        enum "CONDITIONAL_OP"{
description "it defines the type CONDITIONAL OPERATION to check a statement befo
re execution. In this draft, at the moment, only SIMPLE will be assumed";

 }
        enum "SIMPLE_OP"{
description "it defines the type SIMPLE OPERATION: i.e., an operation to be dire
ctly executed;
}
      }
      mandatory true;
    }

    grouping execution-top {
        description "it defines the execution attribute";
      anyxml execute {
        description "Represent the action to perform";
      }
      leaf next-action {
        type transition-id-type;
        description "the id of the next action to execute";
      }
    }


    container simple {
      when "../type = 'SIMPLE_OP'";
      description
        "Simple execution of an action without checking any condition";
      uses execution-top;
    }
```

```
  }

  grouping action-top {
        description "it defines the grouping of action";
    list action {
                description "it defines the list of actions";
      key "id";

      ordered-by user;
      uses action-block;
    }
  }

  grouping on-change {
    description
      "Event occuring when a modification of one or more
       objects occurs";

    leaf threshold-parameter {
        description "it defines the threshold of an event determined by a thresh
old exceed";
      type decimal64;
    }

    leaf threshold-operator {
        description "it defines the operator to check the threshold exceed: <, >
 <=, >=";
      type string;
    }


  }

  grouping transition-top {
        description "it defines the grouping transition";
    leaf name {
        description "it defines the transition name";
      type string;
      mandatory true;
    }



    leaf description {
description "it describes the transition with a string";
      type string;
    }

    // list of all possible events
    uses on-change {
```

```
      when "type = 'ON_CHANGE'";
    }

    container transition-action {
        description "it defines the container actions to take during the transit
ion";
      uses action-top;
    }
  }

  grouping transitions-top {
        description "it defines the grouping transition";
    container transitions {
        description "it defines the container transitions";
      list transition {
                description "it defines the list of transitions";
        key "name";
        uses transition-top;

      }
    }
  }


  // data definition statements

  uses transitions-top;

  // extension statements

  // feature statements

  // augment statements

  // rpc statements

  // notification statements

  // identity statements

  // typedef statements

  typedef state-id-type {
        description "it defines the id type of the states";
    type uint32;
  }


  // grouping statements
```

```
  grouping state-top {
        description "it defines the grouping state";
    leaf id {
        description "it defines the id of the state";
      type state-id-type;
    }

    leaf description {
        description "it describes the state with a string";
      type string;
    }


    grouping next-state-top {
        description "it defines the grouping next state";
      leaf next-state {
          type leafref {
            path "../../../../../../../../../states/state/id";
          }
          description "Id of the next state";
        }
    }

    uses transitions-top {
      augment "transitions/transition/transition-action/action/simple" {
        //uses next-state-top;
        leaf next-state {
          type leafref {
            path "../../../../../../../../states/state/id";
          }
          description "Id of the next state";
        }
      }
    }

  }



  grouping states-top {
        description "it defines the attributes of state-top";
    leaf current-state {
        description "it defines the current state";
      type leafref {
                description "it refers to its id";
        path "../states/state/id";
      }
    }
```

```
    container states {
        description "it defines the container states";
      list state {
        description "it defines the list of states";
        key "id";
        uses state-top;
      }
    }
  }

  // data definition statements


  uses states-top;

  // extension statements


  // feature statements

  // augment statements.

  // rpc statements

  // notification statements


}//module fsm


<CODE ENDS>
```

7. Acknowledgements

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8. Security Considerations

TBD

9. IANA Considerations

TBD

10. References

10.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <https://www.rfc-editor.org/info/rfc6020>.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <https://www.rfc-editor.org/info/rfc6241>.

[RFC7491] King, D. and A. Farrel, "A PCE-Based Architecture for Application-Based Network Operations", RFC 7491, DOI 10.17487/RFC7491, March 2015, <https://www.rfc-editor.org/info/rfc7491>.

10.2. Informative References

[I-D.ietf-i2rs-yang-network-topo]
Clemm, A., Medved, J., Varga, R., Bahadur, N., Ananthakrishnan, H., and X. Liu, "A Data Model for Network Topologies", draft-ietf-i2rs-yang-network-topo-20 (work in progress), December 2017.

[I-D.sambo-netmod-yang-fsm]
Sambo, N., Castoldi, P., Fioccola, G., Cugini, F., Song, H., and T. Zhou, "YANG model for finite state machine", draft-sambo-netmod-yang-fsm-02 (work in progress), March 2018.

[I-D.vergara-ccamp-flexigrid-yang]
Madrid, U., Perdices, D., Lopezalvarez, V., Dios, O., King, D., Lee, Y., and G. Galimberti, "YANG data model for Flexi-Grid Optical Networks", draft-vergara-ccamp-flexigrid-yang-06 (work in progress), January 2018.

[I-D.zhang-ccamp-l1-topo-yang]
zhenghaomian@huawei.com, z., Fan, Z., Sharma, A., and X. Liu, "A YANG Data Model for Optical Transport Network Topology", draft-zhang-ccamp-l1-topo-yang-07 (work in progress), April 2017.

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YANG data model for Flexi-Grid media-channels
draft-vergara-ccamp-flexigrid-media-channel-yang-01.txt

Status of this Memo

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Abstract

This document defines a YANG model for managing flexi-grid optical media channels, complementing the information provided by the flexi-grid TED model.
It is also grounded on other defined YANG abstract models.

Table of Contents

1. Introduction

Transport networks are evolving from current DWDM systems towards elastic optical networks, based on flexi-grid transmission and switching technologies [RFC7698]. Such technology aims at increasing both transport network scalability and flexibility, allowing the optimization of bandwidth usage.

While [I-D.draft-vergara-ccamp-flexigrid-yang] focuses on flexi-grid objects such as nodes, transponders and links, this document presents a YANG model for the flexi-grid media-channel. This YANG module defines the whole path from a source transponder or node to the destination through a number of intermediate nodes in the flexi-grid network.

This document identifies the flexi-grid media-channel components, parameters and their values, characterizes the features and the performances of the flexi-grid elements. An application example is provided towards the end of the document to better understand their utility.

2. Conventions used in this document

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].

In this document, these words will appear with that interpretation only when in ALL CAPS. Lower case uses of these words are not to be interpreted as carrying RFC-2119 significance.

In this document, the characters ">>" preceding an indented line(s) indicates a compliance requirement statement using the key words listed above. This convention aids reviewers in quickly identifying or finding the explicit compliance requirements of this RFC.

3. Flexi-grid media-channel overview

The present model defines a flexi-grid media-channel mainly composed of:

- source address
- source flexi-grid port
- source flexi-grid transponder
- destination address
- destination flexi-grid port
- destination flexi-grid transponder
- A list of links that defines the path
- Other optical attributes

Each path can be a media-channel (only defined by source and destination node) or a network media-channel (aditionally needs source and destination transponders). Therefore, all the attributes are optional to support both situations.

This is achieved by a combination of the traffic engineering tunnel attributes explained in [I-D.draft-ietf-teas-yang-te] and augments when necessary. For instance, source address, source flexi-grid transponder, destination address and destination flexi-grid transponder attributes are directly taken from tunnel, whereas other attributes such as source flexi-grid port, destination flexi-grid port are defined, as they are specific for flexi-grid.

4. Example of use

In order to explain how this model is used, we provide the following example. An optical network usually has multiple transponders, switches (nodes) and links between them. Figure 1 shows a simple topology, where two physical paths interconnect two optical transponders.

```
                               Media channel
            <====================================================>
                                  Path x
            <---------------------------------------------------->

                     +----------+          +----------+
              Link 1 |Flexi-grid|  Link 2  |Flexi-grid| Link 3
                .--->|   node   |<-------->|   node   |<---.
                |    |    B     |          |    C     |    |
                |    +----------+          +----------+    |
                v                                          v
             /-----------\                       /-----------\
            / Flexi-grid  \                     / Flexi-grid  \
            | transponder |                     | transponder |
            \      A      /                     \      E      /
             \-----------/                       \-----------/
                  ^                                     ^
                  |             +----------+            |
                  |    Link 4   |Flexi-grid|   Link 5   |
                  '------------>|   node   |<-----------'
                                |    D     |
                                +----------+
            <---------------------------------------------------->
                                  Path y
```

Figure 1. Topology example.

After the nodes, links and transponders have been defined using [I-D.draft-vergara-ccamp-flexigrid-yang], we can configure the media-channel from the information we have stored in the flexi-grid TED, by querying which elements are available, and planning the resources that have to be provided on each situation. Note that every element in the flexi-grid TED has a reference, and this is the way in which they are called in the media-channel.

1. Depending on the case, it is possible to define either the source and destination node ports, or the source and destination node and transponder. In our case, we would define a network media channel, with source transponder A and source node B, and destination transponder E and destination node C. Thus, we are going to follow path x.

2. Then, for each link in the path x, we indicate which channel we are going to use, providing information about the slots, and what nodes are connected.

3. Finally, the flexi-grid TED has to be updated with each element usage status each time a media channel is created or torn down.

5. Media Channel YANG Model

5.1. YANG Model - Tree

```
module: ietf-flexi-grid-media-channel
  augment /te:te/te:tunnels/te:tunnel:
    +--rw source-port?           fg-ted:flexi-grid-node-port-ref
    +--rw destination-port?      fg-ted:flexi-grid-node-port-ref
    +--rw effective-freq-slot
       +--rw N?   int32
       +--rw M?   int32
  augment /te:te/te:tunnels/te:tunnel/te:state:
    +--ro source-port?           fg-ted:flexi-grid-node-port-ref
    +--ro destination-port?      fg-ted:flexi-grid-node-port-ref
    +--ro effective-freq-slot
       +--ro N?   int32
       +--ro M?   int32
  augment /te:te/te:lsps-state/te:lsp:
    +--ro N?                  int32
    +--ro M?                  int32
    +--ro source-port?        fg-ted:flexi-grid-node-port-ref
    +--ro destination-port?   fg-ted:flexi-grid-node-port-ref
    +--ro link?               fg-ted:flexi-grid-link-ref
    +--ro bidirectional?      boolean
```

5.2. YANG Model - Code

```
   <CODE BEGINS> file "ietf-flexi-grid-media-channel@2017-11-10.yang"
module ietf-flexi-grid-media-channel {
   yang-version 1.1;

   namespace
     "urn:ietf:params:xml:ns:yang:ietf-flexi-grid-media-channel";
   prefix "fg-mc";

   import ietf-flexi-grid-ted {
      prefix "fg-ted";
   }

   import ietf-te {
      prefix "te";
   }

   import ietf-network {
      prefix "nd";
   }
   organization
      "IETF CCAMP Working Group";
   contact
      "Editor: Jorge Lopez de Vergara
                 <jorge.lopez_vergara@uam.es>";

   description
      "This module contains a collection of YANG definitions for
      a Flexi-Grid media channel.

      Copyright (c) 2017 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 2017-11-11 {
      description
         "version 1.";

      reference
         "RFC XXX: A Yang Data Model for Flexi-Grid media-channels";
   }
```

```
   grouping flexi-grid-media-channel {
         description
            "Media association that represents both the topology
            (i.e., path through the media) and the resource
            (frequency slot) that it occupies.  As a topological
            construct, it represents a (effective) frequency slot
            supported by a concatenation of media elements (fibers,
            amplifiers, filters, switching matrices...).  This term
            is used to identify the end-to-end physical layer entity
            with its corresponding (one or more) frequency slots
            local at each link filters.";
         reference "rfc7698";
         leaf source-port {
            type fg-ted:flexi-grid-node-port-ref;
            description "Source port";
          }
         leaf destination-port {
            type fg-ted:flexi-grid-node-port-ref;
            description "Destination port";
          }
         container effective-freq-slot {
         description "The effective frequency slot is an attribute
            of a media channel and, being a frequency slot, it is
            described by its nominal central frequency and slot
            width";
         reference "rfc7698";
            leaf N {
               type int32;
               description
                  "Is used to determine the Nominal Central
                  Frequency. The set of nominal central frequencies
                  can be built using the following expression:
                     f = 193.1 THz + n x 0.00625 THz,
                  where 193.1 THz is ITU-T ''anchor frequency'' for
                  transmission over the C band, n is a positive or
                  negative integer including 0.";
               reference "rfc7698";
            }
            leaf M {
               type int32;
               description
                  "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 an integer greater than or equal to 1.";
               reference "rfc7698";
         }
      }
   }
```

```
   grouping link-channel-attributes {
      description
         "A link channel is one of the concatenated elements of
         the media channel.";
      leaf N {
         type int32;
         description
            "Is used to determine the Nominal Central Frequency.
            The set of nominal central frequencies can be built
            using the following expression:
               f = 193.1 THz + n x 0.00625 THz,
            where 193.1 THz is ITU-T ''anchor frequency'' for
            transmission over the C band, n is a positive or
            negative integer including 0.";
         reference "rfc7698";
      }
      leaf M {
         type int32;
            description
               "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 an integer greater than
               or equal to 1.";
            reference "rfc7698";
      }
      leaf source-port {
         type fg-ted:flexi-grid-node-port-ref;
         description "Source port of the link channel";
      }
      leaf destination-port {
         type fg-ted:flexi-grid-node-port-ref;
         description "Destination port of the link channel";
      }
      leaf link {
         type fg-ted:flexi-grid-link-ref;
         description "Link of the link channel";
      }
      leaf bidirectional {
         type boolean;
         description
            "Determines whether the link is bidirectional or
            not";
      }
   }
```

```
   /* Augment for media-channel */
   augment "/te:te/te:tunnels/te:tunnel" {
       when "/nd:networks/nd:network/nd:network-types/
     fg-ted:flexi-grid-network"{
          description "Augment only for Flexigrid network.";
       }
       description "Augment tunnel with media-channel config";
       uses flexi-grid-media-channel;

   }

      augment "/te:te/te:tunnels/te:tunnel/te:state" {
       when "/nd:networks/nd:network/nd:network-types/
     fg-ted:flexi-grid-network"{
          description "Augment only for Flexigrid network.";
       }
       uses flexi-grid-media-channel;
       description "Augment tunnel with media-channel state";

   }

   /* Augment for LSP */
   augment "/te:te/te:lsps-state/te:lsp" {
      when "/nd:networks/nd:network/nd:network-types/
     fg-ted:flexi-grid-network"{
          description "Augment only for Flexigrid network.";
      }
      uses link-channel-attributes;
      description "Augment LSP for paths";
   }

}

   <CODE ENDS>
```

5.3. License

6. Security Considerations

The transport protocol used for sending the managed information MUST support authentication and SHOULD support encryption.

The defined data-model by itself does not create any security implications.

7. IANA Considerations

The namespace used in the defined models is currently based on the METRO-HAUL project URI. Future versions of this document could register a URI in the IETF XML registry [RFC3688], as well as in the YANG Module Names registry [RFC6020].

8. References

8.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, October 2010.

[RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, January 2004.

8.2. Informative References

[RFC7698] Gonzalez de Dios, O., Casellas, R., Eds. "Framework and Requirements for GMPLS-Based Control of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks", RFC7698, November 2015.

[I-D.draft-vergara-ccamp-flexigrid-yang] Lopez de Vergara, J., Perdices, D., Lopez, V., Gonzalez de Dios, O., King, D., Lee, Y., Galimberti, G., "YANG data model for Flexi-Grid Optical Networks", Internet Draft, draft-vergara-ccamp-flexigrid-yang-05, 2017.

[I-D.draft-ietf-teas-yang-te] Saad, T., Gandhi, R., Liu, X., Beeram, V., Shah, H., Bryskin, I., Chen, X., Jones, R., and B. Wen, "A YANG Data Model for Traffic Engineering Tunnels and Interfaces", draft-ietf-teas-yang-te-09, 2017.

9. Contributors

The model presented in this paper was contributed to by more people than can be listed on the author list. Additional contributors include:

- o Zafar Ali, Cisco Systems
- o Daniel Michaud Vallinoto, Universidad Autonoma de Madrid

10. Acknowledgments

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March 05, 2018

A YANG Data Model for Microwave Topology
draft-ye-ccamp-mw-topo-yang-00

Abstract

This document defines a YANG data model to describe the topologies of microwave/millimeter.

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].

Status of This Memo

Copyright Notice

Table of Contents

1. Terminology and Definitions

The following acronyms are used in this document:

PNC Provisioning Network Controller

MDSC Multi Domain Service Coordinator

2. Introduction

This document defines a YANG data model to describe the topologies of microwave/millimeter(hereafter microwave is used to simplify the text). The microwave topology model augments the TE topology model defines in [I-D.ietf-teas-yang-te-topo].

The microwave topology model is expected to be used between a Provisioning Network Controller(PNC) and a Multi Domain Service

Coordinator(MDSC)([I-D.ietf-teas-actn-framework]). Possible use cases of microwave topology models include:

1. The microwave link frequency could be used to understand the current frequency usage, enabling a whole view of the network topology information, and as an input for network frequency planning.

2. The microwave radio link could change its bandwidth according to the environments under the adatpive modulation mode, e.g., the bandwidth will degrade when there's a heavy rain. To get to know of current microwave link bandwidth is important for path computation and service provisioning across different technologies/networks.

3. Due to bandiwdth changing feature, availability is normally used to describe the microwave radio link characteristic. [RFC8330] defines a mechanism to report bandwidth-availability information through OSPF-TE. It's also necessary to include the information in the YANG data model to optimize the path/route computation.

3. YANG Data Model (Tree Structure)

3.1. The YANG Tree

```
module: ietf-microwave-topology
  augment /nw:networks/nw:network/nw:network-types/tet:te-topology:
    +--rw mw-topology!
  augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-attributes:
    +--rw mw-link-frequency?          uint32
    +--rw mw-link-channel-separation? uint32
    +--ro mw-link-nominal-bandwidth?  rt-types:bandwidth-ieee-float32
    +--ro mw-link-current-bandwidth?  rt-types:bandwidth-ieee-float32
    +--ro mw-link-availability*
       +--ro mw-link-availability     rt-types:percentage
       +--ro mw-link-bandwidth        rt-types:bandwidth-ieee-float32
```

3.2. Relationship with microwave interface YANG model

[I-D.ietf-ccamp-mw-yang] defines an interface YANG model for microwave radio link which is used between the PNC and the physical device for device configuration. The PNC is able to convert the information received from the topology model into the interface model. For example, the link frequency in the topology model is mapped to the tx-frequency of the carrier termination in the interface model.

4. YANG Module

```
 <CODE BEGINS> file "ietf-microwave-topology.yang"

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

   prefix "mwtopo";

   import ietf-network {
     prefix "nw";
   }

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

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

   import ietf-routing-types {
     prefix "rt-types";
   }

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

   ID-draft authors:
    Min Ye (amy.yemin@huawei.com);
    Aihua Guo (aihuaguo@huawei.com);
    Jonas Ahlberg (jonas.ahlberg@ericsson.com);
    Xi Li (Xi.Li@neclab.eu);
    Daniela Spreafico (daniela.spreafico@nokia.com)
   ";

  description
   "This is a module for microwave topology.";

    revision 2018-03-05 {
     description
     "Initial version.";
     reference "";
```

```
   }


   /*
    * Groupings
    */
   grouping mw-link-attributes {
      description "Microwave link attributes";

          leaf mw-link-frequency {
            type uint32;
            units "kHz";
            description "Frequency of the link";
            }

          leaf mw-link-channel-separation {
            type uint32;
            units "kHz";
            description "The distance
             between adjacent channels in a radio frequency channel
             arrangement used in this link";
            reference "ETSI EN 302 217-1";
            }

           leaf mw-link-nominal-bandwidth {
             type rt-types:bandwidth-ieee-float32;
                 units "Mbps";
                 description "The nominal bandwidth of the link";
           }

           leaf mw-link-current-bandwidth {
            type rt-types:bandwidth-ieee-float32;
            units "Mbps";
            description "The current bandwidth of the link";
            }

           list mw-link-availability{
             key "availability";
                 description "List of availability and its corresponding
                      link bandwidth";

                 leaf availability {
                   type rt-types:percentage;
                   description "availability level of the link";
                 }

                 leaf mw-link-bandwidth {
                   type rt-types:bandwidth-ieee-float32;
```

```
                   units "Mbps";
                   description "the bandwidth corresponding to the
                        availability level";
                   }
      }
         }

   /*
    * Data nodes
    */
    augment "/nw:networks/nw:network/nw:network-types/"
         + "tet:te-topology" {
     container mw-topology {
       presence "indicates a topology type of microwave.";
       description "microwave topology type";
     }
     description "augment network types to include microwave network";
   }

   augment "/nw:networks/nw:network/nt:link/tet:te/"
         + "tet:te-link-attributes" {
     when "../../../nw:network-types/tet:te-topology/"
        + "mwtopo:mw-topology" {
       description "This augment is only valid for microwave.";
     }
     description "Microwave link augmentation";

     uses mw-link-attributes;
   }

  }
 <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][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 [RFC5246].

The NETCONF access control model [RFC6536] 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:

TBD.(list subtrees and data nodes and state why they are sensitive)

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:

TBD.(list subtrees and data nodes and state why they are sensitive)

6. IANA Considerations

IANA has assigned a new URI from the "IETF XML Registry" [RFC3688].

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

IANA has recorded a YANG module name in the "YANG Module Names" registry [RFC6020] as follows:

```
Name: ietf-microwave-topology
Namespace: urn:ietf:params:xml:ns:yang:ietf-microwave-topology
Prefix: mwtopo
Reference: RFC xxxx
```

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <https://www.rfc-editor.org/info/rfc3688>.

[RFC5246] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", RFC 5246, DOI 10.17487/RFC5246, August 2008, <https://www.rfc-editor.org/info/rfc5246>.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <https://www.rfc-editor.org/info/rfc6020>.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <https://www.rfc-editor.org/info/rfc6241>.

[RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure Shell (SSH)", RFC 6242, DOI 10.17487/RFC6242, June 2011, <https://www.rfc-editor.org/info/rfc6242>.

[RFC6536] Bierman, A. and M. Bjorklund, "Network Configuration Protocol (NETCONF) Access Control Model", RFC 6536, DOI 10.17487/RFC6536, March 2012, <https://www.rfc-editor.org/info/rfc6536>.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <https://www.rfc-editor.org/info/rfc8040>.

7.2. Informative References

[I-D.ietf-ccamp-mw-yang]
Ahlberg, J., Ye, M., Li, X., Spreafico, D., and M. Vaupotic, "A YANG Data Model for Microwave Radio Link", draft-ietf-ccamp-mw-yang-04 (work in progress), March 2018.

[I-D.ietf-teas-actn-framework]
Ceccarelli, D. and Y. Lee, "Framework for Abstraction and Control of Traffic Engineered Networks", draft-ietf-teas-actn-framework-11 (work in progress), October 2017.

[I-D.ietf-teas-yang-te-topo]
Liu, X., Bryskin, I., Beeram, V., Saad, T., Shah, H., and O. Dios, "YANG Data Model for Traffic Engineering (TE) Topologies", draft-ietf-teas-yang-te-topo-15 (work in progress), February 2018.

[RFC8330] Long, H., Ye, M., Mirsky, G., D’Alessandro, A., and H. Shah, "OSPF Traffic Engineering (OSPF-TE) Link Availability Extension for Links with Variable Discrete Bandwidth", RFC 8330, DOI 10.17487/RFC8330, February 2018, <https://www.rfc-editor.org/info/rfc8330>.

Appendix A. Appendix A Examples of microwave topology

A.1. Appendix A.1 A topology with single microwave radio link

Microwave is a transport technology which can be used to transport client services, such as ETH. When an ETH service is transported by a single microwave radio link, the topology could be shown as the Figure 3. Note that the figure just shows an example, there might be other possiblities to demonstrate the topology.

```
      Node 1                              Node 2
+---------------+                     +---------------+
|               |                     |               |
| +-----------+ |                     | +-----------+ |
| |    LTP11  | |                     | |   LTP21   | | --ETH topo
| +-------o---+ |  ETH-TE-Link-1      | +---o-------+ |
|         |---------------------------------|         |
|               |                     |               |
| +-----------+ |                     | +-----------+ |
| | TTP-1 __  | | microwave tunnel-11 | |  __ TTP-1 | |
| |       \/@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@\/       | |
| |        *  | |                     | |  *        | | --Microwave topo
| |         * | | microwave link 12   | | *         | |
| |    LTP-1 *o ------------------------o* LTP-1    | |
| |           | |                     | |           | |
| +-----------+ |                     | +-----------+ |
|               |                     |               |
+---------------+                     +---------------+
```

Figure 3: ETH transported on a single microwave radio link

In the above ETH topology, the ETH-TE-link is encoded in JSON as below:

```
     ...
     "ietf-network-topology:link": [
       {
         "link-id": "N1,LTP11,N2,LTP21",
         "source": {
           "source-node": "N1",
           "source-tp": "LTP11"
         }
         "destination": {
           "dest-node": "N2",
           "dest-tp": "LTP21"
         }
       }
     ]
     "ietf-te-topology:link/te/te-link-attributes/": [
       {
         "enabled": ture,
             "primary-path":{
              "path-element": {
                "path-element-id": "MW-11"
                    //no backup-path
                    //no protection-type
              }
             }
             "tunnel-termination-points": {
               "source": "N1/TTP-1",
                   "destination": "N2/TTP-1"
             }
             "tunnels" : {
              "sharing": "false",
              "tunnel":{
                "tunnel-name": "MW-11",
                    "sharing": "false"
              }
             }
           }
     ]
```

Note that the example above just shows the particular ETH link, not the full ETH topology.

In the microwave topology, the microwave link is encoded in JSON as below:

```
     ...
     "ietf-network-topology:link": [
       {
         "link-id": "N1,LTP1,N2,LTP1",
         "source": {
           "source-node": "N1",
           "source-tp": "LTP1"
         }
         "destination": {
           "dest-node": "N2",
           "dest-tp": "LTP1"
         }
       }
     ]
     "ietf-te-topology:link/te/te-link-attributes/underlay": [
       {
            "mw-link-frequency":  10728000,
            "mw-link-channel-separation": "28000",
            "mw-link-actual-tx-cm":"qam-512",
            "mw-link-nominal-bandwidth": "1000",
            "mw-link-current-bandwidth": "1000",
            "mw-link-availability":{
             "mw-link-availability":"0.9999",
             "mw-link-bandwidth": "1000"
            }
           }
     ]
```


A.2. Appendix A.2 A topology with microwave radio links bundling

When a ETH service is transported over two microwave radio links, the topologies could be shown as in Figure 4. Note that the figure just shows one example, there might be other possiblities to demonstrate the topology.

```
      Node 1                                 Node 2
+----------------+                    +----------------+
|                |                    |                |
| +------------+ |                    | +------------+ |
| |    LTP11   | |                    | |   LTP21    | | --ETH topo
| +-------o---+ |  ETH-TE-Link-1      | +---o-------+ |
|         |---------------------------------|          |
|                |                    |                |
| +------------+ |                    | +------------+ |
| | TTP-1 __   | | microwave tunnel-11 | |  __ TTP-1 | |
| |       \/@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@\/        | |
| |         *  | |                    | |  *         | | --Microwave topo
| |          * | | mw bundled link 33  | | *          | |
| |    LTP-3 *o -----------------------o* LTP-3     | |
| |            | |                    | |            | |
| |    LTP-2  o |                    | o  LTP-2     | |
| |    LTP-1  o |                    | o  LTP-1     | |
| +------------+ |                    | +------------+ |
|                |                    |                |
+----------------+                    +----------------+
```

Figure 4: ETH transported on single microwave radio links

In the ETH topology, the ETH-TE-link is encoded in JSON as below:

```
...
"ietf-network-topology:link": [
  {
    "link-id": "N1,LTP11,N2,LTP21",
    "source": {
      "source-node": "N1",
      "source-tp": "LTP11"
    }
    "destination": {
      "dest-node": "N2",
      "dest-tp": "LTP21"
    }
  }
]
"ietf-te-topology:link/te/te-link-attributes/": [
  {
    "enabled": ture,
        "primary-path":{
         "path-element": {
           "path-element-id": "MW-33"
               //no backup-path
               //no protection-type
         }
        }
        "tunnel-termination-points": {
          "source": "N1/TTP-1",
              "destination": "N2/TTP-1"
        }
        "tunnels" : {
         "sharing": "false",
         "tunnel":{
           "tunnel-name": "MW-11",
               "sharing": "false"
         }
        }
      }
]
```

Note that the example above just shows the specific ETH link, not the full ETH topology.

In the microwave topology, the micorwave link is encoded in JSON as below:

```
...
"ietf-network-topology:link": [
  {
    "link-id": "N1,LTP1,N2,LTP1",
    "source": {
      "source-node": "N1",
      "source-tp": "LTP3"
    }
    "destination": {
      "dest-node": "N2",
      "dest-tp": "LTP3"
    }
  }
]
"ietf-te-topology:link/te/te-link-config": [
  {
       "bundle-stack-level":{
         "component" {
           "component-links-1": {
         "sequence": "mw-11",
         "src-tp-ref": "N1-LTP1",
         "des-tp-ref" : "N2-LTP1"
               }
                "component-links-2": {
         "sequence": "mw-22",
         "src-tp-ref": "N1-LTP2"
         "des-tp-ref" : "N2-LTP2"
               }
         }
       }
      }
]
```

Note that the example above just shows the microwave component links, it doesn’t show the full microwave topology.

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March 5, 2018

A YANG Data Model for Client-layer Topology
draft-zheng-ccamp-client-topo-yang-02

Abstract

A transport network is a server-layer network to provide connectivity services to its client. In this draft the topology of client is described.

Status of This Memo

Copyright Notice

Table of Contents

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 [I-D.ietf-netmod-yang-tree-diagrams]. 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 /nd:networks/nd:network/nd:network-types/tet:te-topology:
    +--rw eth-tran-topology!
  augment /nd:networks/nd:network/lnk:link/tet:te/tet:te-link-attributes:
    +--rw max-bandwidth?          uint64
    +--rw available-bandwidth?    uint64
    +--rw available-vlan-range?   etht-types:vid-range-type
  augment /nd:networks/nd:network/nd:node/lnk: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-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
    |  +--:(asymmetrical)
    |     +--rw ingress-bandwidth-profile
    |     |  +--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 egress-bandwidth-profile
    |        +--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 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
```

3.2. YANG Tree for topology Model of other Client Layer

This section will be completed later.

4. YANG Code for Topology Client Layer

4.1. The ETH Topology YANG Code

```
<CODE BEGINS> file "ietf-eth-te-topology@2017-09-12.yang"


module ietf-eth-te-topology {

        namespace "urn:ietf:params:xml:ns:yang:ietf-eth-te-topology";

        prefix "ethtetopo";

        import ietf-network {
                prefix "nd";
        }

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

        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:
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    ";

        description
                "This module defines a YANG data model for describing
                layer-2 Ethernet transport topologies.";

        revision 2018-03-01 {
                description
                        "Initial revision";
                reference
                        "draft-zheng-ccamp-client-topo-yang";
        }

        /*
        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 Networ
k.";
                        description "Eth transport topology type";
                }
        }

        grouping eth-link-te-attributes {
                description "Ethernet TE link attributes";

                leaf max-bandwidth {
```

```
                        type uint64{
                                range "0..10000000000";
                        }
                        units "Kbps";
                        description
                                "Maximum bandwith value expressed in kilobits pe
r second";
                }

                leaf available-bandwidth {
                        type uint64{
                                range "0..10000000000";
                        }
                        units "Kbps";
                        description
                                "Available bandwith value expressed in kilobits
per second";
                }

                leaf available-vlan-range {
                        type etht-types:vid-range-type;
                        description
                                "The range of the VLAN values that are available
.";
                }
        }

        grouping ltp-bandwidth-profiles {
                description
                        "A grouping which represents the bandwidt 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 d
escribe the ingress
                                        and the egress bandwidth profile.";

                                container ingress-egress-bandwidth-profile {
                                        description
                                                "The bandwith profile used in th
e 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 t
he ingress direction.";
                                        uses etht-types:etht-bandwidth-profiles;
                                }
                                container egress-bandwidth-profile {
                                        description
                                                "The bandwidth profile used in t
he 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 classificat
ion.";
```

```
                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, th
e list is empty.";
                }
                leaf vlan-bundling {
                        type boolean;
                        description
                                "In case VLAN classification is supported, indic
ates whether VLAN bundling classification is also supported.";
                }
                leaf vlan-range {
                        type etht-types:vid-range-type;
                        description
                                "In case VLAN classification is supported, indic
ates the of available VLAN ID values.";
                }
        }

        grouping svc-vlan-push {
                description
                        "Grouping defining the capabilities for VLAN push or swa
p 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 lis
t 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 attribute
s.";

                leaf client-facing {
                        type boolean;
                        description
                                "indicates whether this LTP is a client-facing l
tp.";
                }

                container supported-classification {
                        description
                                "Service classification capabilities supported b
y 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 bas
ed on the VLAN tag(s)
                                        supported by the ETH LTP.";

                                leaf vlan-tag-classification {
                                        type boolean;
                                        description
                                                "Indicates that the ETH LTP supp
orts VLAN service classification.";
                                }
                                container outer-tag {
                                        description
                                                "Service classification capabili
ties based on the outer VLAN tag,
                                                supported by the ETH LTP.";
                                        uses svc-vlan-classification;
                                }
                                container second-tag {
                                        description
                                                "Service classification capabili
ties based on the second VLAN tag,
                                                supported by the ETH LTP.";
                                        /*
                                                Open issue: indicates that secon
d-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
                                        "Description.";
                        leaf asymmetrical-operations {
                                type boolean;
                                description
                                        "Indicates whether the ETH LTP supports
also asymmetrical VLAN operations.
                                        It is assumed that symmetrical VLAN oper
ations are alwyas supported.";
```

```
                        }
                        leaf transparent-vlan-operations {
                                type boolean;
                                description
                                        "Indicates that the ETH LTP supports tra
nsparent operations.";
                        }
                        container vlan-pop {
                                description
                                        "Indicates VLAN pop or swap operations c
apabilities.";

                                leaf vlan-pop-operations {
                                        type boolean;
                                        description
                                                "Indicates that the ETH LTP supp
orts 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 supp
orts VLAN push or swap operations.";
                                }
                                container outer-tag {
                                        description
                                                "Indicates the supported VLAN op
eration capabilities on the outer VLAN tag.";
                                        uses svc-vlan-push;
                                }
                                container second-tag {
                                        description
                                                "Indicates the supported VLAN op
eration 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 "/nd:networks/nd:network/nd:network-types/tet:te-topology" {
                description
                        "Augment network types to include ETH transport newtork"
;

                uses eth-tran-topology-type;
        }

        augment "/nd:networks/nd:network/lnk:link/tet:te/tet:te-link-attributes"
 {
                when "../../../nd:network-types/tet:te-topology/eth-tran-topolog
y" {
                        description
                                "Augment only for ETH transport network.";
                }
                description
                        "Augment ETH transport link config attributes";

                uses eth-link-te-attributes;
        }

        augment "/nd:networks/nd:network/nd:node/lnk:termination-point" {
                when "../../nd: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 svc {
                        presence "client-facing LTP.";

                        description
                                "ETH LTP Service attributes.";
                        uses eth-ltp-svc-attributes;
                }
        }
}
```

<CODE ENDS>

4.2. Other OTN client signal YANG Code

TBD.

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.

6. IANA Considerations

TBD.

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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11. References

11.1. Normative References

[I-D.ietf-ccamp-otn-topo-yang]
zhenghaomian@huawei.com, z., Fan, Z., Sharma, A., Liu, X., Belotti, S., Xu, Y., Wang, L., and O. Dios, "A YANG Data Model for Optical Transport Network Topology", draft-ietf-ccamp-otn-topo-yang-02 (work in progress), October 2017.

[I-D.ietf-ccamp-otn-tunnel-model]
zhenghaomian@huawei.com, z., Fan, Z., Sharma, A., Rao, R., Belotti, S., Lopezalvarez, V., Li, Y., and Y. Xu, "OTN Tunnel YANG Model", draft-ietf-ccamp-otn-tunnel-model-01 (work in progress), October 2017.

[I-D.ietf-teas-yang-te-topo]
Liu, X., Bryskin, I., Beeram, V., Saad, T., Shah, H., and O. Dios, "YANG Data Model for Traffic Engineering (TE) Topologies", draft-ietf-teas-yang-te-topo-15 (work in progress), February 2018.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <https://www.rfc-editor.org/info/rfc6241>.

[RFC7139] Zhang, F., Ed., Zhang, G., Belotti, S., Ceccarelli, D., and K. Pithewan, "GMPLS Signaling Extensions for Control of Evolving G.709 Optical Transport Networks", RFC 7139, DOI 10.17487/RFC7139, March 2014, <https://www.rfc-editor.org/info/rfc7139>.

[RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, DOI 10.17487/RFC7950, August 2016, <https://www.rfc-editor.org/info/rfc7950>.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <https://www.rfc-editor.org/info/rfc8040>.

11.2. Informative References

[I-D.ietf-ccamp-wson-yang]
Lee, Y., Dhody, D., Zhang, X., Guo, A., Lopezalvarez, V., King, D., Yoon, B., and R. Vilata, "A Yang Data Model for WSON Optical Networks", draft-ietf-ccamp-wson-yang-10 (work in progress), February 2018.

[I-D.ietf-netmod-yang-tree-diagrams]
Bjorklund, M. and L. Berger, "YANG Tree Diagrams", draft-ietf-netmod-yang-tree-diagrams-06 (work in progress), February 2018.

[I-D.zhang-teas-transport-service-model]
Zhang, X. and J. Ryoo, "A Service YANG Model for Connection-oriented Transport Networks", draft-zhang-teas-transport-service-model-01 (work in progress), October 2016.

[RFC7062] Zhang, F., Ed., Li, D., Li, H., Belotti, S., and D. Ceccarelli, "Framework for GMPLS and PCE Control of G.709 Optical Transport Networks", RFC 7062, DOI 10.17487/RFC7062, November 2013, <https://www.rfc-editor.org/info/rfc7062>.

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A YANG Data Model for Client-layer Tunnel
draft-zheng-ccamp-client-tunnel-yang-02

Abstract

A transport network is a server-layer network to provide connectivity services to its client. In this draft the tunnel of client is described, with the definition of client tunnel YANG model.

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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 tunnel model in Traffic-Engineered network has been defined in both generic way and technology-specific way. The generic model, which is the base TE tunnel YANG model, can be found at [I-D.ietf-teas-yang-te]. Technology-specific models, such as OTN/ WSON tunnel model, have also been defined in [I-D.ietf-ccamp-otn-tunnel-model] and [I-D.lee-ccamp-wson-tunnel-model] respectively. Corresponding tunnel 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 tunnel, using YANG language defined in [RFC7950]. The model is augmenting the generic TE tunnel model, and can be used by applications exposing to a network controller via a REST interface. Furthermore, it can be used by an application to describe the client tunnel that constructed above the server-layer network. It is also worth noting that the client layer network will only need the tunnel model when there is a demand for switching techniques, such as Carrier Ethernet and MPLS-TP. The transparent signals do not need this model.

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 [I-D.ietf-netmod-yang-tree-diagrams]. 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 Client-layer Tunnel

3.1. YANG Tree for Ethernet Tunnel

```
module: ietf-eth-te-tunnel
  augment /te:te/te:tunnels/te:tunnel:
    +--rw src-eth-tunnel-endpoint
    |  +--rw vlanid?     etht-types:vlanid
    |  +--rw tag-type?   etht-types:eth-tag-type
    +--rw dst-eth-tunnel-endpoint
    |  +--rw vlanid?     etht-types:vlanid
    |  +--rw tag-type?   etht-types:eth-tag-type
    +--rw bandwidth-profile
       +--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
```

3.2. YANG Tree for Tunnel of other Client Signal Model

This section will be completed later.

4. YANG Code for Client-layer Tunnel

4.1. The ETH Tunnel YANG Code

```
<CODE BEGINS> file "ietf-eth-te-tunnel@2018-03-01.yang"

module ietf-eth-te-tunnel {

        namespace "urn:ietf:params:xml:ns:yang:ietf-eth-te-tunnel";

        prefix "eth-tunnel";

        import ietf-te {
                prefix "te";
        }

        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@huawei.com);
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        Yang Zhao (zhaoyangyjy@chinamobile.com);
        Xufeng Liu (Xufeng_Liu@jabil.com);
        Giuseppe Fioccola (giuseppe.fioccola@telecomitalia.it);
    ";

        description
                "This module defines a model for ETH transport tunnel";

        revision 2018-03-01 {
                description
                        "Initial revision";
                reference
                        "draft-zheng-ccamp-client-tunnel-yang-02";
        }

        grouping eth-tunnel-endpoint {
                description "Parameters for ETH tunnel.";

                leaf vlanid {
                        type etht-types:vlanid;
                        description
                                "VLAN tag id.";
                }

                leaf tag-type {
                        type etht-types:eth-tag-type;
                        description "VLAN tag type.";
                }
        }

        augment "/te:te/te:tunnels/te:tunnel" {
                description
                        "Augment with additional parameters required for ETH
                        service.";

                container src-eth-tunnel-endpoint {
                        description
                                "Source ETH tunnel endpoint.";
```

```
                                uses eth-tunnel-endpoint;
                        }

                        container dst-eth-tunnel-endpoint {
                                description
                                        "Destination ETH tunnel endpoint.";

                                uses eth-tunnel-endpoint;
                        }

                        container bandwidth-profile {
                                description
                                        "ETH tunnel bandwidth profile specification.";

                                uses etht-types:etht-bandwidth-profiles;
                        }
                }
        }

<CODE ENDS>
```

4.2. Other Client-layer Tunnel YANG Code

TBD.

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. This is a part of L2 work, need to discuss how to go with other L2 network models. The expectation is to include all potential L2 TE part in this work.

6. IANA Considerations

TBD.

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] 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].

9. Acknowledgements

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11. References

11.1. Normative References

[I-D.ietf-ccamp-otn-topo-yang]
zhenghaomian@huawei.com, z., Fan, Z., Sharma, A., Liu, X., Belotti, S., Xu, Y., Wang, L., and O. Dios, "A YANG Data Model for Optical Transport Network Topology", draft-ietf-ccamp-otn-topo-yang-02 (work in progress), October 2017.

[I-D.ietf-ccamp-otn-tunnel-model]
zhenghaomian@huawei.com, z., Fan, Z., Sharma, A., Rao, R., Belotti, S., Lopezalvarez, V., Li, Y., and Y. Xu, "OTN Tunnel YANG Model", draft-ietf-ccamp-otn-tunnel-model-01 (work in progress), October 2017.

[I-D.ietf-teas-yang-te]
Saad, T., Gandhi, R., Liu, X., Beeram, V., Shah, H., and I. Bryskin, "A YANG Data Model for Traffic Engineering Tunnels and Interfaces", draft-ietf-teas-yang-te-13 (work in progress), March 2018.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <https://www.rfc-editor.org/info/rfc6241>.

[RFC7139] Zhang, F., Ed., Zhang, G., Belotti, S., Ceccarelli, D., and K. Pithewan, "GMPLS Signaling Extensions for Control of Evolving G.709 Optical Transport Networks", RFC 7139, DOI 10.17487/RFC7139, March 2014, <https://www.rfc-editor.org/info/rfc7139>.

[RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, DOI 10.17487/RFC7950, August 2016, <https://www.rfc-editor.org/info/rfc7950>.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <https://www.rfc-editor.org/info/rfc8040>.

11.2. Informative References

[I-D.ietf-netmod-yang-tree-diagrams]
Bjorklund, M. and L. Berger, "YANG Tree Diagrams", draft-ietf-netmod-yang-tree-diagrams-06 (work in progress), February 2018.

[I-D.lee-ccamp-wson-tunnel-model]
Lee, Y., Dhody, D., Lopezalvarez, V., King, D., Yoon, B., and R. Vilata, "A Yang Data Model for WSON Tunnel", draft-lee-ccamp-wson-tunnel-model-04 (work in progress), January 2018.

[I-D.zhang-teas-transport-service-model]
Zhang, X. and J. Ryoo, "A Service YANG Model for Connection-oriented Transport Networks", draft-zhang-teas-transport-service-model-01 (work in progress), October 2016.

[RFC7062] Zhang, F., Ed., Li, D., Li, H., Belotti, S., and D. Ceccarelli, "Framework for GMPLS and PCE Control of G.709 Optical Transport Networks", RFC 7062, DOI 10.17487/RFC7062, November 2013, <https://www.rfc-editor.org/info/rfc7062>.

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Interworking of GMPLS Control and Centralized Controller System

draft-zheng-ccamp-gmpls-controller-inter-work-01

Abstract

Generalized Multi-Protocol Label Switching (GMPLS) control allows each network element (NE) to perform resource discovery, routing and signaling in a distributed manner. On the other hand, with the development of software-defined transport networking technology, central controllers are introduced to transport networks to control a set of NEs.

In transport networks, the GMPLS control has many mature mechanisms such as RSVP-TE, OSPF-TE, and LMP, so that GMPLS can be applied for the NE-level control in the centralized controller systems.

This document describes how GMPLS control interworks with centralized controller systems (e.g. ACTN) in transport network.

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This Internet-Draft will expire on September 5, 2018.

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Conventions used in this document

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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1. Introduction

Generalized Multi-Protocol Label Switching (GMPLS) [RFC3945] extends MPLS to support different classes of interfaces and switching capabilities such as Time-Division Multiplex Capable (TDM), Lambda Switch Capable (LSC), and Fiber-Switch Capable (FSC). Each network element (NE) running a control plane collects network information from other NEs and provisions services through signaling in a distributed manner.

On the other hand, Software-Defined Networking (SDN) technologies have been introduced to control the transport network in a centralized manner. Central controllers, which can locate outside of the network, can collect network information from each node and provision services to corresponding nodes. One of the examples is the Abstraction and Control of Traffic Engineered Networks (ACTN) [I-D.ietf-teas-actn-framework], which defines a hierarchical architecture with PNC, MDSC and CNC as central controllers for different network abstraction levels.

In such centralized controller systems, GMPLS can be applied for the NE-level control. Introducing GMPLS in centralized controller system can reuse the mature mechanisms defined for GMPLS and be practical for legacy transport networks. This document describes how GMPLS control interworks with centralized controller system in transport network.

2. Overview

In this section, overviews of GMPLS control plane and centralized controller system are discussed as well as the cooperation between GMPLS control plane and centralized controller system.

2.1. Overview of GMPLS Control Plane

GMPLS separates the control plane and the data plane to support time-division, wavelength, and spatial switching, which are significant in transport networks. For the NE level control in GMPLS, each node has its controller to perform service provisioning, protection, and restoration. At the same time, the controller can negotiate available link resources with controllers in adjacent nodes, and it can also collect node and link resources in the network to construct the network topology and compute routing paths for serving service requests.

Several protocols have been designed for GMPLS control [RFC3945] including link management [RFC4204], signaling [RFC3471], and routing [RFC4202] protocols. The controllers applying these protocols communicate with each other to exchange resource information and establish LSP. In this way, controllers in different nodes in the network have the same network topology and provision services by their local policies.

2.2. Overview of Centralized Controller System

With the development of SDN technologies, centralized controller system has been introduced to transport networks such as ACTN. In centralized controller system, a controller is aware of the network topology and is responsible for provisioning incoming service requests. In ACTN, multiple abstraction levels are designed and controllers at different levels implement different functions. This kind of abstraction enables multi-vendor, multi-domain, and multi-technology control.

For example in ACTN, an MDSC coordinates several PNCs controlling different domains. Each PNC reports its topology, which can be abstracted, to the MDSC, so that the MDSC learns the picture of multiple domains. When a multi-domain service arrives at the MDSC, the MDSC first computes an end-to-end routing path. Then the MDSC splits this path to multiple segment according to domain boundaries and allocate each segment to corresponding PNC for detailed path computation and LSP segment setup. After each PNC reporting the establishment of corresponding LSP segment, this multi-domain service is accommodated.

2.3. GMPLS Control Interwork with Centralized Controller System

Centralized controller system as ACTN provides the architecture and communication between central controllers of different abstraction levels to coordinate multiple domains. Within each domain, GMPLS control can be applied to each NE. The bottom-level central controller like PNC can act as a NE to collect network information and initiate LSP. Following figure shows an example of GMPLS interworking with ACTN.

```
                        +----------+
                        |   MDSC   |
                        +----------+
                          ^      ^
                          |      |
                +---------+      +---------+
                |  RESTConf / YANG models  |
                V                          V
           +---------+                +---------+
           |   PNC   |                |   PNC   |
           +---------+                +---------+
              ^   ^                      ^   ^
              |   |                      |   |
       OSPF-TE|   |PCEP           OSPF-TE|   |PCEP
              |   |                      |   |
              |   V                      |   V
         .-------------.   Inter-   .-------------.
        /               \  domain  /               \
       |       LMP       |  link  |       LMP       |
      |      OSPF-TE     ==========     OSPF-TE      |
       |     RSVP-TE     |        |     RSVP-TE     |
        \               /          \               /
          '------------'             '------------'
           GMPLS domain               GMPLS domain
```

Figure 1: Example of GMPLS interworks with ACTN

In Figure 1, each domain runs GMPLS control. The PNC listens LSAs flooded in the domain and learns the topology. For path computation in the domain with PNC implementing a PCE, NEs use PCEP to ask the PNC for a path and get replies. The MDSC communicates with PNCs using RESTConf or YANG models. As a PNC has learned its domain topology, it can report the topology to the MDSC. When a service arrives, the MDSC computes the path and coordinates PNCs to establish the corresponding LSP segment.

3. Link Management Protocol

Link management protocol (LMP) [RFC4204] runs between a pair of nodes and is used to manage TE links. In addition to setup and maintain control channels, LMP can be used to verify the data link connectivity and correlate the link property. In this way, link resources, which are fundamental resources in the network, are discovered by both ends of the link.

4. Routing Options

In GMPLS control, link state information is flooded within the network as defined in [RFC4202]. Each node in the network can build the network topology according to the flooded link state information. Routing protocols such as OSPF-TE [RFC4203] and ISIS-TE [RFC5307] have been extended to support different interfaces in GMPLS.

In centralized controller system, central controller can be placed at the GMPLS network and passively receive the information flooded in the network. In this way, the central controller can construct and update the network topology.

4.1. OSPF-TE

OSPF-TE is introduced for TE networks in [RFC3630]. OSPF extensions have been defined in [RFC4203] to enable the capability of link state information for GMPLS network. Based on this work, OSPF protocol has been extended to support technology-specific routing. The routing protocol for OTN, WSON and optical flexi-grid network are defined in [RFC7138], [RFC7688] and [I-D.ietf-ccamp-flexible-grid-ospf-ext], respectively.

4.2. ISIS-TE

ISIS-TE is introduced for TE networks in [RFC5305] and is extended to support GMPLS routing functions [RFC5307], and has been updated to [RFC7074] to support the latest GMPLS switching capability and Types fields.

5. Path Computation

Once a controller learn the network topology, it can utilize the available resources to serve service requests by performing path computation. Path computation is one of the key objectives in various types of controllers. In the given architecture, it is possible for different components that have the capability to compute the path.

5.1. Constraint-based Path Computing in GMPLS Control

In GMPLS control, a routing path is computed by the ingress node [RFC3473] and is based on the ingress node TED. Constraint-based path computation is performed according to the local policy of the ingress node.

5.2. Path Computation Element (PCE)

PCE has been introduced in [RFC4655] as a functional component that provides services to compute path in a network. In [RFC5440], the path computation is accomplished by using the Traffic Engineering Database (TED), which maintains the link resources in the network. The emergence of PCE efficiently improve the quality of network planning and offline computation, but there is a risk that the computed path may be infeasible if there is a diversity requirement, because stateless PCE has no knowledge about the former computed paths.

To address this issue, stateful PCE has been proposed in [RFC8231]. Besides the TED, an additional LSP Database (LSP-DB) is introduced to archive each LSP computed by the PCE. In this way, PCE can easily figure out the relationship between the computing path and former computed paths. In this approach, PCE provides computed paths to PCC, and then PCC decides which path is deployed and when to be established.

In PCE Initiation [I-D.ietf-pce-pce-initiated-lsp], PCE is allowed to trigger the PCC to setup, maintenance, and teardown of the PCE-initiated LSP under the stateful PCE model. This would allow a dynamic network that is centrally controlled and deployed.

In centralized controller system, the PCE can be implement in a central controller, and the central controller performs path computation according to its local policies. On the other hand, the PCE can also be placed outside of the central controller. In this case, the central controller acts as a PCC to request path computation to the PCE through PCEP.

6. Signaling Options

Signaling mechanism is used to setup LSPs in GMPLS control. Messages are sent hop by hop between the ingress node and the egress node of the LSP to allocate labels. Once the labels are allocated along the path, the LSP setup is accomplished. Signaling protocols such as RSVP-TE [RFC3473] and CR-LDP [RFC3472] have been extended to support different interfaces in GMPLS.

In centralized controller system, the central controller can manage LSPs by using PCE-initiation [I-D.ietf-pce-pce-initiated-lsp] to notify the corresponding ingress node. The ingress node will maintain the LSP through GMPLS signaling.

6.1. RSVP-TE

RSVP-TE is introduced in [RFC3209] and extended to support GMPLS signaling in [RFC3473]. Several label formats are defined for a generalized label request, a generalized label, suggested label and label sets. Based on [RFC3473], RSVP-TE has been extended to support technology-specific signaling. The RSVP-TE extensions for OTN, WSON, optical flexi-grid network are defined in [RFC7139], [RFC7689], and [RFC7792], respectively.

6.2. CR-LDP

In order to support the label formats and signaling mechanism defined in [RFC3471], CR-LDP is extended in [RFC3472]. Several label formats are defined and bidirectional LSPs are supported.

7. Interworking Scenarios

7.1. Topology Collection & Synchronization

Topology information is necessary on both network elements and controllers. The topology on network element is usually raw information, while the topology on the controller can be either raw or abstracted. Three different abstraction method has been described in [I-D.ietf-teas-actn-framework], and different controllers can select the corresponding method depending on application.

When there are changes in the network topology, the related network element(s) need to report to all the other network elements, together with the controller, to sync up the topology information. The inter-NE synchronization can be achieved via protocols mentioned in section 3 and 4. The topology synchronization between NE can controllers can either be achieved by PCEP-LS in [PCEP-LS] or netconf protocol with YANG model.

7.2. Multi-domain/layer Service Provisioning

Based on the topology information on controllers and network elements, service provisioning can be deployed. Plenty of methods have been specified for single domain service provisioning, such as using PCEP and RSVP-TE.

Multi-domain/layer service provisioning would request coordination among the controller hierarchies. Given the service request, the end-to-end delivery procedure may include interactions on MPI and SBI. The computation for a cross-domain/layer path is usually completed by MDSC, who has a global view of the topologies. Then the configuration is decomposed into lower layer controllers, including both MDSC and PNCs, to configure the network elements to set up the path.

A combination of the centralized and distributed protocols may be necessary for the interaction between network elements and controller. A typical example would be the PCE Initiation scenario, in which a PCE message (PCInitiate) is sent from the controller to the first-end node, and then trigger a RSVP procedure along the path.

7.3. Recovery

The GMPLS recovery functions are described in [RFC4426]. Two models, span protection and end-to-end protection and restoration, are discussed with different protection schemes and message exchange requirements. Related RSVP-TE extensions to support end-to-end recovery is described in [RFC4872]. The extensions in [RFC4872] include protection, restoration, preemption, and rerouting mechanisms for an end-to-end LSP. Besides end-to-end recovery, a GMPLS segment recovery mechanism is defined in [RFC4873]. By introducing secondary record route objects, LSP segment can be switched to another path like fast reroute [RFC4090].

For the recovery with controllers, timely interaction between controller and network elements are required. Usually the re-routing can be decomposed into path computation and delivery, the controller can take some advantage in the path computation due to the global topology view. And the delivery can be achieved by the procedure described in section 7.2.

7.4. Controller Reliability

Given the important role in the network, the reliability of controller is critical. Once a controller is shut down, the network should operate as well. It can be either achieved by controller back up or functionality back up. There are several of controller backup or federation mechanisms in the literature. It is also more reliable to have some function back up in the network element, to guarantee the performance in the network.

8. Network Management

TBD.

9. Security Considerations

TBD.

10. IANA Considerations

This document requires no IANA actions.

11. References

11.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", RFC 2119, March 1997.

[RFC3209] Awduche, D., Berger, L., Gan, D., Li, T., Srinivasan, V., and G. Swallow, "RSVP-TE: Extensions to RSVP for LSP Tunnels", RFC 3209, December 2001.

[RFC3471] Berger, L., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Functional Description", RFC 3471, January 2003.

[RFC3472] Ashwood-Smith, P., Ed. and L. Berger, Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Constraint-based Routed Label Distribution Protocol (CR-LDP) Extensions", RFC 3472, January 2003.

[RFC3473] Berger, L., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Extensions", RFC 3473, January 2003.

[RFC3630] Katz, D., Kompella, K., and D. Yeung, "Traffic Engineering (TE) Extensions to OSPF Version 2", RFC 3630, September 2003.

[RFC3945] Mannie, E., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Architecture", RFC 3945, October 2004.

[RFC4090] Pan, P., Ed., Swallow, G., Ed., and A. Atlas, Ed., "Fast Reroute Extensions to RSVP-TE for LSP Tunnels", RFC 4090, May 2005.

[RFC4202] Kompella, K., Ed. and Y. Rekhter, Ed., "Routing Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4202, October 2005.

[RFC4203] Kompella, K., Ed. and Y. Rekhter, Ed., "OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4203, October 2005.

[RFC4204] Lang, J., Ed., "Link Management Protocol (LMP)", RFC 4204, October 2005.

[RFC4426] Lang, J., Ed., Rajagopalan, B., Ed., and D. Papadimitriou, Ed., "Generalized Multi-Protocol Label witching (GMPLS) Recovery Functional Specification", RFC 4426, March 2006.

[RFC4655] Farrel, A., Vasseur, J., and J. Ash, "A Path Computation Element (PCE)-Based Architecture", RFC 4655, August 2006.

[RFC4872] Lang, J., Ed., Rekhter, Y., Ed., and D. Papadimitriou, Ed., "RSVP-TE Extensions in Support of End-to-End Generalized Multi-Protocol Label Switching (GMPLS) Recovery", RFC 4872, May 2007.

[RFC4873] Berger, L., Bryskin, I., Papadimitriou, D., and A. Farrel, "GMPLS Segment Recovery", RFC 4873, May 2007.

[RFC5305] Li, T. and H. Smit, "IS-IS Extensions for Traffic Engineering", RFC 5305, October 2008.

[RFC5307] Kompella, K., Ed. and Y. Rekhter, Ed., "IS-IS Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 5307, October 2008.

[RFC5440] Vasseur, JP., Ed. and JL. Le Roux, Ed., "Path Computation Element (PCE) Communication Protocol (PCEP)", RFC 5440, March 2009.

[RFC7074] Berger, L. and J. Meuric, "Revised Definition of the GMPLS Switching Capability and Type Fields", RFC 7074, November 2013.

[RFC7138] Ceccarelli, D., Ed., Zhang, F., Belotti, S., Rao, R., and J. Drake, "Traffic Engineering Extensions to OSPF for GMPLS Control of Evolving G.709 Optical Transport Networks", RFC 7138, March 2014.

[RFC7139] Zhang, F., Ed., Zhang, G., Belotti, S., Ceccarelli, D., and K. Pithewan, "GMPLS Signaling Extensions for Control of Evolving G.709 Optical Transport Networks", RFC 7139, March 2014.

[RFC7688] Lee, Y., Ed. and G. Bernstein, Ed., "GMPLS OSPF Enhancement for Signal and Network Element Compatibility for Wavelength Switched Optical Networks", RFC 7688, November 2015.

[RFC7689] Bernstein, G., Ed., Xu, S., Lee, Y., Ed., Martinelli, G., and H. Harai, "Signaling Extensions for Wavelength Switched Optical Networks", RFC 7689, November 2015.

[RFC7792] Zhang, F., Zhang, X., Farrel, A., Gonzalez de Dios, O., and D. Ceccarelli, "RSVP-TE Signaling Extensions in Support of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks", RFC 7792, March 2016.

[RFC8231] Crabbe, E., Minei, I., Medved, J., and R. Varga, "Path Computation Element Communication Protocol (PCEP) Extensions for Stateful PCE", RFC 8231, September 2017.

[I-D.ietf-ccamp-flexible-grid-ospf-ext] Zhang, X., Zheng, H., Casellas, R., Dios, O., and D. Ceccarelli, "GMPLS OSPF-TE Extensions in support of Flexi-grid DWDM networks", draft-ietf-ccamp-flexible-grid-ospf-ext-09 (work in progress), February 2017.

[RFC8281] Crabbe, E., Minei, I., Sivabalan, S., and R. Varga, "PCEP Extensions for PCE-initiated LSP Setup in a Stateful PCE Model", October 2017.

[I-D.ietf-teas-actn-framework] Ceccarelli, D. and Y. Lee, "Framework for Abstraction and Control of Traffic Engineered Networks", draft-ietf-teas-actn-framework work in progress.

[I-D. dhodylee-pce-pcep-ls] Dhody, D., Lee, Y., Ceccarelli, D., "PCEP Extensions for Distribution of Link-State and TE Information", draft-dhodylee-pce-pcep-ls, work in progress.

11.2. Informative References

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A YANG Data Model for Optical Transport Network Client Signals
draft-zheng-ccamp-otn-client-signal-yang-02

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 Traffic-engineered models and OTN models, however, the access to the network has not been described. These information is useful to both client and provider.

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

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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. Currently there has been topology and tunnel model defined for transport network, such as [I-D.ietf-ccamp-otn-topo-yang] and [I-D.ietf-ccamp-otn-tunnel-model], which has described the network model between PEs. However, there is a missing piece between the PE and CE, which is expected to be solved in this document.

This document defines a data model of all OTN network client signals, using YANG language defined in [RFC7950]. The model can be used by applications exposing to a transport controller via a REST 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 OTN tunnel to be set up to support this service;

o To request/update an end-to-end service by using an existing OTN tunnel;

o To receive notification with regard to the information change of the given service;

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 [RFC7139]. 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].

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 [I-D.ietf-netmod-yang-tree-diagrams]. 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. OTN Client Signal Overview

The OTN is usually a server-layer network designed to provide connectivity services for a client-layer network to carry the client traffic opaquely across the server-layer network resources. A transport network may be constructed from equipments utilizing any of a number of different transport technologies such as the evolving optical transport infrastructure (SONET/SDH and OTN) or packet transport as epitomized by the MPLS Transport Profile (MPLS-TP).

A full list of G-PID was summarized in [RFC7139], which can be divided into a few categories of OTN client signal. The first category of service type is Ethernet related, including GE, WAN/LAN to support EPL/EVPL service. Another category of service type would be client service which includes SDH/SONET, OTN service, SAN storage (FICON, Fiber Channel) and other applications such as video service (HD-SDI, 3G-SDI, etc.).

The G-PID signals can also be categorized into transparent and non-transparent. Examples of transparent signals may include Ethernet, ODU, STM-n and so on. In this approach the OTN devices do not is not aware of the client signal type, and this information is only necessary among the controllers. Once 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 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 in this draft are applicable for both of the two above categories.

4. YANG Model for OTN Client Signal

4.1. YANG Tree for Ethernet Service

```
module: ietf-eth-tran-service
    +--rw etht-svc
       +--rw globals
       |  +--rw etht-svc-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-descr?          string
          +--rw etht-svc-type?           etht-types:service-type
          +--rw access-provider-id?      te-types:te-global-id
          +--rw access-client-id?        te-types:te-global-id
          +--rw access-topology-id?      te-types:te-topology-id
          +--rw etht-svc-access-ports* [access-port-id]
          |  +--rw access-port-id                             uint16
          |  +--rw access-node-id?                            te-types:te-node-id
          |  +--rw access-ltp-id?                             te-types:te-tp-id
          |  +--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-name?   string
          |  |  +--:(asymmetrical)
          |  |     +--rw ingress-bandwidth-profile-name?          string
          |  |     +--rw egress-bandwidth-profile-name?           string
          |  +--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 second-tag!
          |        |           +--rw tag-type?     etht-types:eth-tag-type
          |        |           +--rw vlan-value?   etht-types:vlanid
```

```
          |        +--:(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 second-tag!
          |              |        +--rw tag-type?     etht-types:eth-tag-type
          |              |        +--rw vlan-value?   etht-types:vlanid
          |              +--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 second-tag!
          |                       +--rw tag-type?     etht-types:eth-tag-type
          |                       +--rw vlan-value?   etht-types:vlanid
          +--rw etht-svc-tunnels* [tunnel-name]
          |  +--rw tunnel-name                string
          |  +--rw (svc-multiplexing-tag)?
          |  |  +--:(other)
          |  |  +--:(none)
          |  |  +--:(vlan-tag)
          |  |  +--:(pw)
          |  +--rw src-split-horizon-group?   string
          |  +--rw dst-split-horizon-group?   string
          +--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
          +--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
             +--ro sending-rate-too-high?     uint32
             +--ro sending-rate-too-low?      uint32
             +--ro receiving-rate-too-high?   uint32
             +--ro receiving-rate-too-low?    uint32
```

4.2. YANG Tree for other OTN 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-descr?     string
             +--rw access-provider-id?   te-types:te-global-id
             +--rw access-client-id?     te-types:te-global-id
             +--rw access-topology-id?   te-types: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 svc-tunnels* [tunnel-name]
             |  +--rw tunnel-name    string
             +--ro operational-state?    identityref
             +--ro provisioning-state?   identityref
```

5. YANG Code for OTN Client Signal

5.1. The ETH Service YANG Code

```
<CODE BEGINS> file "ietf-eth-tran-service@2018-03-01.yang"

module ietf-eth-tran-service {

  namespace "urn:ietf:params:xml:ns:yang:ietf-eth-tran-service";

  prefix "ethtsvc";

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

  import ietf-te-types {
    prefix "te-types";
  }
```

```
  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);
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    ";

  description
    "This module defines a YANG data model for describing
     the Ethernet transport services.";

        revision 2018-03-01 {
                description
                        "Initial revision";
                reference
                        "draft-zheng-ccamp-otn-client-signal-yang";
        }

  /*
  Groupings
  */

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

    leaf tag-type {
      type etht-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 etht-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.";
    }
  }

  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 = "s-vlan-tag-typ
e" and ' +
                                'tag-type = "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 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 the ingress
          and the egress bandwidth profile.";

        leaf ingress-egress-bandwidth-profile-name {
          type "string";
          description
            "Name of the bandwidth profile.";
        }
      }
      case asymmetrical {
        description
          "Ingress and egress bandwidth profiles can be specified.";
        leaf ingress-bandwidth-profile-name {
          type "string";
          description
            "Name of the bandwidth profile used in
             the ingress direction.";
        }
        leaf egress-bandwidth-profile-name {
          type "string";
          description
            "Name of the bandwidth profile used in
             the egress direction.";
        }
      }
    }
  }

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

    leaf access-node-id {
      type te-types:te-node-id;
      description
        "The identifier of the access node in
         the ETH transport 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 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 = "classi
fy-s-vlan" and ' +
                                                  'tag-type = "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
          "include parameters for vlan-operation";
      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 etht-svc-tunnel-parameters {
    description
      "ETH transport services tunnel parameters";

    leaf tunnel-name {
      type string;
      description
        "TE service tunnel instance name.";
    }
    choice svc-multiplexing-tag {
      description
        "Service multiplexing is optional and flexible.";

      case other {
        /*
         placeholder to support proprietary multiplexing
         (for further discussion)
        */
                    }

      case none {
        /* no additional information is needed */
                    }

      case vlan-tag {
        /*
          No additional information is needed
          The C-Tag or S-Tag used for service mulitplexing is defined
          by the VLAN classification and operations configured in the
          etht-svc-access-parameters grouping
        */
                    }

      case pw {
        /* to be completed (for further discussion) */
                    }
    }

/*
        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 Tunne
l source TTP";
                }
                leaf dst-split-horizon-group {
                        type string;
                        description "Identify a split horizon group at the Tunne
l destination TTP";
                }
  }

  grouping te-topology-identifier {
    description
        "An identifier to uniquely identify the TE topology.";
    leaf access-provider-id {
      type te-types:te-global-id;
      description
        "An identifier to uniquely identify a provider.";
    }
    leaf access-client-id {
      type te-types:te-global-id;
      description
        "An identifier to uniquely identify a client.";
    }
    leaf access-topology-id {
      type te-types:te-topology-id;
      description
        "Identifies the topology the
        service access ports belong to.";
    }
  }

        grouping  etht-svc-pm-threshold_config {
                description
                        "Configuraiton parameters for Ethernet service PM thresh
olds.";

                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 p2p ETH transport service.";
    }

                leaf etht-svc-descr {
                        type string;
```

```
                        description
                                "Description of the ETH transport service.";
                }

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

                uses te-topology-identifier;

    list etht-svc-access-ports {
      key access-port-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 trasport services access port instances.";

      leaf access-port-id {
        type uint16;
        description
          "ID of the service access port instance";
      }
        uses etht-svc-access-parameters;
    }
    list etht-svc-tunnels {
      key tunnel-name;
      description
        "List of the TE Tunnels supporting the ETH
        transport service.";

      uses etht-svc-tunnel-parameters;
    }
                container pm-config {
                        description
                                "ETH service performance monitoring";

                        leaf pm-enable {
                                type boolean;
                                description
                                        "Boolean value indicating whether PM is
enabled.";
```

```
                        }
                        uses etht-svc-pm-threshold_config;
                }
    leaf admin-status {
      type identityref {
        base te-types:tunnel-state-type;
      }
      default te-types:tunnel-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.";
                }
                uses etht-svc-pm-stats;
  }

  /*
  Data nodes
  */

  container etht-svc {
    description
```

```
      "ETH transport services.";

    container globals {
      description
      "ETH profile information.";
      list etht-svc-bandwidth-profiles {
        key bandwidth-profile-name;
        description
          "List of bandwidth profile templates used by
           Ethernet services.";

        uses etht-types:etht-bandwidth-profiles;
      }
    }

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

      uses etht-svc-instance_config;

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

        uses etht-svc-instance_state;
      }
    }
  }
}

<CODE ENDS>
```

5.2. YANG Code for ETH transport type

```
<CODE BEGINS> file "ietf-eth-tran-types@2018-03-01.yang"
module ietf-eth-tran-types {

        namespace "urn:ietf:params:xml:ns:yang:ietf-eth-tran-types";

        prefix "etht-types";

        organization
                "Internet Engineering Task Force (IETF) CCAMP WG";
```

```
  contact
    "
      WG List: <mailto:ccamp@ietf.org>

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        Giuseppe Fioccola (giuseppe.fioccola@telecomitalia.it);
    ";

        description
                "This module defines the ETH transport types.";

        revision 2018-03-01 {
                description
                        "Initial revision";
                reference
                        "draft-zheng-ccamp-otn-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-L
AN).";
        }

        /*
        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 VL
AN Ids, or
                                contiguous ranges of VLAN Ids. Valid VLAN Ids mu
st 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.";
        }

        /*
        Grouping Definitions
        */
        grouping etht-bandwidth-profiles {
                description
                        "Bandwidth profile configuration paramters.";

                leaf bandwidth-profile-name {
                        type string;
                        description
                                "Name of the bandwidth profile.";
                }
                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 in KBytes";
                }
                leaf EIR {
                        type uint64;
                        /*
                                Need to indicate that EIR is not supported by RF
C 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 weather the color-mode is color-aware
 or color-blind.";
                }
                leaf coupling-flag {
                        type boolean;
                        /*
                                Need to indicate that Coupling Flag is defined o
nly for MEF 10

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


<CODE ENDS>
```

5.3. Other OTN client signal YANG Code

```
<CODE BEGINS> file "ietf-trans-client-service@2018-02-09.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";
  }
```

```
  import ietf-otn-types {
    prefix "otn-types";
  }

  organization
    "Internet Engineering Task Force (IETF) CCAMP WG";
  contact
    "

      ID-draft editor:
        Aihua Guo (aihuaguo@huawei.com);
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        Xufeng Liu (Xufeng_Liu@jabil.com);
        Giuseppe Fioccola (giuseppe.fioccola@telecomitalia.it);
    ";

  description
    "This module defines a YANG data model for describing
     simple transport client services.";

  revision 2018-02-09 {
    description
      "Initial version";
    reference
      "ADD REFERENCE HERE";
  }

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

    leaf access-node-id {
      type te-types:te-node-id;
      description
        "The identifier of the access node in the underlying
         transport 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 otn-types:client-signal;
       }
       description
         "Identifiies the client signal type associated with this port";
                 }
     }

   grouping client-svc-tunnel-parameters {
     description
       "Transport client services tunnel parameters";

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

   grouping te-topology-identifier {
     description
       "description";
     leaf access-provider-id {
       type te-types:te-global-id;
       description
         "An identifier to uniquely identify a provider.";
     }

     leaf access-client-id {
       type te-types:te-global-id;
       description
         "An identifier to uniquely identify a client.";
     }

     leaf access-topology-id {
       type te-types:te-topology-id;
       description
         "Identifies the topology the service access ports belong to.";
     }
   }

   grouping  client-svc-instance_config {
     description
       "Configuraiton parameters for client services.";
```

```
    leaf client-svc-name {
      type string;
      description
        "Name of the p2p transport client service.";
    }

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

        uses te-topology-identifier;

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

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

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

        list svc-tunnels {
          key tunnel-name;
          description
                "List of the TE Tunnels supporting the client service.";
          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 service operational state.";
        }
        leaf provisioning-state {
          type identityref {
                base te-types:lsp-state-type;
          }
          config false;
          description "Client service provisioning state.";
        }
  }

  /*
   * 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>
```

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 assume that there won't be much common part between Ethernet service model and other client signals service model, therefore the two groups of models are defined independently.

It is possible that there can be something in common for Ethernet service and other client signal service. If there is any need to construct a base model, we will also work it out in this draft. It is worth noting that a previous ID draft

[I-D.zhang-teas-transport-service-model] is also addressing the same problem by defining a base model. But unfortunately we have not found any chance to augment to that model. Need to determine how we should go depending on the discussion in WG.

7. IANA Considerations

TBD.

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-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.

10. Acknowledgements

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12. References

12.1. Normative References

[I-D.ietf-ccamp-otn-topo-yang]
zhenghaomian@huawei.com, z., Fan, Z., Sharma, A., Liu, X., Belotti, S., Xu, Y., Wang, L., and O. Dios, "A YANG Data Model for Optical Transport Network Topology", draft-ietf-ccamp-otn-topo-yang-02 (work in progress), October 2017.

[I-D.ietf-ccamp-otn-tunnel-model]
zhenghaomian@huawei.com, z., Fan, Z., Sharma, A., Rao, R., Belotti, S., Lopezalvarez, V., Li, Y., and Y. Xu, "OTN Tunnel YANG Model", draft-ietf-ccamp-otn-tunnel-model-01 (work in progress), October 2017.

[I-D.ietf-teas-yang-te-topo]
Liu, X., Bryskin, I., Beeram, V., Saad, T., Shah, H., and O. Dios, "YANG Data Model for Traffic Engineering (TE) Topologies", draft-ietf-teas-yang-te-topo-15 (work in progress), February 2018.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <https://www.rfc-editor.org/info/rfc6241>.

[RFC7139] Zhang, F., Ed., Zhang, G., Belotti, S., Ceccarelli, D., and K. Pithewan, "GMPLS Signaling Extensions for Control of Evolving G.709 Optical Transport Networks", RFC 7139, DOI 10.17487/RFC7139, March 2014, <https://www.rfc-editor.org/info/rfc7139>.

[RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, DOI 10.17487/RFC7950, August 2016, <https://www.rfc-editor.org/info/rfc7950>.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <https://www.rfc-editor.org/info/rfc8040>.

12.2. Informative References

[I-D.ietf-netmod-yang-tree-diagrams]
Bjorklund, M. and L. Berger, "YANG Tree Diagrams", draft-ietf-netmod-yang-tree-diagrams-06 (work in progress), February 2018.

[I-D.zhang-teas-transport-service-model]
Zhang, X. and J. Ryoo, "A Service YANG Model for Connection-oriented Transport Networks", draft-zhang-teas-transport-service-model-01 (work in progress), October 2016.

[RFC7062] Zhang, F., Ed., Li, D., Li, H., Belotti, S., and D. Ceccarelli, "Framework for GMPLS and PCE Control of G.709 Optical Transport Networks", RFC 7062, DOI 10.17487/RFC7062, November 2013, <https://www.rfc-editor.org/info/rfc7062>.

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