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Microwave Radio Link YANG Data Models
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Abstract

YANG model for managing microwave radio link functionality.

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1. Introduction

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].

This document is being discussed within the microwave community.

This document defines a YANG RFC 6020 [RFC6020] module for managing the radio link functionality of a microwave node. The YANG module is augmenting RFC 7223 [RFC7223] in order to model a microwave link and interface in analogy with most other data links in a router or switch.

In summary, the YANG module defined in this internet draft is: ericsson-radio-link (should be renamed to something like: if-microwave-radio-link) - Defines the model for basic configuration of a microwave radio link.

1.1. Terminology

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].

Other definitions to clarify....

1.2. Tree Diagrams

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in these diagrams is as follows:

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write), and "ro" means state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" means a presence container, 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. Objectives

The aim of of the YANG models contained in this draft is to provide the model that is required to implement the basic radio link management of microwave devices.

This model may be augmented by vendor specific YANG modules in order to manage product specific functionality.

However, the intention is that it should not be necessary to have any vendor specific extensions to the YANG model defined in this document to implement standard microwave radio link connectivity.

3. Microwave Model

The microwave radio link model provides the parameters for managing the radio link part of a microwave node.

The "ericsson-radio-link" YANG module has the following structure:

```
module: ericsson-radio-link
   +--rw radio-link-protection-pairs!
   |  +--rw radio-link-protection-pair* [name]
   |     +--rw name                            string
   |     +--rw protection-switch-mode?         enumeration
   |     +--rw revertive-preferred-tx?         if:interface-ref
   |     +--rw revertive-wait-to-restore?      uint16
   |     +--rw radio-link-protection-members*   if:interface-ref
   +--ro radio-link-protection-pairs-state
   |  +--ro radio-link-protection-pair* [name]
   |     +--ro name                 string
   |     +--ro protection-status?   enumeration
   +--rw xpic-pairs!
   |  +--rw xpic-pair* [name]
```

```
   |     +--rw name            string
   |     +--rw mode?           boolean
   |     +--rw xpic-members*   if:interface-ref
   +--rw mimo-groups!
      +--rw mimo-group* [name]
         +--rw name            string
         +--rw mode?           boolean
         +--rw mimo-members*   if:interface-ref
augment /if:interfaces/if:interface:
   +--rw id?                       string
   +--rw mode?                     enumeration
   +--rw expected-far-end-id?      string
   +--rw far-end-id-check?         boolean
   +--rw carrier-terminations*     if:interface-ref
   +--rw rlp-pairs*                -> /radio-link-protection-pairs/radio-link-prot
ection-pair/name
   +--rw xpic-pairs*               -> /xpic-pairs/xpic-pair/name
   +--rw mimo-group?               -> /mimo-groups/mimo-group/name
augment /if:interfaces/if:interface:
   +--rw carrier-id?                    string
   +--rw tx-frequency?                  uint32
   +--rw rx-frequency?                  uint32
   +--rw duplex-distance?               uint32
   +--rw duplex-config?                 boolean
   +--rw polarization?                  enumeration
   +--rw power
   |  +--rw (power-mode)?
   |     +--:(RTPC)
   |     |  +--rw selected-output-power?        int16
   |     +--:(ATPC)
   |        +--rw selected-min-output-power?    int16
   |        +--rw selected-max-output-power?    int16
   |        +--rw target-input-power-far-end?   int16
   +--rw reference-sec?                 enumeration
   +--rw coding-modulation
   |  +--rw (coding-modulation-mode)?
   |     +--:(fixed)
   |     |  +--rw selected-cm?        coding-modulation
   |     +--:(adaptive)
   |        +--rw selected-min-acm?   coding-modulation
   |        +--rw selected-max-acm?   coding-modulation
   +--rw if-loop?                       boolean
   +--rw rf-loop?                       boolean
   +--rw ct-performance-thresholds
      +--rw input-power-alarm-threshold?          int16
      +--rw output-power-alarm-threshold?         int16
      +--rw ber-alarm-threshold?                  enumeration
      +--rw rl-1-threshold-level?                 int16
      +--rw rlts-1-15min-set-alarm-threshold?     uint16
```

```
      +--rw rlts-1-15min-reset-alarm-threshold?   uint16
      +--rw rlts-1-24h-set-alarm-threshold?       uint32
      +--rw tl-1-threshold-level?                 int16
      +--rw tlts-1-15min-set-alarm-threshold?     uint16
      +--rw tlts-1-15min-reset-alarm-threshold?   uint16
      +--rw tlts-1-24h-set-alarm-threshold?       uint32
      +--rw es-15min-set-alarm-threshold?         uint16
      +--rw es-15min-reset-alarm-threshold?       uint16
      +--rw es-24h-set-alarm-threshold?           uint32
      +--rw ses-15min-set-alarm-threshold?        uint16
      +--rw ses-15min-reset-alarm-threshold?      uint16
      +--rw ses-24h-set-alarm-threshold?          uint32
      +--rw bbe-15min-set-alarm-threshold?        uint32
      +--rw bbe-15min-reset-alarm-threshold?      uint32
      +--rw bbe-24h-set-alarm-threshold?          uint32
      +--rw acm-15min-set-alarm-threshold?        uint16
      +--rw acm-15min-reset-alarm-threshold?      uint16
      +--rw acm-24h-set-alarm-threshold?          uint32
augment /if:interfaces-state/if:interface:
   +--ro tx-oper-status?       enumeration
   +--ro actual-ouput-power?   decimal64
   +--ro actual-input-power?   decimal64
   +--ro actual-tx-cm?         coding-modulation
   +--ro actual-rx-cm?         coding-modulation
   +--ro selected-min-speed?   yang:gauge64
   +--ro selected-max-speed?   yang:gauge64
   +--ro xpic-status?          enumeration
   +--ro mimo-status?          enumeration
   +--ro actual-snir?          decimal64
   +--ro actual-xpi?           decimal64
   +--ro actual-si?            decimal64
   +--ro capabilities
      +--ro min-tx-frequency?             uint32
      +--ro max-tx-frequency?             uint32
      +--ro min-rx-frequency?             uint32
      +--ro max-rx-frequency?             uint32
      +--ro duplex-type?                  enumeration
      +--ro channel-separation?           decimal64
      +--ro available-min-output-power?   int16
      +--ro available-max-output-power?   int16
      +--ro available-min-acm?            coding-modulation
      +--ro available-max-acm?            coding-modulation
      +--ro available-min-speed?          yang:gauge64
      +--ro available-max-speed?          yang:gauge64
augment /if:interfaces-state/if:interface/if:statistics:
   +--ro min-rltm?   decimal64
   +--ro max-rltm?   decimal64
   +--ro min-tltm?   decimal64
```

```
   +--ro max-tltm?   decimal64
   +--ro bbe?        yang:counter32
   +--ro es?         yang:counter32
   +--ro ses?        yang:counter32
   +--ro uas?        yang:counter32
   +--ro bber?       decimal64
   +--ro esr?        decimal64
   +--ro sesr?       decimal64
```

4. Microwave Module

This YANG module augments the interfaces defined in RFC 7223 [RFC7223].

```
<CODE BEGINS> file "ericsson-radio-link.yang"
module ericsson-radio-link {
  namespace "urn:com:ericsson:yang:common:radio-link";
  prefix rl;

  import ietf-yang-types {
    prefix yang;
  }
  import ietf-interfaces {
    prefix if;
  }
  import iana-if-type {
    prefix ianaift;
  }

  organization
    "Ericsson AB";
  contact
    "jonas.ahlberg@ericsson.com";
  description
    "This is a module for the entities in
     a generic microwave system.";

  revision 2016-03-11 {
    description
      "Draft revision.";
    reference "";
  }

  /*
   * 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.";
  }

  /*
   * Typedefs
   */

  typedef coding-modulation {
    type enumeration {
      enum "half-bpsk-strong";
      enum "half-bpsk";
      enum "half-bpsk-light";
      enum "bpsk-strong";
      enum "bpsk";
      enum "bpsk-light";
      enum "4-qam-strong";
      enum "4-qam";
      enum "4-qam-light";
      enum "16-qam-strong";
      enum "16-qam";
      enum "16-qam-light";
      enum "32-qam-strong";
      enum "32-qam";
      enum "32-qam-light";
      enum "64-qam-strong";
      enum "64-qam";
      enum "64-qam-light";
      enum "128-qam-strong";
      enum "128-qam";
      enum "128-qam-light";
      enum "256-qam-strong";
      enum "256-qam";
      enum "256-qam-light";
      enum "512-qam-strong";
      enum "512-qam";
      enum "512-qam-light";
      enum "1024-qam-strong";
      enum "1024-qam";
      enum "1024-qam-light";
      enum "2048-qam-strong";
```

```
      enum "2048-qam";
      enum "2048-qam-light";
      enum "4096-qam-strong";
      enum "4096-qam";
      enum "4096-qam-light";
    }
    description
      "The coding and modulation schemes supported.";
  }

  /*
   * Radio Link Terminal (RLT) - Configuration data nodes
   */

  augment "/if:interfaces/if:interface" {
    when "if:type = 'rl: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 enumeration {
        enum "1+0";
        enum "1+1";
        enum "2+0";
        enum "2+1";
        enum "2+2";
        enum "3+0";
        enum "3+1";
        enum "3+2";
        enum "3+3";
        enum "4+0";
        enum "4+1";
        enum "4+2";
        enum "4+3";
        enum "4+4";
        enum "5+0";
        enum "5+1";
        enum "5+2";
        enum "5+3";
        enum "6+0";
```

```
        enum "6+1";
        enum "6+2";
        enum "7+0";
        enum "7+1";
        enum "8+0";
      }
      default "1+0";
      description
        "A description of the mode in which the radio link
         terminal is configured. The format is X+Y.
                 X represent the number of bonded carrier terminations.
                 Y represent the number of protecting carrier
                 terminations.";
    }
    leaf expected-far-end-id {
      type string;
      default "";
      description
        "Expected ID of the radio link terminal at far-end.";
    }
    leaf far-end-id-check {
      type boolean;
      default "false";
      description
        "Enable(true)/disable(false) check of the ID of the
         radio link terminal at far-end. When true, the system
         verifies that far-end radio link terminal ID is equal to
         the expected. If ok then the radio link terminal status
         is UP. If not ok, then the status is stated as DOWN.";
    }
    leaf-list carrier-terminations {
      type if:interface-ref;
      must "/if:interfaces/if:interface[if:name = current()]"
         + "/if:type = 'carrier-termination'" {
        description
          "The type of interface must be
           'carrier-termination'.";
      }
      description
        "A list of references to carrier terminations
         included in the radio link terminal.";
    }
    leaf-list rlp-pairs {
      type leafref {
        path "/rl:radio-link-protection-pairs/"
           + "rl:radio-link-protection-pair/rl:name";
      }
      description
```

```
          "A list of references to the carrier termination
           pairs configured for radio link protection in this
           radio link terminal.";
      }
      leaf-list xpic-pairs {
        type leafref {
          path "/rl:xpic-pairs/rl:xpic-pair/rl:name";
        }
        description
          "A list of references to the XPIC pairs used in this
           radio link terminal. One pair can be used by two
           terminals.";
      }
      leaf mimo-group {
        type leafref {
          path "/rl:mimo-groups/rl:mimo-group/rl:name";
        }
        description
          "A reference to the MIMO group used in this
           radio link terminal. One group can be used by more
           than one terminal.";
      }
    }

    /*
     * Carrier Termination - Configuration data nodes
     */

    augment "/if:interfaces/if:interface" {
      when "if:type = 'rl: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-frequency {
        type uint32;
        units "kHz";
```

```
      default "0";
      description
        "Selected transmitter frequency.";
    }
    leaf rx-frequency {
      type uint32;
      units "kHz";
      default "0";
      description
        "Selected receiver frequency.
         Only writeable when duplex-config=disabled and
         duplex-type=variable.";
    }
    leaf duplex-distance {
      type uint32;
      units "kHz";
      default "0";
      description
        "Distance between Tx & Rx frequencies.
         Only writeable when duplex-config=true and
         duplex-type=variable.";
    }
    leaf duplex-config {
      type boolean;
      default "false";
      description
        "Enable (true) or disable (false) configuration of
         rxFrequency using a defined duplex distance.";
    }
    leaf polarization {
      type enumeration {
        enum "horizontal";
        enum "vertical";
        enum "not-specified";
      }
      default "not-specified";
      description
        "Polarization - A textual description for info only.";
    }
    container power {
      description
        "Container including the choice of power mode.";
      choice power-mode {
        description
          "A choice of Remote Transmit Power Control (RTPC)
           or Automatic Transmit Power Control (ATPC).";
        case RTPC {
          leaf selected-output-power {
```

```
            type int16 {
              range "-99..40";
            }
            units "dBm";
            description
              "Selected output power in RTPC mode.";
          }
        }
        case ATPC {
          leaf selected-min-output-power {
            type int16 {
              range "-99..40";
            }
            units "dBm";
            description
              "Selected minimum output power in
               ATPC mode.";
          }
          leaf selected-max-output-power {
            type int16 {
              range "-99..40";
            }
            units "dBm";
            description
              "Selected maximum output power in
               ATPC mode.";
          }
                leaf target-input-power-far-end {
                      type int16 {
                              range "-99..-30";
                      }
                      units "dBm";
                      description
                              "The wanted received input power at far-end,
                               when running ATPC.";
                }
        }
      }
    }
    leaf reference-sec {
      type enumeration {
        enum "1";
        enum "2";
        enum "3";
        enum "4l";
        enum "4h";
        enum "5l";
        enum "5la";
```

```
        enum "5lb";
        enum "5h";
        enum "5ha";
        enum "5hb";
        enum "6l";
        enum "6la";
        enum "6lb";
        enum "6h";
        enum "6ha";
        enum "6hb";
        enum "7";
        enum "7a";
        enum "7b";
        enum "8";
        enum "8a";
        enum "8b";
      }
      description
        "Each modulation is compliant to a Spectrum Efficiency
         Class (SEC). When running Adaptive Coding/Modulation,
         one SEC has to be selected for all the coding/
         modulations between selected-min-acm and
         selected-max-acm. This parameter is called Reference
         SEC. This setting might affect
         available-max-output-power, in order to fulfill
         spectrum requirements.";
    }
    container coding-modulation {
      description
        "Container including the choice of coding &
         modulation mode.";
      choice coding-modulation-mode {
        description
          "A choice of fixed or adaptive coding/modulation mode.";
        case fixed {
          leaf selected-cm {
            type coding-modulation;
            description
              "Selected fixed coding/modulation.";
          }
        }
        case adaptive {
          leaf selected-min-acm {
            type coding-modulation;
            description
              "Selected minimum coding/modulation.
               Adaptive coding/modulation shall not go
               below this value.";
```

```
          }
          leaf selected-max-acm {
            type coding-modulation;
            description
              "Selected maximum coding/modulation.
               Adaptive coding/modulation shall not go
               above this value.";
          }
        }
      }
    }
    leaf if-loop {
      type boolean;
      default "false";
      description
        "Enable (true) or disable (false) the IF loop,
                which loops the signal back to the client side
                (not the radio side).";
    }
    leaf rf-loop {
      type boolean;
      default "false";
      description
        "Enable (true) or disable (false) the RF loop,
                which loops the signal back to the client side
                (not the radio side).";
    }
    container ct-performance-thresholds {
      description
        "Specification of thresholds for when alarms should
         be sent and cleared for various performance counters.";
    leaf input-power-alarm-threshold {
      type int16 {
        range "-99..-30";
      }
      units "dBm";
      default "-93";
      description
        "Specification of at which input power an alarm should
         be raised.";
    }
      leaf output-power-alarm-threshold {
        type int16 {
          range "-99..40";
        }
        units "dBm";
        description
          "An alarm is sent when the actual output power is
```

```
          below the specified threshold.";
      }
      leaf ber-alarm-threshold {
        type enumeration {
          enum "10e-9";
          enum "10e-8";
          enum "10e-7";
          enum "10e-6";
          enum "10e-5";
          enum "10e-4";
          enum "10e-3";
          enum "10e-2";
          enum "10e-1";
                }
        default "10e-6";
        description
          "Specification of at which BER an alarm should
           be raised.";
      }
      leaf rl-1-threshold-level {
        type int16 {
          range "-99..40";
        }
        units "dBm";
        description
          "Specifies the threshold level for Received Level 1.
           When the received level (input power) is below this
           level the Received Level Threshold Seconds 1 (RLTS1)
           is counted.";
      }
      leaf rlts-1-15min-set-alarm-threshold {
        type uint16 {
          range "1..900";
        }
        units "seconds";
        description
          "Specifies the threshold value in seconds for RLTS1.
           An alarm is send as soon as the received level has
           been below the Received Level 1 threshold for the
           number of seconds configured in this threshold
           during a 15 minutes interval.";
      }
      leaf rlts-1-15min-reset-alarm-threshold {
        type uint16 {
          range "1..900";
        }
        units "seconds";
        description
```

```
            "Specifies the threshold value in seconds for RLTS1.
             An alarm clearing is sent when the received level
             has been below the RLTS1 threshold less seconds than
             indicated by this threshold for a 15 minutes
             interval.";
      }
      leaf rlts-1-24h-set-alarm-threshold {
        type uint32 {
          range "1..86400";
        }
        units "seconds";
        description
          "Specifies the threshold value in seconds for RLTS1.
           An alarm is send as soon as the received level has
           been below the Received Level 1 threshold for the
           number of seconds configured in this threshold
           during a 24 hours interval.
           The alarm is cleared after the next 24 hours if
           the threshold is not crossed.";
      }
      leaf tl-1-threshold-level {
        type int16 {
          range "-100..35";
        }
        units "dBm";
        description
          "Specifies the threshold level for Transmitted
           Level 1. When the transmitted level (output power)
           is above this level the Transmitted Level Threshold
           Seconds 1 (TLTS1) is counted.";
      }
      leaf tlts-1-15min-set-alarm-threshold {
        type uint16 {
          range "1..900";
        }
        units "seconds";
        description
          "Specifies the threshold value in seconds for TLTS1.
           An alarm is send as soon as the transmitted level
           has been above the Transmitted Level 1 threshold
           for the number of seconds configured in this
           threshold during a 15 minutes interval.";
      }
      leaf tlts-1-15min-reset-alarm-threshold {
        type uint16 {
          range "1..900";
        }
        units "seconds";
```

```
          description
            "Specifies the threshold value in seconds for TLTS1.
             An alarm clearing is sent when the transmitted level
             has been above the TLTS1 threshold less seconds than
             indicated by this threshold for a 15 minutes
             interval.";
        }
        leaf tlts-1-24h-set-alarm-threshold {
          type uint32 {
            range "1..86400";
          }
          units "seconds";
          description
            "Specifies the threshold value in seconds for TLTS1.
             An alarm is send as soon as the transmitted level
             has been above the Transmitted Level 1 threshold for
             the number of seconds configured in this threshold
             during a 24 hours interval.
             The alarm is cleared after the next 24 hours if
             the threshold is not crossed.";
        }
        leaf es-15min-set-alarm-threshold {
          type uint16 {
            range "1..900";
          }
          units "seconds";
          description
            "An alarm is sent when the number of Errored Seconds
             (es) exceeds the specified threshold in a
             15 minutes interval.";
        }
        leaf es-15min-reset-alarm-threshold {
          type uint16 {
            range "1..900";
          }
          units "seconds";
          description
            "An alarm clearing is sent when the the number of
             Errored Seconds (es) has been below the specified
             threshold in a 15 minutes interval.";
        }
        leaf es-24h-set-alarm-threshold {
          type uint32 {
            range "1..86400";
          }
          units "seconds";
          description
            "An alarm is sent when the number of Errored Seconds
```

```
            (es) exceeds the specified threshold in a
            24 hours interval.
            The alarm is cleared after the next 24 hours if
            the threshold is not crossed.";
      }
      leaf ses-15min-set-alarm-threshold {
        type uint16 {
          range "1..900";
        }
        units "seconds";
        description
          "An alarm is sent when the number of Severely
           Errored Seconds (ses) exceeds the specified
           threshold in a 15 minutes interval.";
      }
      leaf ses-15min-reset-alarm-threshold {
        type uint16 {
          range "1..900";
        }
        units "seconds";
        description
          "An alarm clearing is sent when the the number of
           Severely Errored Seconds (ses) has been below the
           specified threshold in a 15 minutes interval.";
      }
      leaf ses-24h-set-alarm-threshold {
        type uint32 {
          range "1..86400";
        }
        units "seconds";
        description
          "An alarm is sent when the number of Severely
           Errored Seconds (ses) exceeds the specified
           threshold in a 24 hours interval.
           The alarm is cleared after the next 24 hours if
           the threshold is not crossed.";
      }
      leaf bbe-15min-set-alarm-threshold {
        type uint32;
        units "number of block errors";
        description
          "An alarm is sent when the number of Background
           Block Errors (bbe) exceeds the specified threshold
           in a 15 minutes interval.";
      }
      leaf bbe-15min-reset-alarm-threshold {
        type uint32;
        units "number of block errors";
```

```
          description
            "An alarm clearing is sent when the the number of
             Background Block Errors (bbe) has been below the
             specified threshold in a 15 minutes interval.";
        }
        leaf bbe-24h-set-alarm-threshold {
          type uint32;
          units "number of block errors";
          description
            "An alarm is sent when the number of Background
             Block Errors (bbe) exceeds the specified threshold
             in a 24 hours interval.
             The alarm is cleared after the next 24 hours if
             the threshold is not crossed.";
        }
        leaf acm-15min-set-alarm-threshold {
          type uint16 {
            range "1..900";
          }
          units "seconds";
          description
            "An alarm is sent when time in minimum coding &
             modulation (selected-min-acm) exceeds the specified
                     threshold in a 15 minutes interval.";
        }
        leaf acm-15min-reset-alarm-threshold {
          type uint16 {
            range "1..900";
          }
          units "seconds";
          description
            "An alarm clearing is sent when the the time in
             minimum coding & modulation (selected-min-acm)
                     has been below the specified threshold in a 15 minutes
                     interval.";
        }
        leaf acm-24h-set-alarm-threshold {
          type uint32 {
            range "1..86400";
          }
          units "seconds";
          description
            "An alarm is sent when time in minimum coding &
             modulation (selected-min-acm) exceeds the specified
                     threshold in a 24 hours interval.
             The alarm is cleared after the next 24 hours if
             the threshold is not crossed.";
        }
```

```
    }
  }

  /*
   * Carrier Termination - Operational state data nodes
   */

  augment "/if:interfaces-state/if:interface" {
    when "if:type = 'rl:carrier-termination'";
    description
      "Addition of state data nodes for carrier termination to
       the standard Interface state data model, for interfaces of
       the type 'carrier-termination'.";
    leaf tx-oper-status {
      type enumeration {
        enum "off";
        enum "on";
        enum "standby";
      }
      description
        "Shows the operative status of the transmitter.";
    }
    leaf actual-ouput-power {
      type decimal64 {
        fraction-digits 1;
        range "-99..40";
      }
      units "dBm";
      description
        "Actual transmitted output power (0.1 dBm resolution).";
    }
    leaf actual-input-power {
      type decimal64 {
        fraction-digits 1;
        range "-99..-20";
      }
      units "dBm";
      description
        "Actual input power (0.1 dBm resolution).";
    }
    leaf actual-tx-cm {
      type coding-modulation;
      description
        "Actual coding/modulation in transmitting direction.";
    }
    leaf actual-rx-cm {
      type coding-modulation;
      description
```

```
        "Actual coding/modulation in receiving direction.";
    }
    leaf selected-min-speed {
      type yang:gauge64;
      units "bit/s";
      description
        "Selected minimum speed, derived from selected-min-acm
         (adaptive) or selected-cm (fixed).";
    }
    leaf selected-max-speed {
      type yang:gauge64;
      units "bit/s";
      description
        "Selected maximum speed, derived from selected-max-acm
         (adaptive) or selected-cm (fixed).";
    }
    leaf xpic-status {
      type enumeration {
        enum "locked";
        enum "unlocked";
        enum "na";
      }
      description
        "Status of the XPIC. Only valid if XPIC is enabled.";
    }
    leaf mimo-status {
      type enumeration {
        enum "locked";
        enum "unlocked";
        enum "na";
      }
      description
        "Status of the MIMO. Only valid if MIMO is enabled.";
    }
    leaf actual-snir {
      type decimal64 {
        fraction-digits 1;
        range "0..99";
      }
      units "dB";
      description
        "Actual signal to noise plus interference ratio.
         (0.1 dB resolution).";
    }
    leaf actual-xpi {
      type decimal64 {
        fraction-digits 1;
        range "0..99";
```

```
      }
      units "dBc";
      description
        "The actual carrier to cross-polar interference.
         Only valid if XPIC is enabled. (0.1 dBc resolution).";
    }
    leaf actual-si {
      type decimal64 {
        fraction-digits 1;
        range "-99..99";
      }
      units "dBc";
      description
        "Actual MIMO Spatial Interference.
         Only valid if MIMO is enabled. (0.1 dBc resolution).";
    }
    container capabilities {
      description
        "Capabilities of the 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 duplex-type {
        type enumeration {
          enum "fixed";
          enum "variable";
```

```
        }
        description
          "The duplex type is given by the equipment used.
           It can be a fixed duplex distance or a variable
           distance which can be configured by selecting
           rx-frequency or duplex-distance.";
      }
      leaf channel-separation {
                type decimal64 {
                        fraction-digits 1;
                }
                units "MHz";
        description
          "The amount of bandwidth allocated to a carrier.";
      }
      leaf available-min-output-power {
        type int16;
        units "dBm";
        description
          "The minimum output power supported.";
      }
      leaf available-max-output-power {
        type int16;
        units "dBm";
        description
          "The maximum output power supported.";
      }
      leaf available-min-acm {
        type coding-modulation;
        description
          "Minimum coding-modulation possible to use.";
      }
      leaf available-max-acm {
        type coding-modulation;
        description
          "Maximum coding-modulation possible to use.";
      }
      leaf available-min-speed {
        type yang:gauge64;
        units "bit/s";
        description
          "Minimum speed that can be supported given
           by the available-min-acm.";
      }
      leaf available-max-speed {
        type yang:gauge64;
        units "bit/s";
        description
```

```
          "Maximum speed that can be supported given
           by the available-max-acm.";
      }
    }
  }
  augment "/if:interfaces-state/if:interface/if:statistics" {
    when "../if:type = 'rl:carrier-termination'";
    description
      "Addition of state data nodes in the container statistics
       for carrier terminations to the standard Interface data
       model, for interfaces of the type 'carrier-termination'.";

    leaf min-rltm {
      type decimal64 {
        fraction-digits 1;
        range "-99..-20";
      }
      units "dBm";
      description
        "Minimum input power since last reset.";
    }
    leaf max-rltm {
      type decimal64 {
        fraction-digits 1;
        range "-99..-20";
      }
      units "dBm";
      description
        "Maximum input power since last reset.";
    }

    leaf min-tltm {
      type decimal64 {
        fraction-digits 1;
        range "-99..40";
      }
      units "dBm";
      description
        "Minimum output power since last reset.";
    }
    leaf max-tltm {
      type decimal64 {
        fraction-digits 1;
        range "-99..40";
      }
      units "dBm";
      description
        "Maximum output power since last reset.";
```

```
    }
    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.";
    }
    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.";
    }
    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.";
    }
    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.";
    }
    leaf bber {
      type decimal64 {
        fraction-digits 18;
      }
      units "ratio";
      description
        "Background Block Error (BBER) ratio, that is, the
         ratio of errored blocks to total blocks during a fixed
         measurement interval. BBER does not include any blocks
         during SES and Unavailable Time.";
    }
    leaf esr {
      type decimal64 {
        fraction-digits 18;
```

```
      }
      units "ratio";
      description
        "Errored Seconds (ESR) ratio, that is, the ratio of
         Errored Seconds to Available Time during a fixed
         measurement interval.";
    }
    leaf sesr {
      type decimal64 {
        fraction-digits 18;
      }
      units "ratio";
      description
        "Severely Errored Seconds Ratio (SESR), that is, the
         ratio of SES to total seconds in Available Time during
         a fixed measurement interval.";
    }
  }

  /*
   * Radio Link Protection Pairs - Configuration data nodes
   */

  container radio-link-protection-pairs {
    presence "enables radio link protection configuration";
        description
                "Configuration of radio link protected pairs (1+1) of
                carrier terminations in a radio link. More than one
                protected pair per radio-link-terminal is allowed.";
        list radio-link-protection-pair {
      key "name";
          description
                "List of protected pairs of carrier terminations
                in a radio link.";
      leaf name {
        type string;
        description
          "Name used for identification of the radio
           link protection pair";
      }
      leaf protection-switch-mode {
        type enumeration {
          enum "manual";
          enum "auto";
          enum "auto-and-revertive";
        }
        default "auto";
        description
```

```
          "The mode in which the switching mechanism is
           configured.
                   Auto - System automatically switches from the
           degraded to the other receiver(Rx) or transmitter (Tx).
           Manual - Automatic switching is disabled and
           operator can select Tx manually.
           Auto & Revertive - makes it possible to manually
           set the preferred Tx.";
      }
      leaf revertive-preferred-tx {
        type if:interface-ref;
        must "/if:interfaces/if:interface[if:name =  current()]"
           + "/if:type = 'carrier-termination'" {
          description
            "The type of a preferred-tx must be
             'carrier-termination'.";
        }
        description
          "Association to the preferred carrier
           termination in revertive protection mode.";
      }
      leaf revertive-wait-to-restore {
        type uint16;
        units "seconds";
        default "0";
        description
          "The time to wait before switching back to the
           preferred Tx in Auto & Revertive mode.";
      }
      leaf-list radio-link-protection-members {
        type if:interface-ref;
        must "/if:interfaces/if:interface[if:name = current()]"
           + "/if:type = 'carrier-termination'" {
          description
            "The type of a protection member must be
             'carrier-termination'.";
        }
        min-elements 2;
        max-elements "2";
        description
          "Association to a pair of carrier terminations
           configured for radio link protection and used in
           the radio link terminal.";
      }
    }
  }

  /*
```

```
   * Radio Link Protection Pairs - Configuration state data nodes
   */

  container radio-link-protection-pairs-state {
        config false;
        description
                "State data for radio link protected pairs (1+1) of
                carrier terminations in a radio link.";
    list radio-link-protection-pair {
      key "name";
          description
                "List of protected pairs of carrier terminations
                in a radio link.";
      leaf name {
        type string;
        description
          "Name used for identification of the radio
           link protection pair.";
      }
      leaf protection-status {
        type enumeration {
          enum "unprotected";
          enum "protected";
          enum "unable-to-protect";
        }
        description
          "Status of the protection, in a pair of carrier
           terminations configured in a radio link protection
           mode.";
      }
    }
  }

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

  container xpic-pairs {
    presence "enables xpic configuration";
        description
                "Configuration of carrier termination pairs
                for operation in XPIC mode.";
    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 mode {
          type boolean;
          default "false";
          description
            "Enable(true)/disable(false) XPIC";
        }
        leaf-list xpic-members {
          type if:interface-ref;
          must "/if:interfaces/if:interface[if:name = current()]"
             + "/if:type = 'carrier-termination'" {
            description
              "The type of a xpic-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 {
      presence "enables mimo configuration";
          description
                "Configuration of carrier terminations
                for operation in MIMO mode.";
      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 mode {
          type boolean;
          default "false";
          description
            "Enable(true)/disable(false) MIMO";
        }
        leaf-list mimo-members {
          type if:interface-ref;
          must "/if:interfaces/if:interface[if:name = current()]"
```

```
           + "/if:type = 'carrier-termination'" {
          description
            "The type of a mimo-member must be
             'carrier-termination'.";
        }
        min-elements 2;
        description
          "Association to a MIMO group if used in the radio
           link terminal.";
      }
    }
  }
}
<CODE ENDS>
```

5. Acknowledgements

6. IANA Considerations

This document defines a new YANG module and the authors politely request that IANA assigns unique names to the YANG module file contained within this draft, and also appropriate URIs in the "IETF XML Registry".

7. Security Considerations

The YANG module defined in this memo is designed to be accessed via the NETCONF protocol RFC 6241 [RFC6241]. The lowest NETCONF layer is the secure transport layer and the mandatory to implement secure transport is SSH RFC 6242 [RFC6242]. The NETCONF access control model RFC 6536 [RFC6536] provides the means to restrict access for particular NETCONF users to a pre-configured subset of all available NETCONF protocol operations and content.

There are a number of data nodes defined in this 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. 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:

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>.

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[RFC7223] Bjorklund, M., "A YANG Data Model for Interface Management", RFC 7223, DOI 10.17487/RFC7223, May 2014, <http://www.rfc-editor.org/info/rfc7223>.

8.2. Informative References

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[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>.

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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-yang-00

Abstract

This memo defines a Yang model that translates the SNMP mib module defined in draft-galikunze-ccamp-dwdm-if-snmp-mib for managing single channel optical interface parameters of DWDM applications. This model is to support the optical parameters specified in ITU-T G.698.2 [ITU.G698.2] and application identifiers specified in ITU-T G.874.1 [ITU.G874.1] . Note that G.874.1 encompasses vendor-specific codes, which if used would make the interface a single vendor IaDI and could still be managed.

The Yang model defined in this memo can be used for Optical Parameters monitoring and/or configuration of the endpoints of the multi-vendor IaDI optical link.

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Table of Contents

1. Introduction

This memo defines a Yang model that translates 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 is to support the optical parameters specified in ITU-T G.698.2 [ITU.G698.2], application identifiers specified in ITU-T G.874.1 [ITU.G874.1] and the Optical Power at Transmitter and Receiver side. Note that G.874.1 encompasses vendor-specific codes, which if used would make the interface a single vendor IaDI and could still be managed.‘

[Editor’s note: In G.698.2 this corresponds to the optical path from point S to R; network media channel is also used and explained in draft-ietf-ccamp-flexi-grid-fwk-02]

Management will be performed at the edges of the network media channel (i.e., at the transmitters and receivers attached to the S and R reference points respectively) for the relevant parameters specified in G.698.2 [ITU.G698.2], G.798 [ITU.G798], G.874 [ITU.G874], and the performance parameters specified in G.7710/Y.1701 [ITU-T G.7710] and G.874.1 [ITU.G874.1].

G.698.2 [ITU.G698.2] is primarily intended for metro applications that include optical amplifiers. 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 does not 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. The Recommendation currently includes unidirectional DWDM applications at 2.5 and 10 Gbit/s (with 100 GHz and 50 GHz channel frequency spacing). Work is still under way for 40 and 100 Gbit/s interfaces. There is possibility for extensions to a lower channel frequency spacing. This document specifically refers to the "application code" defined in the G.698.2 [ITU.G698.2] and included in the Application Identifier defined in G.874.1 [ITU.G874.1] and G.872 [ITU.G872], plus a few optical parameters not included in the G.698.2 application code specification.

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

The building of a yang model describing the optical parameters defined in G.698.2 [ITU.G698.2], and reflected in G.874.1 [ITU.G874.1], allows the different vendors and operator to retrieve, provision and exchange information across the G.698.2 multi-vendor IaDI in a standardized way. In addition to the parameters specified in ITU recommendations the Yang models support also the "vendor specifica application identifier", the Tx and Rx power at the Ss and Rs points and the channel frequency.

The Yang Model, reporting the Optical parameters and their values, characterizes the features and the performances of the optical components and allow a reliable link design in case of multi vendor optical networks.

Although RFC 3591 [RFC3591], which draft-galikunze-ccamp-DWDM-if-snmp-mib is extending, describes and defines the SNMP MIB of a number of key optical parameters, alarms and Performance Monitoring, as this RFC is over a decade old, it is primarily pre-OTN, and a more complete and up-to-date description of optical parameters and processes can be found in the relevant ITU-T Recommendations. The same considerations can be applied to the RFC 4054 [RFC4054].

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 |-->|------|->| OADM |--|------|->| 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
OADM = 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. 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.

4.1.1. Rs-Ss Configuration

The Rs-Ss configuration table allows configuration of Central Frequency, Power and Application codes as described in [ITU.G698.2] and G.694.1 [ITU.G694.1]
This parameter report the current Transceiver Output power, it can be either a setting and measured value (G, S).

Central frequency (see G.694.1 Table 1) (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 (G, S).

Single-channel application codes(see G.698.2):
This parameter indicates the transceiver application code at Ss and Rs as defined in [ITU.G698.2] Chapter 5.4 - this parameter can be called Optical Interface Identifier OII as per [draft-martinelli-wson-interface-class](G).

Number of Single-channel application codes Supported
This parameter indicates the number of Single-channel application codes supported by this interface (G).

Current Laser Output power:
This parameter report the current Transceiver Output power, it can be either a setting and measured value (G, S).

Current Laser Input power:
This parameter report the current Transceiver Input power (G).

PARAMETERS	Get/Set	Reference
Central frequency Value	G,S	G.694.1 S.6
Single-channel application codes	G	G.698.2 S.5.3
Number of Single-channel application codes Supported	G	N.A.
Current Output Power	G,S	N.A.
Current Input Power	G	N.A.

Table 1: Rs-Ss Configuration

4.1.2. Table of Application Codes

This table has a list of Application codes supported by this interface at point R are defined in G.698.2.

Application code Identifier:
The Identifier for the Application code.

Application code Type:
This parameter indicates the transceiver type of application code at Ss and Rs as defined in [ITU.G874.1], that is used by this interface Standard = 0, PROPRIETARY = 1
The first 6 octets of the printable string will be the OUI (organizationally unique identifier) assigned to the vendor whose implementation generated the Application Identifier Code.

Application code Length:
The number of octets in the Application Code.

Application code:
This is the application code that is defined in G.698.2 or the vendor generated code which has the OUI.

4.2. Use Cases

The use cases are described in draft-kdkgall-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 application code/vendor transceiver class/ Central frequency and the output power. The module can also be used to get the list of supported application codes/transceiver class and also the Central frequency/output power/input power of the interface.

```
        module: ietf-ext-xponder-wdm-if
        augment /if:interfaces/if:interface:
            +--rw optIfOChRsSs
                  +--rw if-current-application-code
                  |  +--rw application-code-id    uint8
                  |  +--rw application-code-type  uint8
                  |  +--rw application-code-length uint8
                  |  +--rw application-code?     string
                  +--ro if-supported-application-codes
                  |  +--ro number-application-codes-supported?   uint32
                  |  +--ro application-codes-list* [application-code-id]
                  |     +--ro application-code-id   uint8
                  |     +--rw application-code-type  uint8
                  |     +--rw application-code-length uint8
                  |     +--ro application-code?    string
                  +--rw output-power?                      int32
                  +--ro input-power?                       int32
                  +--rw central-frequency?                 uint32


       notifications:
      +---n opt-if-och-central-frequency-change
      |  +--ro if-name?      leafref
      |  +--ro new-central-frequency
      |     +--ro central-frequency?   uint32
      +---n opt-if-och-application-code-change
      |  +--ro if-name?              leafref
      |  +--ro new-application-code
      |     +--ro application-code-id?   uint8
      |     +--rw application-code-type  uint8
      |     +--rw application-code-length uint8
      |     +--ro application-code?     string
```

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.

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

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

    revision "2016-03-17" {
           description
               "Initial revision.";
           reference
               "";
    }




      grouping opt-if-och-application-code  {
```

```
                description "Application code entity.";
                leaf application-code-id {
                   type uint8 {
                         range "1..255";
                   }
                   description
                         "Id for the Application code";
                }
                leaf application-code-type {
                   type uint8 {
                         range "0..1";
                }
                  description
                         "Type for the Application code
                           0 - Standard, 1 - Proprietory
                           When the Type is Proprietory, then the
                           first 6 octets of the application-code
                           will be the OUI (organizationally unique
                           identifier)";

                }
                leaf application-code-length {
                   type uint8 {
                         range "1..255";
                   }
                   description
                         "Number of octets in the Application code";

                }
                leaf application-code {
                   type string {
                         length "1..255";
                   }
                   description "This parameter indicates the
                        transceiver application code at Ss and Rs as
                        defined in [ITU.G698.2] Chapter 5.3, that
                        is/should be used by this interface.
                        The optIfOChApplicationsCodeList has all the
                        application codes supported by this
                        interface.";

                }
         }


         grouping opt-if-och-application-code-list {
           description "List of Application codes group.";
           leaf number-application-codes-supported {
```

```
              type uint32;
              description "Number of Application codes
                           supported by this interface";
           }
          list application-code-list {
              key "application-code-id";
              description "List of the application codes";
              uses opt-if-och-application-code;
          }
        }


       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-central-frequency {
          description "Interface Central Frequency";
            leaf  central-frequency {
              type uint32;
              description "This parameter indicate This parameter
                      indicates the frequency of this interface ";

             }
       }

        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 opt-if-och-central-frequency {
            description "The new Central Frequency of the
                         interface";
            uses opt-if-och-central-frequency;
            }
         }

         notification opt-if-och-application-code-change {
            description "A change of Application code has been
                         detected.";
            leaf "if-name" {
                type leafref {
                    path "/if:interfaces/if:interface/if:name";
                }
                description "Interface name";
            }
            container new-application-code {
               description "The new application code for the
                   interface";
               uses opt-if-och-application-code;
            }
         }



         augment "/if:interfaces/if:interface" {
           description "Parameters for an optical interface";
           container optIfOChRsSs {
              description "RsSs path configuration for an interface";
              container if-current-application-code {
                   description "Current Application code of the
                                interface";
                   uses opt-if-och-application-code;
               }

               container if-supported-application-codes {
                   config false;
                   description "Supported Application codes of
                                the interface";
                   uses opt-if-och-application-code-list;
               }

               uses opt-if-och-power;

               uses opt-if-och-central-frequency;
```

```
            }
         }
      }
```

<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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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-01

Abstract

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

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Table of Contents

1. Introduction

This extension addresses the use cases described by "draft-kdkgall-ccamp-dwdm-if-mng-ctrl-fwk-00". 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-galikunze-ccamp-dwdm-if-snmp-mib-01" and "draft-dharini-ccamp-dwdm-if-yang-00".

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 |-->|------|->| OADM |--|------|->| 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
OADM = 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-kdkgall-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 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-01" and "draft-dharini-ccamp-dwdm-if-yang-00" 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-galikunze-ccamp-dwdm-if-snmp-mib-01" 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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March 17, 2016

An SNMP MIB extension to RFC3591 to manage optical interface parameters of "G.698.2 single channel" in DWDM applications

draft-galikunze-ccamp-dwdm-if-snmp-mib-01

Abstract

This memo defines a module of the Management Information Base (MIB) used by Simple Network Management Protocol (SNMP) in TCP/IP- based internet. In particular, it defines objects for managing single channel optical interface parameters of DWDM applications, using the approach specified in G.698.2 [ITU.G698.2] . This interface, described in ITU-T G.872, G.709 and G.798, is one type of OTN multi-vendor Intra-Domain Interface (IaDI). This RFC is an extension of RFC3591 to support the optical parameters specified in ITU-T G.698.2 and application identifiers specified in ITU-T G.874.1 [ITU.G874.1]. Note that G.874.1 encompasses vendor-specific codes, which if used would make the interface a single vendor IaDI and could still be managed.

The MIB module defined in this memo can be used for Optical Parameters monitoring and/or configuration of the endpoints of the multi-vendor IaDI based on the Black Link approach.

Status of This Memo

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

This Internet-Draft will expire on September 18, 2016.

Copyright Notice

Table of Contents

1. Introduction

This memo defines a portion of the Management Information Base (MIB) used by Simple Network Management Protocol (SNMP)in TCP/IP-based internets. In particular, it defines objects for managing single channel optical interface parameters of DWDM applications, using the approach specified in G.698.2. This RFC is an extension of RFC3591 to support the optical parameters specified in ITU-T G.698.2 [ITU.G698.2] and application identifiers specified in ITU-T G.874.1 [ITU.G874.1] . Note that G.874.1 encompasses vendor-specific codes, which if used would make the interface a single vendor IaDI and could still be managed.

The Black Link approach allows supporting an optical transmitter/ receiver pair of one vendor to inject an optical tributary signal and run it over an optical network composed of amplifiers, filters, add-drop multiplexers from a different vendor. In the OTN architecture, the 'black-link' represents a pre-certified network media channel conforming to G.698.2 specifications at the S and R reference points.

[Editor's note: In G.698.2 this corresponds to the optical path from point S to R; network media channel is also used and explained in draft-ietf-ccamp-flexi-grid-fwk-02]

Management will be performed at the edges of the network media channel (i.e., at the transmitters and receivers attached to the S and R reference points respectively) for the relevant parameters specified in G.698.2 [ITU.G698.2], G.798 [ITU.G798], G.874 [ITU.G874], and the performance parameters specified in G.7710/Y.1701 [ITU-T G.7710] and G.874.1 [ITU.G874.1].

G.698.2 [ITU.G698.2] is primarily intended for metro applications that include optical amplifiers. 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 does not 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. The Recommendation currently includes unidirectional DWDM applications at 2.5 and 10 Gbit/s (with 100 GHz and 50 GHz channel frequency spacing). Work is still under way for 40 and 100 Gbit/s interfaces. There is possibility for extensions to a lower channel frequency spacing. This document specifically refers to the "application code" defined in the G.698.2 [ITU.G698.2] and included in the Application Identifier defined in G.874.1 [ITU.G874.1] and G.872 [ITU.G872], plus a few optical parameters not included in the G.698.2 application code specification.

This draft refers and supports also the draft-kunze-g-698-2-management-control-framework

The building of an SNMP MIB describing the optical parameters defined in G.698.2 [ITU.G698.2], and reflected in G.874.1 [ITU.G874], allows the different vendors and operator to retrieve, provision and exchange information across the G.698.2 multi-vendor IaDI in a standardized way.

The MIB, reporting the Optical parameters and their values, characterizes the features and the performances of the optical components and allow a reliable black link design in case of multi vendor optical networks.

Although RFC 3591 [RFC3591] describes and defines the SNMP MIB of a number of key optical parameters, alarms and Performance Monitoring, as this RFC is over a decade old, it is primarily pre-OTN, and a more complete and up-to-date description of optical parameters and processes can be found in the relevant ITU-T Recommendations. The same considerations can be applied to the RFC 4054 [RFC4054]

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].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies a MIB module that is compliant to the SMIv2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

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 the linear "black link" approach, for single-channel connection (Ss and Rs) 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 |-->|------|->| OADM |--|------|->| 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
      OADM = Optical Add Drop Mux
```

from Fig. 5.1/G.698.2

Figure 1: Linear Black Link approach

G.698.2 [ITU.G698.2] defines also Ring "Black Link" approach configurations [Fig. 5.2/G.698.2] and Linear "black link" approach for Bidirectional applications[Fig. 5.3/G.698.2]

4.1. Use Cases

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

4.2. Optical Parameters Description

The G.698.2 pre-certified 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 specified in G.698.2 [ITU.G698.2] section 5.3 referring 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 (G) the parameter can be retrieve with a GET, when (S) it can be provisioned by a SET, (G,S) can be either GET and SET.

To support the management of these parameters, the SNMP MIB in RFC 3591 [RFC3591] is extended with a new MIB module defined in section 6 of this document. This new MIB module includes the definition of new configuration table of the OCh Layer for the parameters at Tx (S) and Rx (R).

4.2.1. Rs-Ss Configuration

The Rs-Ss configuration table allows configuration of Central Frequency, Power and Application identifiers as described in [ITU.G698.2] and G.694.1 [ITU.G694.1]
This parameter report the current Transceiver Output power, it can be either a setting and measured value (G, S).

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), in particular Section 6/G.694.1 (G, S).

Single-channel application identifiers (see G.698.2):
   This parameter indicates the transceiver application identifier at Ss and Rs as defined in [ITU.G698.2] Chapter 5.4 - this parameter can be called Optical Interface Identifier OII as per [draft-martinelli-wson-interface-class] (G).

Number of Single-channel application identifiers Supported

This parameter indicates the number of Single-channel application codes supported by this interface (G).

Current Laser Output power:
This parameter report the current Transceiver Output power, see RFC3591.

Current Laser Input power:
This parameter report the current Transceiver Input power see RFC3591.

PARAMETERS	Get/Set	Reference
Central Frequency	G,S	G.694.1 S.6
Single-channel Application Identifier number in use	G	G.874.1
Single-channel Application Identifier Type in use	G	G.874.1
Single-channel Application Identifier in use	G	G.874.1
Number of Single-channel Application Identifiers Supported	G	N.A.
Current Output Power	G,S	RFC3591
Current Input Power	G	RFC3591

Table 1: Rs-Ss Configuration

4.2.2. Table of Application Identifiers

This table has a list of Application Identifiers supported by this interface at point R are defined in G.698.2.

Application Identifier Number:
The number that uniquely identifies the Application Identifier.

Application Identifier Type:
Type of application Identifier: STANDARD / PROPRIETARY in G.874.1

Note: if the A.I. type = PROPRIETARY, the first 6 Octets of the Application Identifier (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.

Application Identifier:
This is the application Identifier that is defined in G.874.1.

4.3. Use of ifTable

This section specifies how the MIB II interfaces group, as defined in RFC 2863 [RFC2863], is used for the link ends of a black link. Only the ifGeneralInformationGroup will be supported for the ifTable and the ifStackTable to maintain the relationship between the OCh and OPS layers. The OCh and OPS layers are managed in the ifTable using IfEntries that correlate to the layers depicted in Figure 1.

For example, a device with TX and/or RX will have an Optical Physical Section (OPS) layer, and an OCh layer. There is a one to n relationship between the OPS and OCh layers.

EDITOR NOTE: Reason for changing from OChr to OCh: Edition 3 of G.872 removed OChr from the architecture and G.709 was subsequently updated to account for this architectural change.

Figure 2 In the following figures, opticalPhysicalSection are abbreviated as OPS.

```
      _____________________
                           \
         Path Data Unit    |\
             (ODUk)        | \
      _____________________|  \ __________________
                           |   |                  |  >
        Tandem Data Unit   |   |                  |  |
             (ODUkT)       |   |    OCh  Layer    |   > n och IfEntries
      _____________________|   |                  |  |
                           |   |__________________|  >
              Optical      |  /|                  |  >
          Transport Unit   | / |                  |  |
              (OTUk)       |/  |    OPSn Layer    |   > m ops IfEntries
      _____________________/   |                  |  |
                               |__________________|  >
```

Figure 2: OTN Layers for OPS and OCh

Each opticalChannel IfEntry is mapped to one of the m opticalPhysicalSection IfEntries, where m is greater than or equal to 1. Conversely, each opticalTransPhysicalSection port entry is mapped to one of the n opticalChannel IfEntries, where n is greater than or equal to 1.

The design of the Optical Interface MIB provides the option to model an interface either as a single bidirectional object containing both sink and source functions or as a pair of unidirectional objects, one containing sink functions and the other containing source functions.

If the sink and source for a given protocol layer are to be modelled as separate objects, then there need to be two ifTable entries, one that corresponds to the sink and one that corresponds to the source, where the directionality information is provided in the configuration tables for that layer via the associated Directionality objects. The agent is expected to maintain consistent directionality values between ifStackTable layers (e.g., a sink must not be stacked in a 1:1 manner on top of a source, or vice-versa), and all protocol layers that are represented by a given ifTable entry are expected to have the same directionality.

When separate ifTable entries are used for the source and sink functions of a given physical interface, association between the two uni-directional ifTable entries (one for the source function and the other for the sink functions) should be provided. It is recommended that identical ifName values are used for the two ifTable entries to indicate such association. An implementation shall explicitly state what mechanism is used to indicate the association, if ifName is not used.

4.3.1. Use of ifTable for OPS Layer

Only the ifGeneralInformationGroup needs to be supported.

ifTable Object	Use for OTN OPS Layer
ifIndex	The interface index.
ifDescr	Optical Transport Network (OTN) Optical Physical Section (OPS)
ifType	opticalPhysicalSection (xxx)

<<<Editor Note: Need new IANA registration value for xxx. >>>

ifTable Object	Use for OTN OPS Layer
ifSpeed	Actual bandwidth of the interface in bits per second. If the bandwidth of the interface is greater than the maximum value of 4,294,967,295 then the maximum value is reported and ifHighSpeed must be used to report the interface’s speed.
ifPhysAddress	An octet string with zero length. (There is no specific address associated with the interface.)
ifAdminStatus	The desired administrative state of the interface. Supports read-only access.
ifOperStatus	The operational state of the interface. The value lowerLayerDown(7) is not used, since there is no lower layer interface. This object is set to notPresent(6) if a component is missing, otherwise it is set to down(2) if either of the objects optIfOPSnCurrentStatus indicates that any defect is present.

ifLastChange   The value of sysUpTime at the last change in ifOperStatus.

ifName   Enterprise-specific convention (e.g., TL-1 AID) to identify the physical or data entity associated with this interface or an OCTET STRING of zero length. The enterprise-specific convention is intended to provide the means to reference one or more enterprise-specific tables.

ifLinkUpDownTrapEnable Default value is enabled(1). Supports read-only access.

ifHighSpeed   Actual bandwidth of the interface in Mega-bits per second. A value of n represents a range of 'n-0.5' to 'n+0.499999'.

ifConnectorPresent Set to true(1).

ifAlias   The (non-volatile) alias name for this interface as assigned by the network manager.

4.3.2. Use of ifTable for OCh Layer

Use of ifTable for OCh Layer See RFC 3591 [RFC3591] section 2.4

4.3.3. Use of ifStackTable

Use of the ifStackTable and ifInvStackTable to associate the opticalPhysicalSection and opticalChannel interface entries is best illustrated by the example shown in Figure 3. The example assumes an ops interface with ifIndex i that carries two multiplexed OCh interfaces with ifIndex values of j and k, respectively. The example shows that j and k are stacked above (i.e., multiplexed into) i. Furthermore, it shows that there is no layer lower than i and no layer higher than j and/or k.

Figure 3

HigherLayer	LowerLayer
0	j
0	k
j	i
k	i
i	0

Figure 3: Use of ifStackTable for an OTN port

For the inverse stack table, it provides the same information as the interface stack table, with the order of the Higher and Lower layer interfaces reversed.

5. Structure of the MIB Module

EDITOR NOTE:text will be provided based on the MIB module in Section 6

6. Object Definitions

EDITOR NOTE: Once the scope in Section 1 and the parameters in Section 4 are finalized, a MIB module will be defined. It could be an extension to the OPT-IF-MIB module of RFC 3591. >>>

```
   OPT-IF-698-MIB DEFINITIONS ::= BEGIN

      IMPORTS
              MODULE-IDENTITY,
              OBJECT-TYPE,
              Gauge32,
              Integer32,
              Unsigned32,
              Counter64,
              transmission,
              NOTIFICATION-TYPE
                      FROM SNMPv2-SMI
              TEXTUAL-CONVENTION,
              RowPointer,
              RowStatus,
              TruthValue,
              DisplayString,
              DateAndTime
                      FROM SNMPv2-TC
              SnmpAdminString
                      FROM SNMP-FRAMEWORK-MIB
              MODULE-COMPLIANCE, OBJECT-GROUP
                      FROM SNMPv2-CONF
              ifIndex
                      FROM IF-MIB
              optIfMibModule
                     FROM OPT-IF-MIB;


   --  This is the MIB module for the optical parameters -
   --  Application codes associated with the black link end points.



   optIfXcvrMibModule MODULE-IDENTITY
       LAST-UPDATED "201401270000Z"
       ORGANIZATION "IETF Ops/Camp MIB Working Group"
       CONTACT-INFO
          "WG charter:
             http://www.ietf.org/html.charters/

           Mailing Lists:
           Editor: Gabriele Galimberti
           Email:  ggalimbe@cisco.com"
       DESCRIPTION
          "The MIB module to describe Black Link tranceiver
           characteristics to rfc3591.
```

```
           Copyright (C) The Internet Society (2014).  This version
           of this MIB module is an extension to rfc3591;  see the RFC
           itself for full legal notices."
       REVISION  "201305050000Z"
       DESCRIPTION
          "Draft version 1.0"
       REVISION  "201305050000Z"
       DESCRIPTION
          "Draft version 2.0"
       REVISION  "201302270000Z"
       DESCRIPTION
          "Draft version 3.0"
       REVISION  "201307020000Z"
       DESCRIPTION
          "Draft version 4.0
           Changed the draft to include only the G.698 parameters."
       REVISION  "201311020000Z"
       DESCRIPTION
          "Draft version 5.0
           Mib has a table of application code/vendor
           transcievercode G.698"
       REVISION  "201401270000Z"
       DESCRIPTION
          "Draft version 6.0"
       REVISION  "201407220000Z"
       DESCRIPTION
          "Draft version 8.0
          Removed Vendor transceiver code"
       REVISION  "201502220000Z"
       DESCRIPTION
          "Draft version 11.0
           Added reference to OUI in the first 6 Octets of a
           proprietary Application code
           Added a Length field for the Application code
           Changed some names"
       REVISION  "201507060000Z"
       DESCRIPTION
          "Draft version 12.0
          Added Power Measurement Use Cases
          and ITU description" "
          ::= { optIfMibModule 4 }


       ::= { optIfMibModule 4 }

   -- Addition to the RFC 3591 objects
   optIfOChSsRsGroup   OBJECT IDENTIFIER  ::= { optIfXcvrMibModule 1 }
```

```
   -- OCh Ss/Rs config table
   -- The application code/vendor tranceiver class for the Black Link
   -- Ss-Rs will be added to the OchConfigTable

   optIfOChSsRsConfigTable OBJECT-TYPE
       SYNTAX  SEQUENCE OF OptIfOChSsRsConfigEntry
       MAX-ACCESS  not-accessible
       STATUS  current
       DESCRIPTION
           "A table of Och General config extension parameters"
       ::= {  optIfOChSsRsGroup 1 }

   optIfOChSsRsConfigEntry OBJECT-TYPE
       SYNTAX      OptIfOChSsRsConfigEntry
       MAX-ACCESS  not-accessible
       STATUS  current
       DESCRIPTION
           "A conceptual row that contains G.698 parameters for an
           interface."
       INDEX   { ifIndex }
       ::= { optIfOChSsRsConfigTable 1 }

   OptIfOChSsRsConfigEntry ::=
       SEQUENCE {
           optIfOChCentralFrequency                    Unsigned32,
           optIfOChCfgApplicationIdentifierNumber      Unsigned32,
           optIfOChCfgApplicationIdentifierType        Unsigned32,
           optIfOChCfgApplicationIdentifierLength      Unsigned32,
           optIfOChCfgApplicationIdentifier            DisplayString,
           optIfOChNumberApplicationCodesSupported     Unsigned32
      }

   optIfOChCentralFrequency  OBJECT-TYPE
       SYNTAX  Unsigned32
       MAX-ACCESS  read-write
       UNITS "THz"
       STATUS  current
       DESCRIPTION
           " This parameter indicates the frequency of this interface.
           "
       ::= { optIfOChSsRsConfigEntry  1 }

   optIfOChCfgApplicationIdentifierNumber  OBJECT-TYPE
       SYNTAX Unsigned32
       MAX-ACCESS  read-write
       STATUS  current
       DESCRIPTION
           "This parameter uniquely indicates the transceiver
```

```
             application code at Ss and Rs as defined in [ITU.G874.1],
             that is used by this interface.
             The optIfOChSrcApplicationIdentifierTable has all the
             application codes supported by this interface. "
        ::= { optIfOChSsRsConfigEntry  2 }

    optIfOChCfgApplicationIdentifierType  OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS  read-write
        STATUS  current
        DESCRIPTION
            "This parameter indicates the transceiver type of
             application code at Ss and Rs as defined in [ITU.G874.1],
             that is used by this interface.
             The optIfOChSrcApplicationIdentifierTable has all the
             application codes supported by this interface
             Standard = 0, PROPRIETARY = 1. "
        ::= { optIfOChSsRsConfigEntry  3 }

    optIfOChCfgApplicationIdentifierLenght  OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS  read-write
        STATUS  current
        DESCRIPTION
            "This parameter indicates the number of octets in the
             Application Identifier.
             "
        ::= { optIfOChSsRsConfigEntry  4 }


    optIfOChCfgApplicationIdentifier  OBJECT-TYPE
        SYNTAX DisplayString
        MAX-ACCESS  read-write
        STATUS  current
        DESCRIPTION
            "This parameter indicates the transceiver application code
             at Ss and Rs as defined in [ITU.G698.2] Chapter 5.3, that
             is used by this interface. The
             optIfOChSrcApplicationCodeTable has all the application
             codes supported by this interface.
             If the optIfOChCfgApplicationIdentifierType is 1
             (Proprietary), then the first 6 octets of the printable
             string will be the OUI (organizationally unique identifier)
             assigned to the vendor whose implementation generated the
             Application Identifier."
        ::= { optIfOChSsRsConfigEntry  5 }

    optIfOChNumberApplicationIdentifiersSupported  OBJECT-TYPE
```

```
        SYNTAX Unsigned32
        MAX-ACCESS  read-only
        STATUS  current
        DESCRIPTION
           " Number of Application codes supported by this interface."
        ::= { optIfOChSsRsConfigEntry  6 }

    -- Table of Application codes supported by the interface
    --  OptIfOChSrcApplicationCodeEntry

    optIfOChSrcApplicationIdentifierTable  OBJECT-TYPE
        SYNTAX  SEQUENCE OF OptIfOChSrcApplicationIdentifierEntry
        MAX-ACCESS  not-accessible
        STATUS  current
        DESCRIPTION
            "A Table of Application codes supported by this interface."
        ::= { optIfOChSsRsGroup 2 }

    optIfOChSrcApplicationIdentifierEntry OBJECT-TYPE
        SYNTAX      OptIfOChSrcApplicationIdentifierEntry
        MAX-ACCESS  not-accessible
        STATUS  current
        DESCRIPTION
            "A conceptual row that contains the Application code for
             this interface."
        INDEX  { ifIndex, optIfOChApplicationIdentiferNumber  }
        ::= { optIfOChSrcApplicationIdentifierTable 1 }

    OptIfOChSrcApplicationIdentifierEntry ::=
        SEQUENCE {
            optIfOChApplicationIdentiferNumber            Integer32,
            optIfOChApplicationIdentiferType              Integer32,
            optIfOChApplicationIdentiferLength            Integer32,
            optIfOChApplicationIdentifier                 DisplayString
         }


    optIfOChApplicationIdentiferNumber  OBJECT-TYPE
        SYNTAX  Integer32 (1..255)
        MAX-ACCESS  not-accessible
        STATUS  current
        DESCRIPTION
          " The number/identifier of the application code supported at
            this interface. The interface can support more than one
            application codes.
          "
        ::= { optIfOChSrcApplicationIdentifierEntry  1}
```

```
   optIfOChApplicationIdentiferType  OBJECT-TYPE
       SYNTAX  Integer32 (1..255)
       MAX-ACCESS  read-only
       STATUS  current
       DESCRIPTION
         " The type of identifier of the application code supported at
           this interface. The interface can support more than one
           application codes.
           Standard = 0, PROPRIETARY = 1
         "
       ::= { optIfOChSrcApplicationIdentifierEntry  2}


   optIfOChApplicationIdentiferLength  OBJECT-TYPE
       SYNTAX  Integer32 (1..255)
       MAX-ACCESS  read-only
       STATUS  current
       DESCRIPTION
         " This parameter indicates the number of octets in the
           Application Identifier.
         "
       ::= { optIfOChSrcApplicationIdentifierEntry  3}

   optIfOChApplicationIdentifier  OBJECT-TYPE
       SYNTAX DisplayString
       MAX-ACCESS  read-only
       STATUS  current
       DESCRIPTION
           " The application code supported by this interface DWDM
             link.
             If the optIfOChApplicationIdentiferType is 1 (Proprietary),
             then the first 6 octets of the printable string will be
             the OUI (organizationally unique identifier) assigned to
             the vendor whose implementation generated the Application
             Identifier."
       ::= { optIfOChSrcApplicationIdentifierEntry  4}




   -- Notifications

   -- Central Frequency Change Notification
   optIfOChCentralFrequencyChange NOTIFICATION-TYPE
       OBJECTS { optIfOChCentralFrequency }
       STATUS  current
       DESCRIPTION
           "Notification of a change in the central frequency."
```

```
     ::= { optIfXcvrMibModule 1 }

END
```

7. Relationship to Other MIB Modules

7.1. Relationship to the [TEMPLATE TODO] MIB

7.2. MIB modules required for IMPORTS

8. Definitions

[TEMPLATE TODO]: put your valid MIB module here.
A list of tools that can help automate the process of checking MIB definitions can be found at http://www.ops.ietf.org/mib-review-tools.html

9. Security Considerations

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These are the tables and objects and their sensitivity/vulnerability:

o

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example by using IPsec), even then, there is no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

It is RECOMMENDED that implementers consider the security features as provided by the SNMPv3 framework (see [RFC3410], section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is NOT RECOMMENDED. Instead, it is RECOMMENDED to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of this MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

10. IANA Considerations

Option #1:

The MIB module in this document uses the following IANA-assigned OBJECT IDENTIFIER values recorded in the SMI Numbers registry:

```
Descriptor        OBJECT IDENTIFIER value
----------        -----------------------

sampleMIB  { mib-2 XXX }
```

Option #2:

Editor’s Note (to be removed prior to publication): the IANA is requested to assign a value for "XXX" under the ’mib-2’ subtree and to record the assignment in the SMI Numbers registry. When the assignment has been made, the RFC Editor is asked to replace "XXX" (here and in the MIB module) with the assigned value and to remove this note.

Note well: prior to official assignment by the IANA, an internet draft MUST use place holders (such as "XXX" above) rather than actual numbers. See RFC4181 Section 4.5 for an example of how this is done in an internet draft MIB module.

Option #3:

This memo includes no request to IANA.

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Appendix A. Change Log

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

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

Appendix B. Open Issues

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

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A YANG model to manage the optical optical parameters for in a WDM network
draft-galimbe-ccamp-iv-yang-00

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

Status of This Memo

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

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

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

Table of Contents

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 SND controller features is tu support multi vendor network and support the service calculation and deployment in multilayer topologies, for the DWDM mayer it is fundamentad 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.

For the optical impairments related to the DWDM Transceiver the draft draft-dharini-ccamp-dwdm-if-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-kdkgall-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 |------------>| OADM |-- -------->| 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
OADM = 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. Rs-Ss Configuration

For Rs-Ss configuration this draft refers the draft-dharini-ccamp-dwdm-if-yang

7.1.2. Table of Application Codes

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

7.2. Use Cases

The use cases are described in draft-kdkgall-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
   +--rw gain-degrade-high?   dbm-t
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 channel-t
   |  +--rw grid?              uint32
   |  +--rw channel-spacing?   uint32
   |  +--rw identifier?        uint32
   |  +--rw n?                 uint32
   +--rw channel-n-m
      +--rw grid?              uint32
      +--rw channel-spacing?   uint32
      +--rw n?                 uint32
      +--rw m?                 uint32
```

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.

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

```
       revision "2016-03-11" {
              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 ";
      }

      grouping channel-ITU {
      description "channel-ITU";
      container channel-t {
            description "wavelength notation according to RFC-6205";
             leaf grid {
               type uint32;
               description "grid type e.g.: 0=reserved, 1=DWDM, 2=CWDM";
             }
             leaf channel-spacing {
               type uint32;
               description "DWDM grid e.g.: 1=100GHz, 2=50GHz, 3=25GHz";
             }
             leaf identifier {
               type uint32;
               description "Channel identifier";
             }
             leaf n {
               type uint32;
               description "N Value (Channel n-m notation)";
             }
           }
         }

      grouping channel-flex {
        description "channel-flex";
        container channel-n-m {
          description "Channel N / M Notation to describe the
                       MEdiachannel";
           leaf grid {
             type uint32;
              description "grid type e.g.: 0=reserved, 1=DWDM, 2=CWDM";
```

```
            }
          leaf channel-spacing {
            type uint32;
             description "DWDM grid e.g.: 1=100GHz, 2=50GHz, 3=25GHz";
       }
          leaf n {
             type uint32;
              description "N Value (Channel n-m notation)";
       }
          leaf m {
            type uint32;
               description "M Value (Channel n-m notation)";
         }
       }
     }




     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";
         }
        }
        uses channel-ITU;
        uses channel-flex;
     }

      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;
         description "High Gain Degrade Value";
       }
     }


     grouping feasibility-limit-list {
       list feasibility-limit {
         key "id";
         description "Feasibility limit power / osnr pair";
         leaf id {
           type uint32;
           description "Unique Identifier";
         }
         leaf power {
           type decimal64 {
             fraction-digits 2;
           }
           units "dB";
           description "Feasibility power";
         }
```

```
         leaf osnr {
           type decimal64 {
             fraction-digits 2;
           }
           description "Feasibility Signal / Noise";
         }
       }
       description "
         Ordered list of feasibility limits
         (should match order of supported FEC types
         given in fec-type-list).
       ";

     }

     grouping power-failure-low-alarm-grp {
       description "
         Optical Power failure alarm ";
         leaf power-failure-low {
         type dbm-t;
         units "dBm";
         default -1;
         description "Power Failure Low Value";
       }
     }






     grouping noise {
       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 in intended
          per channel and is independent of the number of active
          channels in OMS";
       }
       description "Noise feasibility";
     }

     grouping noise-sigma {
       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";
       }
       description "Noise Sigma feasibility";
     }

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

     grouping 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";
       }
       description "Chromatic Dispersion (CD) Slope feasibility";
     }

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

     grouping pdl {
       leaf pdl {
```

```
         type decimal64 {
           fraction-digits 2;
         }
         units "dB";
         description "Polarization Dependent Loss (PDL) related to
               the OMS";
       }
       description "Polarization Dependent Loss (PDL) feasibility";
     }

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

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

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

       grouping ch-noise-figure {
       list ch-noise-figure {
        description "Channel signal-spontaneous noise figure";
```

```
       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 {
       leaf dgd {
         type decimal64 {
           fraction-digits 2;
         }
         units "db";
         description "differential group delay";
       }
       description "differential group delay";
     }

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

       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 {
       leaf cer {
         type decimal64 {
           fraction-digits 2;
         }
         units "db";
         description "channel extinction";
       }
       description "channel extinction";
     }

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


       }


   }

   <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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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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Link Management Protocol Extensions for Grid Property Negotiation
draft-ietf-ccamp-grid-property-lmp-02

Abstract

ITU-T [G.694.1] introduces the flexible-grid DWDM technique, which provides a new tool that operators can implement to provide a higher degree of network optimization than is possible with fixed-grid systems. This document describes the extensions to the Link Management Protocol (LMP) to negotiate link grid property between the adjacent DWDM nodes before the link is brought up.

Status of This Memo

Copyright Notice

Table of Contents

1. Introduction

ITU-T [G.694.1] introduces the flexible-grid DWDM technique, which provides a new tool that operators can implement to provide a higher degree of network optimization than is possible with fixed-grid systems. A flexible-grid network supports allocating a variable-sized spectral slot to a channel. Flexible-grid DWDM transmission systems can allocate their channels with different spectral bandwidths/slot widths so that they can be optimized for the bandwidth requirements of the particular bit rate and modulation scheme of the individual channels. This technique is regarded to be a promising way to improve the spectrum utilization efficiency and can be used in the beyond 100Gbit/s transport systems.

Fixed-grid DWDM system is regarded as a special case of Flexi-grid DWDM. It is expected that fixed-grid optical nodes will be gradually replaced by flexible nodes and interworking between fixed-grid DWDM and flexible-grid DWDM nodes will be needed as the network evolves. Additionally, even two flexible-grid optical nodes may have different grid properties based on the filtering component characteristics, thus need to negotiate on the specific parameters to be used during neighbor discovery process [FLEX-FWK]. This document describes the extensions to the Link Management Protocol (LMP) to negotiate a link grid property between two adjacent nodes before the link is brought up.

1.1. 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].

2. Terminology

For the flexible-grid DWDM, the spectral resource is called frequency slot which is represented by the central frequency and the slot width. The definition of nominal central frequency, nominal central frequency granularity, slot width and slot width granularity can be referred to [FLEX-FWK].

In this contribution, some other definitions are listed below:

Tuning range: It describes the supported spectrum slot range of the switching nodes or interfaces. It is represented by the supported minimal slot width and the maximum slot width.

Channel spacing: It is used in traditional fixed-grid network to identify spectrum spacing between two adjacent channels.

3. Requirements for Grid Property Negotiation

3.1. Flexi-fixed Grid Nodes Interworking

Figure 1 shows an example of interworking between flexible and fixed-grid nodes. Node A, B, D and E support flexible-grid. All these nodes can support frequency slots with a central frequency granularity of 6.25 GHz and slot width granularity of 12.5 GHz. Given the flexibility in flexible-grid nodes, it is possible to configure the nodes in such a way that the central frequencies and slot width parameters are backwards compatible with the fixed DWDM grids (adjacent flexible frequency slots with channel spacing of

8*6.25 and slot width of 4*12.5 GHz is equivalent to fixed DWDM grids with channel spacing of 50 GHz).

As node C can only support the fixed-grid DWDM property with channel spacing of 50 GHz, to establish a LSP through node B, C, D, the links between B to C and C to D must set to align with the fixed-grid values. This link grid property must be negotiated before establishing the LSP.

```
        +---+         +---+         +---+         +---+        +---+
        | A |---------| B |=========| C |=========| D +--------+ E |
        +---+         +---+         +---+         +---+        +---+
```

Figure 1: An example of interworking between flexible and fixed-grid nodes

```
             ^               ^               ^               ^
     ------->|<----50GHz---->|<----50GHz---->|<----50GHz---->|<------
       ..... |               |               |               | .....
     +-------+-------+-------+-------+-------+--------+------+-------+-
  n=-2               -1               0                1              2
                       Fixed channel spacing of 50 GHz (Node C)
             ^               ^               ^               ^
             |               |               |               |
     --------+---------------+---------------+---------------+---------
       ..... |  n=-8, m=4    |   n=0, m=4    |   n=8, m=4    | .....
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
  n=-16 -14 -12 -10 -8  -6  -4  -2   0   2   4   6   8   10  12  14  16
                                                                     |_|
                           Flexi-grid (Nodes B,D)               6.25 GHz
                    Central frequency granularity=6.25 GHz
                        Slot width granularity=12.5 GHz
```

Figure 2: Representation of fixed channel spacing and flexi-grid spectrum slot

3.2. Flexible-Grid Capability Negotiation

The updated version of ITU-T [G.694.1] has defined the flexible-grid with a central frequency granularity of 6.25 GHz and a slot width granularity of 12.5 GHz. However, devices or applications that make use of the flexible-grid may not be able to support every possible slot width or position. In other words, applications may be defined where only a subset of the possible slot widths and positions are required to be supported. Taking node G in figure 3 as an example, an application could be defined where the nominal central frequency granularity is 12.5 GHz (by only requiring values of n that are even) requiring slot widths being multiple of 25 GHz (by only requiring values of m that are even). Therefore the link between two optical node F and G with different grid granularity must be configured to align with the larger of both granularities. Besides, different nodes may have different slot width tuning ranges. For example, in figure 3, node F can only support slot width with tuning change from 12.5 to 100 GHz, while node G supports tuning range from 25 GHz to 200 GHz. The link property of slot width tuning range for the link between F and G should be chosen as the range intersection, resulting in a range from 25 GHz to 100 GHz.

```
              +---+            +---+
              | F +------------| G |
              +---+            +---+
   +------------------+-------------+-----------+
   |    Unit (GHz)    |    Node F   |   Node G  |
   +------------------+-------------+-----------+
   | Grid granularity | 6.25 (12.5) | 12.5 (25) |
   +------------------+-------------+-----------+
   |   Tuning range   | [12.5, 100] | [25, 200] |
   +------------------+-------------+-----------+
```

Figure 3: An example of flexible-grid capability negotiation

3.3. Summary

In summary, in a DWDM Link between two nodes, the following properties should be negotiated:

o Grid capability: flexible grid or fixed grid DWDM.

o Nominal central frequency granularity: a multiplier of 6.25 GHz.

o Slot width granularity: a multiplier of 12.5 GHz.

o Slot width tuning range: two multipliers of 12.5GHz, each indicate the minimal and maximal slot width supported by a port respectively.

4. LMP extensions

4.1. Grid Property Subobject

According to [RFC4204], the LinkSummary message is used to verify the consistency of the link property on both sides of the link before it is brought up. The LinkSummary message contains negotiable and non-negotiable DATA_LINK objects, carrying a series of variable-length data items called subobjects, which illustrate the detailed link properties. The subobjects are defined in Section 12.12.1 in [RFC4204].

To meet the requirements stated in section 3, this draft extends the LMP protocol by introducing a new DATA_LINK subobject called "Grid property", allowing the grid property correlation between adjacent nodes. The encoding format of this new subobject 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    | Grid  | C.F.G |      S.W.G     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Min Width   |    Reserved   |           Max Width            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4

Type=TBD, Grid property type.

Grid: 4 bits

The value is used to represent which grid the node/interface supports. Values defined in [RFC6205] identify DWDM [G.694.1] and CWDM [G.694.2]. The value defined in [draft-ietf-ccamp-flexigrid-lambda-label] identifies flexible DWDM.

Grid	Value
Reserved	0
ITU-T DWDM	1
ITU-T CWDM	2
ITU-T Flex	3
Future use	4-16

C.F.G (central frequency granularity):

It is a positive integer. Its value indicates the multiple of 6.25 GHz in terms of central frequency granularity.

S.W.G (Slot Width Granularity):

It is a positive integer value which indicates the slot width granularity which is the multiple of 12.5 GHz.

Min Width and Max Width:

Min Width and Max Width are positive integers. Their value indicate the multiple of 12.5 GHz in terms of the slot width tuning range the interface supports. For example, for slot width tuning range from 25 GHz to 100 GHz (with regard to a node with slot width granularity of 12.5 GHz), the values of Min Width and Max Width should be 2 and 8 respectively. For fixed-grid nodes, these two fields are meaningless and should be set to zero.

5. Messages Exchange Procedure

5.1. Flexi-fixed Grid Nodes Messages Exchange

To demonstrate the procedure of grid property correlation, the model shown in Figure 1 is reused. Node B starts sending messages.

o After inspecting its own node/interface property, node B sends node C a LinkSummary message including the MESSAGE ID, TE_LINK ID and DATA_LINK objects. The setting and negotiating of MESSAGE ID and TE_link ID can be referenced to [RFC4204]. As node B supports flexible-grid property, the Grid and C.F.G values in the grid property subobject are set to be 3 (i.e., ITU-T Flex) and 1 (i.e.,1*6.25GHz) respectively. The slot width tuning range is from 12.5 GHz to 200 GHz (i.e., Min Width=1, Max Width=16). Meanwhile, the N bit of the DATA_LINK object is set to 1, indicating that the property is negotiable.

o When node C receives the LinkSummary message from B, it checks the Grid, C.F.G, Min and Max values in the grid property subobject. Node C can only support fixed-grid DWDM and realizes that the flexible-grid property is not acceptable for the link. Since the receiving N bit in the DATA_LINK object is set, indicating that the Grid property of B is negotiable, node C responds to B with a LinkSummaryNack containing a new Error_code object and state that the property of the interface connected to node B needs further negotiation. Meanwhile, an accepted grid property subobject (Grid=2, C.F.G=4, fixed DWDM with channel spacing of 50 GHz) is carried in LinkSummaryNack message. At this moment, the N bit in the DATA_LINK object is set to 0, indicating that the grid property subobject is non-negotiable.

o As the channel spacing and slot width of the corresponding interface of node B can be configured to be any integral multiples of 6.25 GHz and 12.5 GHz respectively, node B supports the fixed DWDM values announced by node C. Consequently, node B will resend the LinkSummary message carrying the grid property subobject with values of Grid=2 and C.F.G=4.

o Once received the LinkSummary message from node B, node C replies with a LinkSummaryACK message. After the message exchange, the link between node B and C is brought up with a fixed channel spacing of 50 GHz.

In the above mentioned grid property correlation scenario, the node supporting a flexible-grid is the one that starts sending LMP messages. The procedure where the initiator is the fixed-grid node is as follows:

o After inspecting its own interface property, Node C sends B a LinkSummary message containing a grid property subobject with Grid=2, C.F.G=4. The N bit in the DATA_LINK object is set to 0, indicating that it is non-negotiable.

o As the channel spacing and slot width of node B can be configured to be any integral multiples of 6.25 GHz and 12.5 GHz respectively, node B is able to support the fixed DWDM parameters. Then, node B will make appropriate configuration and reply node C the LinkSummaryACK message

o After the message exchange, the link between node B and C is brought up with a fixed channel spacing of 50 GHz.

5.2. Flexible Nodes Messages Exchange

To demonstrate the procedure of grid property correlation between to flexi-grid capable nodes, the model shown in figure 3 is reused. The procedure of grid property correlation (negotiating the grid granularity and slot width tuning range) is similar to the scenarios mentioned above.

o The Grid, C.F.G, Min and Max values in the grid property subobject sent from node F to G are set to be 3,1,1,8 respectively. Meanwhile, the N bit of the DATA_LINK object is set to 1, indicating that the grid property is negotiable.

o When node G has received the LinkSummary message from F, it will analyze the Grid, C.F.G, Min and Max values in the Grid property subobject. But the corresponding interface of node G can only support grid granularity of 12.5 GHz and a slotwdith tuning range from 25 GHz to 200 GHz. Considering the interface property of node F, node G will first match these property with its corresponding interface, and then judge the mismatch of the property of the link between node F and G, then respond F a LinkSummaryNack containing a new Error_code object and state that the property need further negotiation. Meanwhile, an accepted grid property subobject (Grid=3, C.F.G=2, Min=2, Max=8, the slot width tuning range is set to the intersection of Node F and G) is carried in LinkSummaryNack message. Meanwhile, the N bit in the DATA_LINK object is set to 1, indicating that the grid property subobject is non-negotiable.

o As the channel spacing and slot width of the corresponding interface of node F can be configured to be any integral multiples of 6.25 GHz and 12.5 GHz respectively, node F can support the lager granularity. The suggested slot width tuning range is acceptable for node F. In consequence, node F will resend the LinkSummary message carrying the grid subobject with values of Grid=3, C.F.G=2, Min=2 and Max=8.

o Once received the LinkSummary message from node F, node G replies with a LinkSummaryACK message. After the message exchange, the link between node F and G is brought up supporting central frequency granularity of 12.5 GHz and slot width tuning range from 25 GHz to 100 GHz.

From the perspective of the control plane, once the links have been brought up, wavelength constraint information can be advertised and the wavelength label can be assigned hop-by-hop when establishing a LSP based on the link grid property.

6. IANA Considerations

This draft introduces the following new assignments:

LMP Sub-Object Class names:

o under DATA_LINK Class name (as defined in [RFC4204])

- Grid property type (sub-object Type = TBD.)

7. Acknowledgments

This work was supported in part by the China NSFC Project 61201260.

8. 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. As such, this document introduces no other new security considerations not covered in [RFC4204].

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OSPF Routing Extension for Links with Variable Discrete Bandwidth

draft-ietf-ccamp-ospf-availability-extension-04.txt

Abstract

A network may contain links with variable discrete bandwidth, e.g., copper, radio, etc. The bandwidth of such links may change discretely in reaction to changing external environment. Availability is typically used for describing such links during network planning. This document introduces an optional ISCD Availability sub-TLV in OSPF routing protocol. This extension can be used for route computation in a network that contains links with variable discrete bandwidth.

Status of this Memo

This Internet-Draft will expire on August 19, 2016.

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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 RFC-2119 [RFC2119].

The following acronyms are used in this draft:

OSPF Open Shortest Path First

PSN Packet Switched Network

SNR Signal-to-noise Ratio

LSP Label Switched Path

ISCD   Interface Switching Capacity Descriptor

LSA   Link State Advertisement

1. Introduction

Some data communication technologies, e.g., microwave, and copper, allow seamless change of maximum physical bandwidth through a set of known discrete values. The parameter availability [G.827, F.1703, P.530] is often used to describe the link capacity during network planning. The availability is a time scale that the requested bandwidth is ensured. Assigning different availability classes to different types of service over such kind of links provides more efficient planning of link capacity. To set up an LSP across these links, availability information is required for the nodes to verify bandwidth satisfaction and make bandwidth reservation. The availability information should be inherited from the availability requirements of the services expected to be carried on the LSP. For example, voice service usually needs ''five nines'' availability, while non-real time services may adequately perform at four or three nines availability. Since different service types may need different availabilities guarantees, multiple <availability, bandwidth> pairs may be required when signaling. The signaling extension for links with discrete bandwidth is defined in [ASTE].

For the route computation, the availability information should be provided along with bandwidth resource information. In this document, an extension on Interface Switching Capacity Descriptor (ISCD) [RFC4202] for availability information is defined to support in routing signaling. The extension reuses the reserved field in the ISCD and also introduces an optional Availability sub-TLV.

If there is a hop that cannot support the Availability sub-TLV, the Availability sub-TLV should be ignored.

2. Overview

A node which has link(s) with variable bandwidth attached should contain a <bandwidth, availability> information list in its OSPF TE LSA messages. The list provides the information that how much bandwidth a link can support for a specified availability. This information is used for path calculation by the node(s).

To setup a label switching path (LSP), a node may collect link information which is spread in OSPF TE LSA messages by network nodes to get know about the network topology, calculate out an LSP route based on the network topology and send the calculated LSP route to signaling to initiate a PATH/RESV message for setting up the LSP.

Availability information is required to carry in the signaling message to better utilize the link bandwidth. The signaling extension for availability can be found in [ASTE].

3. Extension to OSPF Routing Protocol

3.1. ISCD Availability sub-TLV

The Interface Switching Capacity Descriptor (ISCD) sub-TLV is defined in Section 1.4 of [RFC 4203]. The ISCD Availability sub-TLV is defined in this document as a sub-TLV of ISCD. The Switching Capability specific information field of ISCD MAY include one or more ISCD Availability sub-TLV(s). The ISCD Availability sub-TLV has the following 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Type            |               Length          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Availability level                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   LSP Bandwidth at Availability level n       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 0x01, 16 bits;

Length: 16 bits;

Availability level: 32 bits

This field is a 32-bit IEEE floating point number which describes the decimal value of availability guarantee of the switching capacity in the ISCD object which has the AI value equal to Index of this sub-TLV. The value MUST be less than 1.

LSP Bandwidth at Availability level n: 32 bits

This field is a 32-bit IEEE floating point number which describes the LSP Bandwidth at a certain Availability level which was described in the Availability field.

3.2. Signaling Process

A node which has link(s) with variable bandwidth attached SHOULD contain one or more ISCD Availability sub-TLVs in its OSPF TE LSA messages. Each ISCD Availability sub-TLV provides the information about how much bandwidth a link can support for a specified availability. This information SHOULD be used for path calculation by the node(s).

A node that doesn’t support ISCD Availability sub-TLV SHOULD ignore ISCD Availability sub-TLV.

4. Security Considerations

This document does not introduce new security considerations to the existing OSPF protocol.

5. IANA Considerations

This document introduces an Availability sub-TLV of the ISCD sub-TLV of the TE Link TLV in the TE Opaque LSA for OSPF v2. This document proposes a suggested value for the Availability sub-TLV; it is recommended that the suggested value be granted by IANA. Initial values are as follows:

Type	Length	Format	Description
0	-	Reserved	Reserved value
0x01	8	see Section 3.2	Availability

6. References

6.1. Normative References

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7. Acknowledgments

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Ethernet Traffic Parameters with Availability Information
draft-ietf-ccamp-rsvp-te-bandwidth-availability-04.txt

Abstract

A Packet switching network may contain links with variable bandwidth, e.g., copper, radio, etc. The bandwidth of such links is sensitive to external environment. Availability is typically used for describing the link during network planning. This document introduces an optional Availability TLV in Resource ReSerVation Protocol -- Traffic Engineer (RSVP-TE) signaling. This extension can be used to set up a label switching path (LSP) in a Packet Switched Network (PSN) that contains links with discretely variable bandwidth.

Status of this Memo

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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 RFC-2119 [RFC2119].

The following acronyms are used in this draft:

RSVP-TE Resource Reservation Protocol-Traffic Engineering

LSP   Label Switched Path

PSN   Packet Switched Network

SNR   Signal-to-noise Ratio

TLV   Type Length Value

LSA   Link State Advertisement

1. Introduction

The RSVP-TE specification [RFC3209] and GMPLS extensions [RFC3473] specify the signaling message including the bandwidth request for setting up a label switching path in a PSN network.

Some data communication technologies allow seamless change of maximum physical bandwidth through a set of known discrete values. The parameter availability [G.827, F.1703, P.530] is often used to describe the link capacity during network planning. The availability is a time scale that the requested bandwidth is ensured. A more detailed example on the bandwidth availability can be found in Appendix A. Assigning different availability classes to different types of service over such kind of links provides more efficient planning of link capacity. To set up an LSP across these links, availability information is required for the nodes to verify bandwidth satisfaction and make bandwidth reservation. The availability information should be inherited from the availability requirements of the services expected to be carried on the LSP. For example, voice service usually needs ''five nines'' availability, while non-real time services may adequately perform at four or three nines availability. Since different service types may need different availabilities guarantees, multiple <availability, bandwidth> pairs may be required when signaling.

If the availability requirement is not specified in the signaling message, the bandwidth will be reserved as the highest availability. For example, the bandwidth with 99.999% availability of a link is 100 Mbps; the bandwidth with 99.99% availability is 200 Mbps. When a video application requests for 120 Mbps without availability requirement, the system will consider the request as 120 Mbps with 99.999% availability, while the available bandwidth with 99.999% availability is only 100 Mbps, therefore the LSP path cannot be set up. But in fact, video application doesn't need 99.999% availability; 99.99% availability is enough. In this case, the LSP could be set up if availability is specified in the signaling message.

To fulfill LSP setup by signaling in these scenarios, this document specifies an Availability TLV. The Availability TLV can be applicable to any kind of physical links with variable discrete bandwidth, such as microwave or DSL. Multiple Availability TLVs together with multiple Ethernet Bandwidth Profiles can be carried in the Ethernet SENDER_TSPEC object.

2. Overview

A PSN tunnel may span one or more links in a network. To setup a label switching path (LSP), a node may collect link information which is spread in routing message, e.g., OSPF TE LSA message, by network nodes to get to know about the network topology, and calculate out an LSP route based on the network topology, and send the calculated LSP route to signaling to initiate a PATH/RESV message for setting up the LSP.

In case that there is(are) link(s) with variable discrete bandwidth in a network, a <bandwidth, availability> requirement list should be specified for an LSP. Each <bandwidth, availability> pair in the list means that listed bandwidth with specified availability is required. The list could be inherited from the results of service planning for the LSP.

A node which has link(s) with variable discrete bandwidth attached should contain a <bandwidth, availability> information list in its OSPF TE LSA messages. The list provides the information that how much bandwidth a link can support for a specified availability. This information is used for path calculation by the node(s). The routing extension for availability can be found in [ARTE].

When a node initiates a PATH/RESV signaling to set up an LSP, the PATH message should carry the <bandwidth, availability> requirement list as bandwidth request. Intermediate node(s) will allocate the bandwidth resource for each availability requirement from the remaining bandwidth with corresponding availability. An error message may be returned if any <bandwidth, availability> request cannot be satisfied.

3. Extension to RSVP-TE Signaling

3.1. Availability TLV

An Availability TLV is defined as a TLV of the Ethernet SENDEDR_TSPEC object [RFC6003] in this document. The Ethernet SENDER_TSPEC object MAY include more than one Availability TLV. The Availability TLV has the following 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Index      |                   Reserved                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Availability                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: Availability TLV

Index (1 octet):

The Availability TLV MUST come along with Ethernet Bandwidth Profile TLV. If the bandwidth requirements in the multiple Ethernet Bandwidth Profile TLVs have different Availability requirements, multiple Availability TLVs SHOULD be carried. In such a case, the Availability TLV has one to one correspondence with Ethernet Bandwidth Profile TLV by having the same value of Index field. If all the bandwidth requirements in the Ethernet Bandwidth Profile have the same Availability requirement, one Availability TLV SHOULD be carried. In this case, the Index field is set to 0.

Reserved (3 octets): These bits SHOULD be set to zero when sent and MUST be ignored when received.

Availability (4 octets): a 32-bit floating number describes the decimal value of availability requirement for this bandwidth request. The value MUST be less than 1.

3.2. Signaling Process

The source node initiates PATH messages which carry a number of bandwidth request information, including one or more Ethernet Bandwidth Profile TLVs and one or more Availability TLVs. Each Ethernet Bandwidth Profile TLV corresponds to an availability parameter in the Availability TLV.

The intermediate and destination nodes check whether they can satisfy the bandwidth requirements by comparing each bandwidth requirement inside the SENDER_TSPEC objects with the remaining link sub-bandwidth resource with respective availability guarantee on the local link when received the PATH message.

- If all <bandwidth, availability> requirements can be satisfied (the requested bandwidth under each availability parameter is smaller than or equal to the remaining bandwidth under the corresponding availability parameter on its local link), it SHOULD reserve the bandwidth resource from each remaining sub-bandwidth portion on its local link to set up this LSP. Optionally, the higher availability bandwidth can be allocated to lower availability request when the lower availability bandwidth cannot satisfy the request.

- If at least one <bandwidth, availability> requirement cannot be satisfied, it SHOULD generate PathErr message with the error code "Admission Control Error" and the error value "Requested Bandwidth Unavailable" (see [RFC2205]).

If two LSPs request for the bandwidth with the same availability requirement, a way to resolve the contention is comparing the node ID, the node with the higher node ID will win the contention. More details can be found in [RFC3473].

If a node does not support Availability TLV, it SHOULD generate PathErr message with the error code "Extended Class-Type Error" and the error value "Class-Type mismatch" (see [RFC2205]).

4. Security Considerations

This document does not introduce new security considerations to the existing RSVP-TE signaling protocol.

5. IANA Considerations

IANA maintains registries and sub-registries for RSVP-TE used by GMPLS. IANA is requested to make allocations from these registries as set out in the following sections.

5.1 Ethernet Sender TSpec TLVs

IANA maintains a registry of GMPLS parameters called ''Generalized Multi-Protocol Label Switching (GMPLS) Signaling Parameters''.

IANA has created a new sub-registry called ''Ethernet Sender TSpec TLVs / Ethernet Flowspec TLVs'' to contain the TLV type values for TLVs carried in the Ethernet SENDER_TSPEC object. A new type for Availability TLV is defined as follow:

Type	Description	Reference
TBD	Availability	[This ID]

6. References

6.1. Normative 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, December 2001.

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[F.1703] ITU-R Recommendation, ''Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections'', January, 2005.

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[EN 302 217] ETSI standard, ''Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas'', April, 2009

[ARTE] H., Long, M., Ye, Mirsky, G., Alessandro, A., Shah, H., ''OSPF Routing Extension for Links with Variable Discrete Bandwidth'', Work in Progress, June, 2015

7. Appendix: Bandwidth Availability Example

In mobile backhaul network, microwave links are very popular for providing connection of last hops. In case of heavy rain, to maintain the link connectivity, the microwave link MAY lower the modulation level since demodulating the lower modulation level needs a lower Signal-to-Noise Ratio (SNR). This is called adaptive modulation technology [EN 302 217]. However, a lower modulation level also means lower link bandwidth. When link bandwidth is reduced because of modulation down-shifting, high-priority traffic can be maintained, while lower-priority traffic is dropped. Similarly, the copper links MAY change their link bandwidth due to external interference.

Presuming that a link has three discrete bandwidth levels:

The link bandwidth under modulation level 1, e.g., QPSK, is 100 Mbps;

The link bandwidth under modulation level 2, e.g., 16QAM, is 200 Mbps;

The link bandwidth under modulation level 3, e.g., 256QAM, is 400 Mbps.

In sunny day, the modulation level 3 can be used to achieve 400 Mbps link bandwidth.

A light rain with X mm/h rate triggers the system to change the modulation level from level 3 to level 2, with bandwidth changing from 400 Mbps to 200 Mbps. The probability of X mm/h rain in the local area is 52 minutes in a year. Then the dropped 200 Mbps bandwidth has 99.99% availability.

A heavy rain with Y(Y>X) mm/h rate triggers the system to change the modulation level from level 2 to level 1, with bandwidth changing from 200 Mbps to 100 Mbps. The probability of Y mm/h rain in the local area is 26 minutes in a year. Then the dropped 100 Mbps bandwidth has 99.995% availability.

For the 100M bandwidth of the modulation level 1, only the extreme weather condition can cause the whole system unavailable, which only happens for 5 minutes in a year. So the 100 Mbps bandwidth of the modulation level 1 owns the availability of 99.999%.

In a word, the maximum bandwidth is 400 Mbps. According to the weather condition, the sub-bandwidth and its availability are shown as follows:

Sub-bandwidth(Mbps)	Availability
200	99.99%
100	99.995%
100	99.999%

8. Acknowledgments

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A framework for Management and Control of DWDM optical interface parameters

draft-kdkgall-ccamp-dwdm-if-mng-ctrl-fwk-01

Abstract

To ensure an efficient data transport, meeting the requirements requested by today's IP-services the control and management of DWDM interfaces is a precondition for enhanced multilayer networking and for an further automation of network provisioning and operation. This document describes use cases and requirements for the control and management of optical interfaces parameters according to different types of single channel DMDM interfaces. The focus is on automating the network provisioning process irrespective on how it is triggered i.e. by EMS, NMS or GMPLS. This document covers management as well as control plane considerations in different management cases of a single channel DWDM interface The purpose is to identify the necessary information elements and processes to be used by control or management systems for further processing.

Status of This Memo

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1. Introduction

The usage of the Colored interfaces in the Client Nodes connected to a DWDM Network (which include ROADMs and optical amplifiers) adds further networking option for operators opening to new scenarios and requiring more control/management plane integration.

Carriers deploy their networks today as a combination of transport and packet infrastructures to ensure high availability and flexible data transport. Both network technologies are usually managed by different operational units using different management concepts. This is the status quo in many carrier networks today. In the case of a black link deployment, where the optical transport interface moves into the client device (e.g. , router), it is necessary to coordinate the management of the optical interface at the client domain with the optical transport domain. There are different levels of coordination, which are specified in this framework.

The objective of this document is to provide a framework that describes the solution space for the control and management of single channel interfaces and give use cases on how to manage the solutions. In particular, it examines topological elements and related network management measures. From an architectural point of view, the network can be consideres as a black link, that is a set of pre-configured/qualified unidirectional, single-fiber, network connections between the G.698.2 reference points S and R. The optical transport network is managed and controlled in order to provide Oprical Connections at the intended centre frequencies and the optical interfaces are managed and controlled to generate signals of the intended centre frequencies and further parameters as specified in ITU-T Recommendations G.698.2 and G.798. The Management or Control planes of the Client and DWDM network must know the parameters of the Interfaces to properly set the optical link.

Furthermore, support for Fast Fault Detection can benefit from the solution proposed.

Optical Routing and Wavelength assignment based on WSON is out of scope although can benefit of the way the optical parameters are exchanged between the Client and the DWDM Network.

Additionally, the wavelength ordering process and the process how to determine the demand for a new wavelength from A to Z is out of scope.

Note that the Control and Management Planes are two separate entities that are handling the same information in different ways. This document covers management as well as control plane considerations in different management cases of single channel DWDM interfaces.

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 and Definitions

Current generation WDM netwoks are single vendor networks where the optical line system and the transponders are tightly integrated. The DWDM interfaces migration from the Transponders to the Client interfaces changes this scenario, by introducing a standardized interface at the level of OCh between the Client DWDM interface and the DWDM network.

Black Link: The Black Link [ITU.G698.2] allows supporting an optical transmitter/receiver pair of a single vendor or from different vendors to provide a single optical channel interface and transport it over an optical network composed of amplifiers, filters, add-drop multiplexers which may be from a different vendor. Therefore the standard defines the ingress and egress parameters for the optical interfaces at the reference points Ss and Rs.

Single Channel DWDM Interface: The single channel interfaces to DWDM systems defined in G.698.2, which currently include the following features: channel frequency spacing: 50 GHz and wider (defined in [ITU-T G.694.1]); bit rate of single channel: Up to 10 Gbit/s. Future revisions are expected to include application codes for bit rates up to 40 Gb/s.

Forward error correction (FEC): FEC is a way of improving the performance of high-capacity optical transmission systems. Employing FEC in optical transmission systems yields system designs that can accept relatively large BER (much more than 10-12) in the optical transmission line (before decoding).

Administrative domain [G.805]: For the purposes of this Recommendation an administrative domain represents the extent of resources which belong to a single player such as a network operator, a service provider or an end-user. Administrative domains of different players do not overlap amongst themselves.

Intra-domain interface (IaDI) [G.872]: A physical interface within an administrative domain.

Inter-domain interface (IrDI) [G.872]: A physical interface that represents the boundary between two administrative domains.

Management Plane [G.8081]: The management plane performs management functions for the transport plane, the control plane and the system as a whole. It also provides coordination between all the planes. The following management functional areas are performed in the management plane: performance management; fault management; configuration management; accounting management and security management.

Control Plane[G.8081]: The control plane performs neighbour discovery, call control and connection control functions. Through signalling, the control plane sets up and releases connections, and may restore a connection in case of a failure. The control plane also performs other functions in support of call and connection control, such as neighbour discovery and routing information dissemination.

Transponder: A Transponder is a network element that performs O/E/O (Optical /Electrical/Optical) conversion. In this document it is referred only transponders with 3R (rather than 2R or 1R regeneration) as defined in [ITU.G.872].

Client DWDM interface: A Transceiver element that performs E/O (Electrical/Optical) conversion. In this document it is referred as the DWDM side of a transponder as defined in [ITU.G.872].

3. Solution Space Client DWDM interface

The management of optical interfaces using the Black Link approach deals with aspects related to the management of single-channel optical interface parameters of physical point-to-point and ring DWDM applications on single-mode optical fibres.

The solution allows the direct connection of a wide variety of equipments using a DWDM link, for example:

1. A digital cross-connect with multiple optical interfaces, supplied by a different vendor from the line system

2. Multiple optical client devices, each from a different vendor, supplying one channel each

3. A combination of the above

Table 1 provides a list of management regarding the configuration of optical parameters.

Task	Domain	a	b	c	d
determination of centre frequency	optical	R	R	R	R
configuration of centre frequency at optical IF	client	NR	NR	R	R
path computation of wavelength	optical	NR	NR	R	R
routing of wavelength	optical	NR	NR	R	R
wavelength setup across optical network	optical	?	?	R	R
detection of wavelength fault	client	R	R	R	R
fault isolation, identification of root failure	optical	NR	R	R	R
repair actions within optical network	optical	R	R	R	R
protection switching of wavelength	optical	NR	NR	R	R
restoration of wavelength	optical	NR	NR	R	R

Note: R = relevant, NR = not relevant

Table 1: List of tasks related to Client - Network interconnection management

Furthermore the following deployment cases will be considered:

a. Passive WDM

b. P2P WDM systems

c. WDM systems with OADMs

d. Transparent optical networks supporting specific IPoWDM functions, nterfaces, protocols etc.

Case a) is added for illustration only, since passive WDM is specified in ITU-T Recommendations G.695 and G.698.1.

Case b) and case c)are motivated by the usage of legacy equipment using the traditional connection as described in Figure 1 combined with the BL approach.

3.1. Comparison of approaches for transverse compatibility

3.1.1. Multivendor DWDM line system with transponders

As illustrated in Figure 1, for this approach interoperability is achieved via the use of optical transponders providing OEO (allowing conversion to appropriate parameters). The optical interfaces labelled "single channel non-DWDM interfaces from other vendor(s)" and "Single channel non DWDM interfaces to/from other vendor(s)" can then be any short reach standardized optical interface that both vendors support, such as those found in [ITU-T G.957] [ITU-T G.691], [ITU-T G.693], [ITU-T G.959.1], etc.

```
               IrDI                            IaDI
                |                                |
                .                                .
                |   +----------------------------|----+
                .   |     +    WDM Domain     +  .    |
                |   |     |\                 /|  |    |
   +------+     .   |     | \     |\        / |  .    |       +------+
   |  TX/ |-->--+---+--T/-|OM|----|/-------|OD|--+-\T-+---->--| RX/  |
   |  RX  |--<--+---+--T/-|  |----- /|-----|  |--.-\T-+----<--| TX   |
   +------+     |   |     | /       \|      \ |  |    |       +------+
                .   |     |/                 \|  .    |
                |   |     +                   +  |    |
                .   +----------------------------.----+
                |                                |

           TX/RX = Single channel non-DWDM interfaces
           T/ = Transponder
           OM = Optical Mux
           OD = Optical Demux
```

Figure 1: Inter and Intra-Domain Interface Identification

In the scenario of Figure 1 the administrative domain is defined by the Interdomain Interface (IrDI). This interface terminates the DWDM domain. The line side is characterized by the IaDI. This interface specifies the internal parameter set of the optical administrative domain. In the case of Client DWDM interface deployment this interface moves into the client devices and extends the optical and administrative domain towards the client node. ITU-T G.698.2 specifies the parameter set for a certain set of applications.

This document elaborates only the IaDI Interface as specified in ITU-T G.698.2 as transversely compatible and multi-vendor interface within one administrative domain controlled by the network operator. This administrative domain can contain several vendor domains (vendor A for the DWDM sub-network, and vendors B1 and B2 at the transmitter and receiver terminal side).

3.1.2. Black Link Deployments

In case of a Black Link deployment as shown in Figure 2, through the use of the single channel DWDM interfaces defined in [ITU.G698.2], multi-vendor interconnection can also be achieved while removing the need for one s hort reach transmitter and receiver pair per channel (eliminating the transponders).

Figure 2 shows a set of reference points, for the linear "black-link" approach, for single-channel connection (Ss and Rs) between transmitters (Tx) and receivers (Rx). Here the DWDM network elements include an optical multiplexer (OM) and an optical demultiplexer (OD) (which are used as a pair with the peer element), one or more optical amplifiers and may also include one or more OADMs.

```
     |==================== Black Link =======================|


        +-------------------------------------------------+
     Ss |  |           DWDM Network Elements           |  | Rs
+---+ | |  | \                                       / |  | | +---+
Tx L1---|->|   \    +------+            +------+   /   |--|-->Rx L1
+---+   |  |    |   |      |  +------+  |      |  |    |  |   +---+
+---+   |  |    |   |      |  |      |  |      |  |    |  |   +---+
Tx L2---|->| OM |-|>|------|->| OADM |--|------|->| OD |--|-->Rx L2
+---+   |  |    |   |      |  |      |  |      |  |    |  |   +---+
+---+   |  |    |   |      |  +------+  |      |  |    |  |   +---+
Tx L3---|->|   /    | DWDM |    |  ^    | DWDM |   \   |--|-->Rx L3
+---+   |  | /      | Link +----|--|----+ Link |     \ |  |   +---+
        +-----------+           |  |           +----------+
                             +--+  +--+
                             |        |
                             v        |
                           +---+    +---+
                            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
    OADM = Optical Add Drop Mux
```

Linear DWDM network as per ITU-T G.698.2

Figure 2: Linear Black Link

In Figure 2, if the administrative domain consists of several domains (e.g. A for a DWDM network, B1 for the DWDM Tx, and B2 for the DWDM Rx), it is typical that there will be a separate Element Management Systems (EMS) will be used for each vendor domain (e.g. EMS-a for domain A, EMS-b1 for domain B1, and EMS-b2 for domain B2). Each EMS may have a common standard north bound management interface to a

Network Management System (NMS), allowing consistent end-to-end management of the connection.

To facilitate consistent end-to-end network management, the north bound management interface from the EMS to the NMS should be consistent (frome a management information point of view) with the standard protocol-neutral (or protocol-specific) information model used in the EMS south bound management interface to its subtending NEs (TX and/or RX). The [Interface-MIB] defines such a protocol-specific information using SNMP/SMI, Yang models and LMP TLV to support the direct exchange of information between the Client and the Network control planes.

4. Solutions for managing and controlling the optical interface

Operation and management of WDM systems is traditionally seen as a homogenous group of tasks that could be carried out best when a single management system or an umbrella management system is used. Currently each WDM vendor provides an Element Management System (EMS) that also administers the wavelengths.

Therefore from the operational point of view there are the following approaches will be considered to manage and operate optical interfaces.

<vspace>:

1. Separate operation and management of client device and the transport network

   a.Direct link between the client device and the management system of the optical network (e.g. EMS, NMS)

   b.Indirect link to the management system of the optical network using a protocol between the client device and the directly connected WDM system node to exchange management information with the optical domain

2. Common operation and management of client device and the Transport network

The first option keeps the status quo in large carrier networks as mentioned above. In that case it must be ensured that the full FCAPS Management (Fault, Configuration, Accounting, Performance and Security) capabilities are supported. This means from the management staff point of view nothing changes. The transceiver/receiver optical interface will be part of the optical management domain and will be managed from the transport management staff.

The second solution addresses the case where underlying WDM transport network is mainly used to interconnect a homogeneous set of client nodes (e.g. IP routers or digital crossconnects). Since the service creation and restoration could be done by to higher layers (e.g. IP), this may lead to more efficient network operation and a higher level of integration.

4.1. Separate Operation and Management Approaches

4.1.1. Direct connection to the management system

As depicted in Figure 3 (case 1a) one possibility to manage the optical interface within the client domain is a direct connection to the management system of the optical domain. This ensures manageability as usual.

```
                        +-----+
                        | NMS |
                        |_____|
                        /_____/
                           |
                           |
                           |
                       +---+---+
                +----->+  EMS  |
               /       |       |
              /        +-------+
             /             | MI SNMP or Yang
       SNMP / or Yang      |                DCN Network
       --------------------+----------------------------
          /          +------+----------------------+
         /           |     +|     WDM Domain   +    |
        /            |     |\               /|    |
   +---+--+          |     | \     |\       / |    |          +------+
   |  CL  |-/C------+-----|OM|----|/-------|OD|----+-------/C-|  CL  |
   |      |-/C------+-----|  |----- /|-----|  |----+-------/C-|      |
   +------+          |     | /      \|      \ |    |          +------+
                     |     |/               \|    |
                     |     +                 +    |
                     +------------------------------+

           CL = Client Device
           /C = Single Channel Optical Interface
           OM = Optical Mux
           OD = Optical Demux
           EMS = Element Management System
           MI= Management Interface
```

Figure 3: Connecting Single Channel optical interfaces to the Transport Management system

The exchange of management information between client device and the management system assumes that some form of a direct management communication link exists between the client device and the DWDM management system (e.g. EMS). This may be an Ethernet Link or a DCN connection (management communication channel MCC).

It must be ensured that the optical network interface can be managed in a standardised way to enable interoperable solutions between different optical interface vendors and vendors of the optical network management application. RFC 3591 [RFC3591] defines managed objects for the optical interface type but needs further extension to cover the optical parameters required by this framework document. Therefore an extension to this MIB for the optical interface has been drafted in [Black-Link-MIB]. In that case SNMP is used to exchange data between the client device and the management system of the WDM domain. Yang models are as well needed to enable and SDN controller to easily read/provision the interfaces parameters.

Note that a software update of the optical interface components of the client nodes must not lead obligatory to an update of the software of the EMS and vice versa.

4.1.2. Direct connection to the DWDM management system

The alternative as shown in Figure 4 can be used in cases where a more integrated relationship between transport node (e.g. OM or OD) and client device is aspired. In that case a combination of control plane features and manual management will be used.

```
                        +-----+
                        | NMS |
                        |_____|
                        /_____/
                           |
                           |
                           |
                       +---+---+
                       | EMS   |
                       |       |
                       +-------+
                           | MI  SNMP or Yang
                           |
                           |
           LMP      +------+-----------------------+
       +------------+---+ +|                 +     |
       |            |   | |\                /|     |
   +---+--+         |   +-+ \     |\       / |     |          +------+
   |  CL  |-/C------+--- -|OM|----|/-------|OD|--- +-------/C-|  CL  |
   |      |-/C------+--- -|  |----- /|-----|  |----+-------/C-|      |
   +------+         |     | /       \|      \ |     |          +------+
                    |     |/                \|     |
                    |     +                  +     |
                    +------------------------------+

           CL = Client Device
           /C = Single Channel optical Interface
           OM = Optical Mux
           OD = Optical Demux
           EMS= Element Management System
           MI= Management Interface
```

Figure 4: Direct connection between peer node and first optical network node

For information exchange between the client node and the direct connected node of the optical transport network LMP as specified in RFC 4209 [RFC4209] can (should) be used. This extension of LMP may be used between a peer node and an adjacent optical network node as depicted in Figure 4.

The LMP based on RFC 4209 does not yet support the transmission of configuration data (information). This functionality has to be added to the existing extensions of the protocol. The use of LMP-WDM assumes that some form of a control channel exists between the client node and the WDM equipment. This may be a dedicated lambda, an Ethernet Link, or other signaling communication channel (SCC or IPCC).

4.2. Control Plane Considerations

The concept of black link equally applies to management and control plane mechanisms. The general GMPLS control Plane for wavelength switched optical networks is work under definition in the scope of WSON.One important aspect of the BL is the fact that it includes the wavelength that is supported by the given link. Thus a BL can logically be considered as a fiber that is transparent only for a single wavelength. In other words, the wavelength becomes a characteristic of the link itself. Nevertheless the procedure to light up the fiber may vary depending on the BL implementation. Since the implementation of the BL itself is unknown a priori, different sequences to light up wavelength need to be considered:

1. Transponders first, transponder tuning: The transmitter is switched on and the BL is immediately transparent to its wavelength. This requires the transmitter to carefully tune power and frequency not overload the line system or to create transients.

2. Transponder first, OLS tuning: The transmitter is switched on first and can immediately go to the max power allowed since the OLS performs the power tuning. This leads to an intermediate state where the receiver does not receive a valid signal while the transmitter is sending out one. Alarm suppression mechanisms shall be employed to overcome that condition.

3. OLS first, Transponder tuning: At first the OLS is tuned to be transparent for a given wavelength, then transponders need to be tuned up. Since the OLS in general requires the presence of a wavelength to fine-tune it is internal facilities there may be a period of time where a valid signal is transmitted but the receiver is unable to detect it. This equally need to be covered by alarm suppression mechanisms.

4. OLS first, OLS tuning: The OLS is programmed to be transparent for a given Wavelength, then the transponders need to be switched on and further power tuning takes place. The sequencing of enabling the link needs to be covered as well.

The preferred way to address these in a Control Plane enabled network is neighbour discovery including exchange of link characteristics and link property correlation. The general mechanisms are covered in RFC4209 [LMP-WDM] and RFC 4204[LMP] which provides the necessary protocol framework to exchange those characteristics between client and black link. LMP-WDM is not intended for exchanging routing or signalling information but covers:

1. Control channel manangement

2. Link property correlation

3. Link verification

4. Fault Manangement

Extensions to LMP/LMP-WDM covering the code points of the BL definition are needed. Additionally when client and server side are managed by different operational entities, Link state exchange is required to align the management systems.

4.2.1. Considerations using GMPLS UNI

The deployment of G.698.2 optical interfaces is leading to some functional changes related to the control plane models and has therefore some impact on the existing interfaces especially in the case of an overlay model where the edge node requests resources from the core node and the edges node do not participate in the routing protocol instance that runs among the core nodes. RFC 4208 [RFC4208] defines the GMPLS UNI that will be used between edge and core node. In case of a black link deployment additional functionalities are needed to setup a connection.

It is necessary to differentiate between topology/signalling information and configuration parameters that are needed to setup a wavelength path. RSVP-TE could be used for the signalling and the reservation of the wavelength path. But there are additional information needed before RSVP-TE can start the signalling process. There are three possibilities to proceed:

a. Using RSVP-TE only for the signalling and LMP as described above to exchange information to configure the optical interface within the edge node or

b. RSVP-TE will be used to transport additional information

c. Leaking IGP information instead of exchanging this information needed from the optical network to the edge node (overlay will be transformed to a border-peer model)

Furthermore following issues should be addressed:

a) The Communication between peering edge nodes using an out of band control channel. The two nodes have to exchange their optical capabilities. An extended version of LMP is needed to exchange FEC Modulation scheme,etc. that must be the same. It would be helpful to define some common profiles that will be supported. Only if the profiles match with both interface capabilities it is possible start signalling.

b) Due to the bidirectional wavelength path that must be setup it is obligatory that the upstream edge node inserts a wavelength value into the path message for the wavelength path towards the upstream node itself. But in the case of an overlay model the client device may not have full information which wavelength must/should be selectedand this information must be exchanged between the edge and the core node.

5. Operational aspects using IUT-T G.698.2 specified single channel DWDM interfaces

A Comparison of the Black Link with the traditional operation scenarios provides an insight of similarities and distinctions in operation and management. The following four use cases provide an overview about operation and maintenance processes.

5.1. Bringing into service

It is necessary to differentiate between two operational issues for setting up a light path (a DWDM connection is specific in having defined maximum impairments) within an operational network. The first step is the preparation of the connection if no optical signal is applied. Therefore it is necessary to define the path of the connection.

The second step is to setup the connection between the Cleint DWDM interface and the ROADM port. This is done using the NMS of the optical transport network. From the operation point of view the task is similar in a Black Link scenario and in a traditional WDM environment. The Black Link connection is measured by using BER tester which use optical interfaces according to G.698.2. These measurements are carried out in accordance with ITU-T Recommendation M.xxxx. When needed further Black Link connections for resilience are brought into service in the same way.

In addition some other parameters like the Transmit Optical Power, the Received Optical Power, the Frequency, etc. must be considered.

If the optical interface moves into a client device some of changes from the operational point of view have to be considered. The centre frequency of the Optical Channel was determined by the setup process. The optical interfaces at both terminals are set to the centre frequency before interconnected with the dedicated ports of the WDM network. Optical monitoring is activated in the WDM network after the terminals are interconnected with the dedicated ports in order to monitor the status of the connection. The monitor functions of the optical interfaces at the terminals are also activated in order to monitor the end to end connection.

Furthermore it should be possible to automate this last step. After connecting the client device towards the first control plane managed transport node a control connection may e.g. be automatically established using LMP to exchange configuration information.

If tunable interfaces are used in the scenario it would be possible to define a series of backup wavelength routes for restoration that could be tested and stored in backup profile. In fault cases this wavelength routes can be used to recover the service.

5.2. LMP Use Cases

The use cases described below are assuming that power monitoring functions are available in the ingress and egress network element of the DWDM network, respectively. By performing link property correlation it would be beneficial to include the current transmit power value at reference point Ss and the current received power value at reference point Rs. For example if the Client transmitter power (OXC1) has a value of 0dBm and the ROADM interface measured power (at OLS1) is -6dBm the fiber patch cord connecting the two nodes may be pinched or the connectors are dirty. More, the interface characteristics can be used by the OLS network Control Plane in order to check the Optical Channels feasibility. Finally the OXC1 transceivers parameters (Application Code) can be shared with OXC2 using the LMP protocol to verify the Transceivers compatibility. The actual route selection of a specific wavelength within the allowed set is outside the scope of LMP. In GMPLS, the parameter selection (e.g. central frequency) is performed by RSVP-TE.

G.698.2 defines a single channel optical interface for DWDM systems that allows interconnecting network-external optical transponders across a DWDM network. The optical transponders are considered to be external to the DWDM network. This so-called ’black link’ approach illustrated in Figure 5-1 of G.698.2 and a copy of this figure is provided below. The single channel fiber link between the Ss/Rs reference points and the ingress/egress port of the network element on the domain boundary of the DWDM network (DWDM border NE) is called access link in this contribution. Based on the definition in G.698.2 it is considered to be part of the DWDM network. The access link typically is realized as a passive fiber link that has a specific optical attenuation (insertion loss). As the access link is an integral part of the DWDM network, it is desirable to monitor its attenuation. Therefore, it is useful to detect an increase of the access link attenuation, for example, when the access link fiber has been disconnected and reconnected (maintenance) and a bad patch panel connection (connector) resulted in a significantly higher access link attenuation (loss of signal in the extreme case of an open connector or a fiber cut). In the following section, two use cases are presented and discussed:

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

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

Figure 5 Access Link Power Monitoring

```
                                       +--------------------------+
                                       |    P(in) = P(Tx) - a(Tx) |
                                       |    ___                   |
       +----------+                    |    \ /   Power Monitor   |
       |          | P(Tx)              |     V    P(in)           |
       |  +----+  | Ss    //\\         |     |    |\              |
       |  | TX |----|-----\\//------------------->| \             |
       |  +----+  | Access Link (AL-T) |       .  |  |            |
       |          | attenuation a(Tx)  |       .  |  |==============>
       |          |                    |       .  |  |            |
       | External |                    |      --->| /             |
       | Optical  |                    |          |/              |
       |Transpond.|                    |    P(out)                |
       |          |                    |    ___                   |
       |          |                    |    \ /   Power Monitor   |
       |          | P(Rx)              |     V    P(out)          |
       |  +----+  | Rs    //\\         |     |    |\              |
       |  | RX |<---|-----\\//--------------------| \             |
       |  +----+  | Access Link (AL-R) |       .  |  |            |
       |          | Attenuation a(Rx)  |       .  |  |<==============
       +----------+                    |       .  |  |            |
                                       |      <---| /             |
       P(Rx) = P(out) - a(Rx)          |          |/              |
                                       |                          |
                                       |           ROADM          |
                                       +--------------------------+
```

- For AL-T monitoring: P(Tx) and a(Tx) must be known
- For AL-R monitoring: P(RX) and a(Rx) must be known

An alarm shall be raised if P(in) or P(Rx) drops below a configured threshold (t [dB]):

- P(in) < P(Tx) - a(Tx) - t (Tx direction)
- P(Rx) < P(out) - a(Rx) - t (Rx direction)
- a(Tx) =| a(Rx)

Figure 5: Extended LMP Model

Pure Access Link (AL) Monitoring Use Case

Figure 4 illustrates the access link monitoring use case and the different physical properties involved that are defined below:

- Ss, Rs: Single Channel reference points
- P(Tx): current optical output power of transmitter Tx
- a(Tx): access link attenuation in Tx direction (external transponder point of view)
- P(in): measured current optical input power at the input port of border DWDM NE
- t: user defined threshold (tolerance)
- P(out): measured current optical output power at the output port of border DWDM NE
- a(Rx): access link attenuation in Rx direction (external transponder point of view)
- P(Rx): current optical input power of receiver Rx

Description:
- The access link attenuation in both directions (a(Tx), a(Rx)) is known or can be determined as part of the commissioning process. Typically, both values are the same.
- A threshold value t has been configured by the operator. This should also be done during commissioning.
- A control plane protocol (e.g. this draft) is in place that allows to periodically send the optical power values P(Tx) and P(Rx) to the control plane protocol instance on the DWDM border NE. This is llustrated in Figure 3.
- The DWDM border NE is capable to periodically measure the optical power Pin and Pout as defined in G.697 by power monitoring points depicted as yellow triangles in the figures below.

AL monitoring process:
- Tx direction: the measured optical input power Pin is compared with the expected optical input power P(Tx) - a(Tx). If the measured optical input power P(in) drops below the value (P(Tx) - a(Tx) - t) a low power alarm shall be raised indicating that the access link attenuation has exceeded a(Tx) + t.
- Rx direction: the measured optical input power P(Rx) is compared with the expected optical input power P(out) - a(Rx). If the measured optical input power P(Rx) drops below the value (P(out) - a(Rx) - t) a
low power alarm shall be raised indicating that the access link attenuation has exceeded a(Rx) + t.
-to avoid toggling errors, the low power alarm threshold shall be lower than the alarm clear threshold.

Figure 6 Use case 1: Access Link power monitoring

```
     +----------+                    +--------------------------+
     | +------+ |    P(Tx), P(Rx)    |  +-------+               |
     | |      | | =================> |  |       |               |
     | | LMP  | |    P(in), P(out)   |  |  LMP  |               |
     | |      | | <================= |  |       |               |
     | +------+ |                    |  +-------+               |
     |          |                    |                          |
     |          |                    |    P(in) - P(Tx) - a(Tx) |
     |          |                    |    ___                   |
     |          |                    |    \ /  Power Monitor    |
     |          | P(Tx)              |     V                    |
     |  +----+  | Ss    //\\         |     |     |\             |
     |  | TX |----|-----\\//------------------->| \            |
     |  +----+  | Access Link (AL-T) |       .  |  |           |
     |          | attenuation a(Tx)  |       .  |  |==============>
     |          |                    |       .  |  |           |
     | External |                    |      --->| /             |
     | Optical  |                    |          |/              |
     |Transpond.|                    |    P(out)                |
     |          |                    |    ___                   |
     |          |                    |    \ /  Power Monitor    |
     |          | P(Rx)              |     V                    |
     |  +----+  | Rs    //\\         |     |     |\             |
     |  | RX |<---|-----\\//--------------------| \            |
     |  +----+  | Access Link (AL-R) |       .  |  |           |
     |          | Attenuation a(Rx)  |       .  |  |<==============
     +----------+                    |       .  |  |           |
                                     |      <---| /             |
     P(Rx) = P(out) - a(Rx)          |          |/              |
                                     |                          |
                                     |           ROADM          |
                                     +--------------------------+
```

- For AL-T monitoring: P(Tx) and a(Tx) must be known
- For AL-R monitoring: P(RX) and a(Rx) must be known

An alarm shall be raised if P(in) or P(Rx) drops below a configured threshold (t [dB]):

- P(in) < P(Tx) - a(Tx) - t (Tx direction)
- P(Rx) < P(out) - a(Rx) - t (Rx direction)
- a(Tx) = a(Rx)

Figure 6: Extended LMP Model

Power Control Loop Use Case

This use case is based on the access link monitoring use case as described above. In addition, the border NE is running a power control application that is capable to control the optical output power of the single channel tributary signal at the output port of the border DWDM NE (towards the external receiver Rx) and the optical output power of the single channel tributary signal at the external transmitter Tx within their known operating range. The time scale of this control loop is typically relatively slow (e.g. some 10s or minutes) because the access link attenuation is not expected to vary much over time (the attenuation only changes when re-cabling occurs).
From a data plane perspective, this use case does not require additional data plane extensions. It does only require a protocol extension in the control plane (e.g. this LMP draft) that allows the power control application residing in the DWDM border NE to modify the optical output power of the DWDM domain-external transmitter Tx within the range of the currently used application code. Figure 5 below illustrates this use case utilizing the LMP protocol with extensions defined in this draft.

Figure 7 Use case 2: Power Control Loop

```
     +----------+                       +--------------------------+
     | +------+ | P(Tx),P(Rx),Set(Pout) |  +-------+   +--------+  |
     | |      | | ====================> |  |       |   | Power  |  |
     | | LMP  | | P(in),P(out),Set(PTx) |  |  LMP  |   |Control |  |
     | |      | | <==================== |  |       |   | Loop   |  |
     | +------+ |                       |  +-------+   +--------+  |
     |     |    |                       |                          |
     | +------+ |                       |    P(in) = P(Tx) - a(Tx) |
     | |C.Loop| |                       |    ___                   |
     | +------+ |                       |    \ /  Power Monitor    |
     |     |    | P(Tx)                 |     V                    |
     | +------+ | Ss    //\\            |     |    |\              |
     | | TX |>----|-----\\//---------------------->| \             |
     | +------+ | Access Link (AL-T)    |       .  |  |            |
     |  VOA(Tx) | attenuation a(Tx)     |       .  |  |==============>
     |          |                       |       .  |  |            |
     | External |                       |      --->| /             |
     | Optical  |                       |          |/              |
     |Transpond.|                       |    P(out)                |
     |          |                       |    ___                   |
     |          |                       |    \ /  Power Monitor    |
     |          | P(Rx)                 |     V                    |
     |  +----+  | Rs    //\\            |     |  VOA(out) |\       |
     |  | RX |<---|-----\\//---------------------<|-------| \      |
     |  +----+  | Access Link (AL-R)    |              .  |  |     |
     |          | attenuation a(Rx)     |              .  |  |<=======
     +----------+                       |        VOA(out) |  |     |
                                        |     <--<|-------| /      |
     P(Rx) = P(out) - a(Rx)             |                 |/       |
                                        |                          |
                                        |            ROADM         |
                                        +--------------------------+
```

Figure 7: Extended LMP Model

- The Power Control Loops in Transponder and ROADM controls the Variable Optical Attenuators (VOA) to adjust the proper power in base of the ROADM and Receiver caracteristics and the Access Link attenuation

6. Acknowledgements

The author would like to thank Ulrich Drafz for the very good teamwork during the last years and the initial thoughts related to the packet optical integration. Furthermore the author would like to thank all people involved within Deutsche Telekom for the support and fruitful discussions.

7. IANA Considerations

This memo includes no request to IANA.

8. Security Considerations

The architecture and solution space in scope of this framework imposes no additional requirements to the security models already defined in RFC5920 for packet/optical networks using GMPLS, covering also Control Plane and Management interfaces. Respective security mechanisms of the components and protocols, e.g. LMP security models, can be applied unchanged.

As this framework is focusing on the single operator use case, the security concerns can be relaxed to a subset compared to a setup where information is exchanged between external parties and over external interfaces.

Concerning the access control to Management interfaces, security issues can be generally addressed by authentification techniques providing origin verification, integrity and confidentiality. Additionally, access to Management interfaces can be physically or logically isolated, by configuring them to be only accessible out-of-band, through a system that is physically or logically separated from the rest of the network infrastructure. In case where management interfaces are accessible in-band at the client device or within the optical transport netork domain, filtering or firewalling techniques can be used to restrict unauthorized in-band traffic. Authentication techniques may be additionally used in all cases.

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Framework and Requirements for GMPLS-based Control of Flexible Ethernet Network

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Abstract

Flex Ethernet (FlexE) technology, which is defined by Optical Internetworking Forum (OIF), is a new kind of data plane technology and can be used to provides a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. This includes MAC rates that are both greater than (through bonding) and less than (through sub-rate and channelization) the Ethernet PHY rates used to carry FlexE.

Based on the applications/use cases given in the Flex Ethernet Implementation Agreement, this document defines a framework and control plane requirements for the application of existing GMPLS architecture and control plane protocols to the control of flexible Ethernet network. The actual extensions to the GMPLS protocols will be defined in companion documents.

Status of This Memo

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Table of Contents

1. Introduction

As defined in Flex Ethernet (FlexE) Implementation Agreement, FlexE can provide a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. In a more detailed description, FlexE employs more than one Ethernet PHYs as server layer and these Ethernet PHYs are bonded together as a FlexE group to carry FlexE client signal. The general capabilities supported by FlexE implementation includes:

Bonding of Ethernet PHYs, e.g., supporting a 200G MAC over two bonded 100GBASE-R PHYs.

Sub-rates of Ethernet PHYs, e.g., supporting a 50G MAC over a 100GBASE-R PHY.

Channelization within a PHY or a group of bonded PHYs, e.g, support a 150G and two 25G MACs over two bonded 100GBASE-R PHYs.

Note that hybrids are also possible, for example a sub-rate of a group of bonded PHYs, for example, a 250G MAC over three bonded 100GBASE-R PHYs.

In order to operate on the Ethernet PHYs, FlexE mechanism operates using a calendar which assigns slot positions on sub-calendars on each PHY of the FlexE group to each of the FlexE clients. The calendar has a granularity of 5G, and has a length of 20 slots per 100G of FlexE group capacity.

Based on the FlexE Implementation Agreement, this document defines the framework for GMPLS-based control of flexible Ethernet network to depict the layer model of Flex Ethernet as well as a set of associated control-plane requirements.

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. Overview of FlexE Networks

2.1. FlexE Terminology

This section presents the definitions of the terms used in FlexE networks. More details about these terms can be found in OIF Flex Ethernet (FlexE) Implementation Agreement.

FlexE group: the FlexE Group refers to a group of from 1 to n bonded Ethernet PHYs. This version of the Implementation Agreement supports FlexE groups composed of one or more bonded 100GBASE-R PHYs.

FlexE Client: a FlexE Client is an Ethernet flow based on a MAC data rate that may or may not correspond to any Ethernet PHY rate. The FlexE client MAC rates supported by this implementation agreement are 10, 40, and m * 25 Gb/s.

FlexE Shim: the FlexE Shim is the layer that maps or demaps the FlexE clients carried over a FlexE group. The FlexE mux refers to the transmit direction which maps the FlexE clients over the FlexE group. The FlexE demux refers to the receive direction which demaps the FlexE clients from the FlexE group.

2.2. Scenarios Supported by FlexE

According to the FlexE Implementation Agreement, FlexE can support a variety of cases. A non-exhaustive list includes:

One case of router to transport connection is where the transport network is unaware of FlexE. This may be used with legacy transport equipment that provides PCS-codeword transparent transport of 100GbE, but provides no special support for FlexE. In this case, all PHYs of the FlexE group are carried independently, but over the same fiber route, over the transport network.

Another case of router to transport connection is where the transport network equipment terminates the FlexE group. In the FlexE terminating case, FlexE group is terminated before crossing the transport network and FlexE client is extracted from the FlexE signal and then carried over the transport network.

The final router to transport example described is one where the transport network is aware that it is carrying FlexE PHYs (as opposed to 100GbE), but the FlexE group is not terminated on the transport equipment. Transport network equipment may "crunch" the PHY of the FlexE group by allowing bits or bytes to be discarded from the unavailable calendar slots at the transport network ingress and these bits or bytes re-inserted with fixed values at the transport network egress. This may be used to support cases where the Ethernet PHY rate is be greater than the wavelength rate, the wavelength rate is not an integral multiple of the PHY rate, or there is a reason (for example, wavelengths terminated on different transponder line cards) that it is not possible to terminate the FlexE group in the transport equipment. This kind of equipment is a kind of special transport equipment which can support partial-rate transport.

2.3. FlexE Layer Model

Based on the cases addressed in section 3.2, FlexE has different kinds of mapping hierarchy accordingly. This section gives description of FlexE layer model in different cases. Figure 1 depicts a FlexE layered network scenario. In this network, B and E are FlexE capable nodes, C and D are OTN ODUflex/ODU4 capable nodes. Node B, C are mainly used to encapsulate the client layer signal into the server layer, while node D, E are mainly used to extract the client layer signal from the server layer signal.

As defined in FlexE Implementation Agreement, a FlexE client may be generated internally within a system, received from an Ethernet PHY or from another FlexE shim. In this network scenario, we suppose the FlexE client is generated in router B.

Feature of cases can be found in section 3.2.

In all cases, FlexE client at node B has a path setup request from source B to destination E.

```
+---+                       +---+
| B |                       | E |
+---+                       +---+
    \                      /
     \                    /
     +---+          +---+
     | C |----------| D |
     +---+          +---+
```

Figure 1: FlexE Layer Network

2.3.1. Layer Model in FlexE Unaware Case

In this case which is depicted in Figure 2, there exist four network layers. FlexE client layer represents an end-to-end connection, which is from the source B to destination E. When the FlexE client signal is generated inside node B, the FlexE client signal is first placed into the slots of FlexE, then the FlexE signal is carried by Ethernet PHYs towards the destination E. When the Ethernet PHYs arrive at node C, each PHY will be mapped into a separate ODU4 connection and then transferred towards the ODU layer connection destination D.

Four layers exist in this case, and the mapping hierarchy between node C and node D can be seen in Figure 3.

```
            Ethernet Client Connection
   |------------------------------------------|
                 FlexE Connection
    |----------------------------------------|
  +---+                                    +---+
  | B |          PHY Connections           | E |
  +---+|--------------------------------|+---+
       \                                /
        \                              /
       +---+  ODU4 Connections  +---+
       | C |--------------------| D |
       +---+                    +---+
```

Figure 2: FlexE Unaware Layer Network

```
+-------------------+
| Ethernet Client   |
+-------------------+
|       FlexE       |
+-------------------+
|  PHY    |  PHY    |
+-------------------+
| ODU4    |  ODU4   |
+-------------------+
```

Figure 3: FlexE Unaware Layer Hierarchy

2.3.2. Layer Model in FlexE Terminating Case

In this case, FlexE client layer represents an end-to-end connection, which is from the source B to destination E. When the FlexE client signal is generated inside node B,, the Ethernet signal is first placed into the slots of FlexE, then the FlexE signal is carried by Ethernet PHYs towards the destination C. When the FlexE signal arrives at node C, node C first extracts the FlexE client signal, then maps the Ethernet client signal into ODU signal and transfers towards destination node D. Node D will first extract the FlexE client signal from the ODU signal, then map the Ethernet client signal into FlexE signal, which will then be carried by Ethernet PHYs towards destination node E.

Two segments of FlexE connection exist in this case. one is from node B to node C, and the other is from node D to node E.

```
                   Ethernet Client Connection
               |-----------------------------------------|
              +---+                                      +---+
              | B |                                      | E |
              +---+                                      +---+
    PHY Connections\FlexE Connection                    /
                    \                                  /
                     +---+   ODU Connection   +---+
                     | C |--------------------| D |
                     +---+                    +---+
```

Figure 4: FlexE Terminating Layer Network

Two kinds of mapping hierarchy exist. For the signal transferred on the links between B and C, D and E, the mapping hierarchy can be seen in Figure 5. For the signal transferred on the links between C and D, the mapping hierarchy can be seen in Figure 6.

```
+-------------------+
| Ethernet Client   |
+-------------------+
|       FlexE       |
+-------------------+
|  PHY    |  PHY    |
+-------------------+
```

Figure 5: Mapping Hierarchy of FlexE

```
+-------------------+
| Ethernet Client   |
+-------------------+
|        ODU        |
+-------------------+
```

Figure 6: Mapping Hierarchy on OTN Link

2.3.3. Layer Model in FlexE Aware Case

FlexE client layer represents an end-to-end connection, which is from the source B to destination E. When the FlexE client signal is generated inside node B,, the Ethernet signal is first placed into the slots of FlexE, then the FlexE signal is carried by Ethernet PHYs towards the destination E. When the FlexE signal arrives at node C, node C will first discards unavailable slots, then transfers the left slots to ODU Connection.

In this scenario, Ethernet PHYs connection exist between node B and node C, node D and node E.

```
                     Ethernet Client Connection
            |-----------------------------------------|
                         FlexE Connection
             |---------------------------------------|
           +---+                                   +---+
           | B |                                   | E |
           +---+                                   +---+
  PHY Connections\                                 /
                  \                               /
                  +---+ ODUFlex Connection +---+
                  | C |--------------------| D |
                  +---+                    +---+
```

Figure 7: FlexE Aware Layer Network

Two kinds of mapping hierarchy exist. For the signal transferred on the links between B and C, D and E, the mapping hierarchy can be seen in Figure 8. For the signal transferred on the links between C and D, the mapping hierarchy can be seen in Figure 9.

```
+------------------+
| Ethernet Client  |
+------------------+
|      FlexE       |
+------------------+
|  PHY    |  PHY   |
+------------------+
```

Figure 8: Mapping Hierarchy of FlexE

```
+------------------+
| Ethernet Client  |
+------------------+
|      FlexE       |
+------------------+
|     ODUFlex      |
+------------------+
```

Figure 9: Mapping Hierarchy on OTN Link

3. GMPLS Applicability

The goal of this section is to provide an insight into the application of GMPLS as a control mechanism in FlexE networks. Specific control-plane requirements for the support of FlexE networks are covered in Section 5. This framework is aimed at controlling the FlexE shim layer in different network scenario based on the capability of FlexE described in OIF Flex Ethernet (FlexE) Implementation Agreement.

3.1. General Considerations

The GMPLS control of the FlexE layer deals with the establishment of FlexE connections that are transferred in FlexE capable nodes. GMPLS labels are used to locally represent the FlexE connections and its associated slots transferring.

3.2. Consideration of LSPs in FlexE

The FlexE LSP is a control-plane representation of a FlexE Connection and MUST be carried by Ethernet PHYs LSP or ODU LSP in the network.

Figure 4 depicts a scenario that the FlexE LSP is carried over Ethernet PHYs LSP between node B and node C, node D and node E. When the Ethernet client signal arrives at node B, node B first check if there are enough Ethernet PHYs available for setting up FlexE LSP. If no, node B will first set up Ethernet PHYs LSP from node B to node C, and then set up the FlexE LSP over the Ethernet PHYs LSP. This process involves twice signalling procedures, one is to set up Ethernet PHYs, and the other is used to set up FlexE LSP over the Ethernet PHYs. The set-up signalling of FlexE LSP includes the allocation of resource for Ethernet client.

Figure 7 depicts a scenario that the FlexE LSP is carried over ODU LSP between node C and node D. This scenario is different, and is used to support cases where the Ethernet PHY rate is be greater than the wavelength rate, the wavelength rate is not an integral multiple of the PHY rate. Node C and node D MUST support the partial-rate ability. When the FlexE LSP over Ethernet PHYs arrives at node C, node C first check if there is enough resource for carrying the FlexE LSP signal across the transport network. If no, node C will check if there is enough resource for carrying FlexE LSP signal after discarding the unavailable slots. If yes, node C will first set up the ODUFlex LSP to node D, and then continue the signalling process of FlexE LSP across the transport network.

3.3. Control-Plane Modelling of FlexE Network Elements

FlexE is a new kinds of transport technology, which brings new constraints. These constraints are listed below:

Unavailable slots: this is different from "unused" slot, in that it is known, due to transport network constraints, that not all of the calendar slots generated from the FlexE mux will reach the FlexE demux and therefore no FlexE client should be assigned to those slots. As defined in the Flex Ethernet Implementation Agreement, unavailable slots are always at the end of the sub-calendar configuration for the respective PHY.

Unused slots: unused slots can be allocated to Ethernet client as available resource.

Partial-rate capability: the partial-rate capability is usually supported by an OTN access equipment. If an equipment supports partial-rate, it means this equipment has the capability of discarding unavailable slots and transfers the left slots across OTN transport network.

Slot granularity: currently, only one kinds of 5G slot granularity is defined in OIF Flex Ethernet (FlexE) Implementation Agreement.

3.4. FlexE Layer Resource Allocation Considerations

FlexE LSP transfers based on the slot information, so it SHOULD be able to expose the unused slot resource information towards the client layer. Besides the slot information, there are also many other attributes that need to be specified when allocating resource. In GMPLS-controlled system, these information should be taken into consideration as a label when transferring.

FlexE group number: a bunch of Ethernet PHYs can be bounded together and used as a whole by the FlexE LSP. FlexE LSPs between the same source and destination equipment SHOULD NOT have the same FlexE group number. Source equipment and destination equipment SHOULD be aware of the existing of FlexE group and which Ethernet PHYs are in which FlexE group.

PHY Number: it’s a dynamic and logical number that is assigned through control plane or management plane, which is unique within the context of (source, destination), and has a one-to-one correlation with physical port. This information will also be carried in the FlexE overhead. Source equipment and destination equipment SHOULD negotiate a value for every Ethernet PHYs within one FlexE group.

Slot Assignment information: the FlexE LSP transfers based on the slot positions, so the equipment SHOULD be able to tell which slot is assigned to which client.

Partial-rate: during the process of resource allocation, where the partial-rate would happen should be indicated.

Granularity: currently, only one kinds of 5G slot granularity is defined in OIF Flex Ethernet (FlexE) Implementation Agreement.

3.5. Neighbour Discovery and Link Property Correlation

There are potential interworking problems between different FlexE capable equipment. Devices or equipments might not be able to support the interworking of every slot due to the constraints of transport network or other constraints. In this case, two directly connected FlexE capable equipments SHOULD run the neighbour discovery process and correlate the link property to make sure which slots are unavailable, which slots can be used by the client.

3.6. Routing and Topology Dissemination

The topology and routing information is used by the path computation entity to compute an end-to-end path. Besides the basic interconnected information, there are also some FlexE specific attributes that should be taken into consideration.

Partial-rate: partial-rate capability is a special feature which allows an equipment to discard unavailable slots and transfers the left slots across OTN transport network. Path computation entity is more likely to compute a feasible path if this capability is taken into consideration when computing path.

Unavailable slot information: this information is used to indicate certain slots SHOULD not be considered when computing an end-to-end path. The unavailable slots can not be used to transfer signal because of the transport constraints.

Unused slot information: unused slot can be allocated to the path as available resource.

4. Control-Plane Requirements

The control of FlexE networks places additional requirements on the GMPLS protocols. This section summarizes those requirements for signalling and routing.

4.1. Support for Signalling of FlexE

The signalling procedures shall be able to assign an FlexE group number for a FlexE LSP, so a number of Ethernet PHYs can be bonded together and uniquely indicated.

The signalling procedures shall be able to assign an unique PHY number for each bonded Ethernet PHY, and a correlation relationship

SHOULD also be indicated between the assigned PHY number and real physical port number when signalling.

The signalling procedures shall be able to configure the slots information allocated for a FlexE LSP.

The Signalling procedures shall be able to indicate the palace where partial-rate mapping happens.

4.2. Support for Routing of FlexE

The routing protocol will support all functions described in [RFC4202] and extend them to a FlexE data plane.

The routing protocol SHALL distribute sufficient information to compute paths to enable the signalling procedure to establish LSPs as described in the previous sections.

The routing protocol SHALL update its advertisements of available resources and capabilities to include the partial-rate support information and unused slot information on each Ethernet PHY port.

4.3. Support for Neighbour Discovery and Link Property and Link Correlation

The control plane MAY include support for neighbour discovery such that a FlexE network can be constructed in a "plug-and-play" manner.

The control plane SHOULD allow the nodes at opposite ends of a link to correlate the properties that they will apply to the link. Such a correlation SHOULD include at least the identities of the nodes and the identities that they apply to the link. Other FlexE specific properties, such as the link characteristics of unavailable slot information, SHOULD also be correlated. Such neighbour discovery and link property correlation, if provided, MUST be able to operate in both an out-of-band manner.

5. Security Considerations

TBD

6. Manageability Considerations

TBD

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7.1. Normative References

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RSVP-TE Signaling Extensions in support of Flexible Ethernet networks
draft-wang-ccamp-flexe-signaling-00

Abstract

This draft describes the extensions to the Resource Reservation Protocol Traffic Engineering (RSVP-TE) signalling protocol to support Label Switched Paths (LSPs) in a GMPLS-controlled flexible Ethernet network.

Status of This Memo

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Table of Contents

1. Introduction

Flex Ethernet (FlexE) technology, which is defined by Optical Internetworking Forum (OIF), is a new kind of data plane technology and can be used to provides a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. This includes MAC rates that are both greater than (through bonding) and less than (through sub-rate and channelization) the Ethernet PHY rates used to carry FlexE.

FlexE can provide a generic mechanism for supporting a variety of Ethernet MAC rates that may or may not correspond to any existing Ethernet PHY rate. In a more detailed description, FlexE employs more than one Ethernet PHYs as server layer and these Ethernet PHYs are bonded together as a FlexE group to carry FlexE client signal. The general capabilities supported by FlexE implementation includes:

Bonding of Ethernet PHYs, e.g., supporting a 200G MAC over two bonded 100GBASE-R PHYs.

Sub-rates of Ethernet PHYs, e.g., supporting a 50G MAC over a 100GBASE-R PHY.

Channelization within a PHY or a group of bonded PHYs, e.g, support a 150G and two 25G MACs over two bonded 100GBASE-R PHYs.

Note that hybrids are also possible, for example a sub-rate of a group of bonded PHYs, for example, a 250G MAC over three bonded 100GBASE-R PHYs.

In order to operate on the Ethernet PHYs, FlexE mechanism operates using a calendar which assigns slot positions on sub-calendars on each PHY of the FlexE group to each of the FlexE clients. The calendar has a granularity of 5G, and has a length of 20 slots per 100G of FlexE group capacity.

[FLEXE-FWK] defines a framework and the associated control plane requirements for the Generalized Multi-Protocol Label Switching (GMPLS) [RFC3945] based control of FlexE networks.

Based on the requirements described in FlexE framework document, this document defines additional requirements and protocol extensions to Resource Reservation Protocol-Traffic Engineering (RSVP-TE) [RFC3473] to set up LSPs in networks that support the FlexE.

1.1. FlexE Terminology

For terminology related to flexible Ethernet, please refer to [FLEXE-FWK] and FlexE Implementation Agreement.

1.2. 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 RFC 2119 [RFC2119].

2. Requirements for FlexE Signalling

The architecture for establishing LSPs in a FlexE network is described in [FLEXE-FWK].

The FlexE LSP is a control-plane representation of a FlexE Connection and MUST be carried by Ethernet PHYs LSP or ODU LSP in the network. So in order to set up an end-to-end FlexE LSP, Ethernet PHY LSPs or ODU LSPs MUST be set up in advance. [FLEXE-FWK] gives a description of FlexE layer resource information needed to be reserved when signalling an end-to-end LSP. This section gives a detailed description of these resource information. Based on these information, source equipment and destination equipment will be able to map and demap the FlexE clients from the FlexE group properly.

2.1. FlexE Group

As defined in FlexE Implementation Agreement, the FlexE Group refers to a group of from 1 to n bonded 100GBASE-R Ethernet PHYs. Ethernet PHYs are bounded together and used as a whole by the FlexE LSP. FlexE LSPs between the same source and destination equipment SHOULD NOT have the same FlexE group number. Source equipment and destination equipment SHOULD be aware of the existing of FlexE group and which Ethernet PHYs are in which FlexE group.

This FlexE group information MUST be carried in the generalized label of signalling message during LSP establishment if FlexE group is needed.

2.2. PHY Number

The PHY number is a dynamic and logical number that is assigned through control plane or management plane, which is unique within the context of (source, destination), and has a one-to-one correlation with physical port. This information will also be carried in the FlexE overhead. Source equipment and destination equipment SHOULD negotiate a value for every Ethernet PHYs within one FlexE group.

The PHY number information MUST be carried in the generalized label of signalling message during LSP establishment. Besides the PHY number carried in the generalized label, RSVP_HOP object MUST also be used to indicate the correlation between PHY number and physical port number. The sequence of the PHY numbers listed in the generalized label SHOULD be in accordance with the physical ports carried in RSVP_HOP object.

2.3. Partial-rate

The partial-rate capability is usually supported by an OTN access equipment. If an equipment supports partial-rate, it means this equipment has the capability of discarding unavailable slots and transfers the left slots across OTN transport network. During the process of resource allocation, where the partial-rate would happen should be indicated.

2.4. Slot Assignment

The FlexE LSP transfers based on the slot positions, so the equipment SHOULD be able to tell which slot is assigned to which client according to the generalized label carried in the signalling message. This attribute SHOULD also take the unavailable slots information into consideration.

2.5. Granularity

Currently, only one kinds of 5G slot granularity is defined in OIF Flex Ethernet (FlexE) Implementation Agreement. During signalling process, this information can be inferred through the bandwidth parameters and slot number information within one Ethernet PHY.

3. Protocol Extensions

This section defines the extensions to RSVP-TE signalling for GMPLS [RFC3473] to support FlexE networks.

3.1. Traffic Parameters

In RSVP-TE, the SENDER_TSPEC object in the Path message characterizes the traffic parameters for the data flow from the corresponding sender. The FLOWSPEC object in the Resv message indicates the actual resource reservation. As defined in [RFC3473], bandwidth encodings are carried in the SENDER_TSPEC and FLOWSPEC objects, and these values are set in the Peak Data Rate field of Int-Serv objects, see [RFC2210]. Other bandwidth/service related parameters in the object are ignored and carried transparently. Signalling procedure of RSVP-TE used in FlexE network can also reuse the SENDER_TSPEC object defined in [RFC2210] to describe the traffic parameters for the data flow of the sender.

3.2. Generalized Label

In the case of FlexE network, the GMPLS labels are used to locally represent the FlexE connections and its associated slots transferring. Parameters defined in section 3 are needed to be carried in the generalized label to represent the FlexE connections.

The following is the GENERALIZED_LABEL object format that is used with the TDM Switching Type:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         FlexE Group Number            |        Reserved       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  PHY Number   | Slots Assignment information (bitmap) |   U   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   U   |                      Reserved                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  PHY Number   | Slots Assignment information (bitmap) |   U   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   U   |                      Reserved                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               ......                                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: FlexE Label

FlexE Group Number: 20 bits

The FlexE Group refers to a group of from 1 to n bonded 100GBASE-R Ethernet PHYs.

PHY number: 8 bits

The PHY number is a dynamic and logical number that is assigned through control plane or management plane, which is unique within the context of (source, destination), and has a one-to-one correlation with physical port. This information will also be carried in the FlexE overhead.

Slots Assignment information (bitmap) : 20 bits

This attribute is used to indicate slots assignment information, including slots assigned for the client, which are indicated by the bit set to"1" and slots unused, which are indicated by the bit set to "0".

U field: 8 bits

This field is used to indicate the number of unavailable slot. As defined in OIF FlexE Implementation Agreement, unavailable slots are always at the end of the sub-calendar configuration for the respective PHY, so this draft uses a specific field to describe them.

Note: the number of the Ethernet PHY used by FlexE can be referred from the number of the "PHY number" in the generalized label.

3.3. Flag extensions in Hop Attributes TLVs

The Attribute Flags TLV defined in [RFC5420] is carried in an ERO Hop Attributes subobject. Flags set in the Attribute Flags TLV [RFC5420] carried in an ERO Hop Attributes subobject SHALL be interpreted in the context of the received ERO. Only a subset of defined flags are defined as valid for use in Attribute Flags TLV carried in an ERO Hop Attributes subobject. Invalid flags SHALL be silently ignored.

A bit in the Attribute Flags TLV is assigned to indicate the partial-rate mux and demux. This ERO Hop Attributes subobject MUST come in pairs. The node which do the partial-rate mux MUST check the existence of partial-rate demux flag in the ERO Hop Attributes subobject of the path message. If it does not exist, path will not be set up successfully.

3.4. Signalling Procedure

This section gives description of FlexE layer model in different cases. Figure 2 depicts a FlexE layered network scenario. In this network, B and E are FlexE capable nodes, C and D are OTN ODUflex/ODU4 switch capable nodes. Node B, C are mainly used to encapsulate the client layer signal into the server layer, while node D, E are mainly used to extract the client layer signal from the server layer signal.

```
           +---+                        +---+
           | B |                        | E |
               +---+                                            +---+
                \                      /
                 \                    /
                  +---+          +---+
                  | C |----------| D |
                  +---+          +---+
```

Figure 2: FlexE Layer Network

3.4.1. Procedure for FlexE over Ethernet PHYs

In this case, node C and node D are unaware of the FlexE signal.

Suppose node B receives a FlexE client path set up request from node B to node E and the bandwidth of this path is 150G. There are three Ethernet PHYs between B and C, D and E. Also there exist enough ODU4 connections between node C and node D to bear the traffic from node B. Following is the signalling procedure.

a. Node B intends to send the RSVP-TE path message to set up an end-to-end path towards the destination node E. The bandwidth requirement is 150G.

b. Before node B begins to transfer the FlexE client path message, it will first assert a new FlexE path needs to be set up from node B to node E to carry the Ethernet client traffic by comparing the switching capability carried in the FlexE client path message and the switching capability that node B can support. Node B first blocks the Ethernet client path message, then initiate another new path message to set up the FlexE path from node B to node E. The requested switching capability of the FlexE path is set to TDM and the encoding type is set to "FlexE-LSP".

Before node B send the FlexE path message towards the next hop, node B first check if there are enough Ethernet PHYs to carry the FlexE traffic. Then node B will start the set up of two Ethernet PHYs LSP from node B to node E. The Ethernet PHY path messages are then sent towards the next hop node C. Two Ethernet PHY LSPs will be set up.

c. When node C receives the Ethernet PHY path messages from node B, it will first assert two new ODU4 path needs to be set up from node C to node D to carry the Ethernet PHY traffic by comparing the switching capability carried in the path message and the switching capability that node C can support. Node C first blocks the Ethernet PHY path message, then initiate another new path messages to set up the ODU4 path from node C to node D.

Considering the set up of ODU4 path is not the focus of this draft, procedure of setting up ODU4 paths are not going to be described in this draft. Node C will receive the Resv message from node D and confirm the successful set up of ODU4 paths. The ODU4 LSPs behave as the server layer of Ethernet PHY paths.

d. Node C will then continue sending the Ethernet PHY path messages towards node E to finish the set up of Ethernet PHY LSPs. The Ethernet PHY LSPs from node B to node E behave as the a link with only one hop.

e. After node B receives the Resv message from node E and confirm the successful set up of Ethernet PHY paths, node B will continue sending the FlexE path message towards the next hop node E. The bandwidth requirement is 150G.

f. Node E receives the FlexE path message from node B. Considering there are already two Ethernet PHYs from node B to node E, node E determines to set up the FlexE path over the two Ethernet PHYs by carrying the assigned FlexE group number, dynamic PHY number and slot positions for the Ethernet client in the generalized label.

Besides the generalized label, RSVP_HOP object MUST also be used to indicate the correlation between PHY number and physical port number. The sequence of the PHY numbers listed in the generalized label SHOULD be in accordance with the physical ports number carried in RSVP_HOP object.

Node E then send the assembled Resv message toward the FlexE path source, node B, to finish the set up of FlexE path.

g. After node B receive the Resv message from node E and confirm the successful set up of FlexE path, node B will continue sending the blocked FlexE client path message towards the destination node E to finish the set up of the client path.

FlexE LSP is demonstrated as an Ethernet client link once it was set up. Unused bandwidth on the FlexE LSP can be used further by another FlexE client.

3.4.2. Procedure for FlexE over ODU LSPs

In this case, node C and node D are aware of the FlexE signal.

Suppose node B receives a FlexE client path set up request from node B to node E and the bandwidth of this path is 150G. There are three Ethernet PHYs between B and C, D and E. Also there exist 180G ODUFlex connections between node C and node D to bear the traffic from node B. The number of unavailable slots between B and C is 4, between D and E is 5. Following is the signalling procedure.

a. Node B intends to send the RSVP-TE path message to set up an end-to-end path towards the destination node E. The bandwidth requirement is 150G.

b. Before node B begins to transfer the FlexE client path message, it will first assert a new FlexE path needs to be set up from node B to node E to carry the FlexE client traffic by comparing the switching capability carried in the FlexE client path message and the switching capability that node B can support. Node B’s computation element will compute an end-to-end partial-rate supported path B-C-D-E. Node B then first blocks the Ethernet client path message, then initiate another new path message to set up the FlexE path from node B to node E. The requested switching capability of the FlexE path is set to TDM and the encoding type is set to "Partial-rate FlexE-LSP".

c. Before node B send the FlexE path message towards the next hop, node B first check if there are enough Ethernet PHYs to carry the FlexE traffic. Then node B will start the set up of two Ethernet PHYs LSP from node B to node E with the G-PID field set to "Partial-rate FlexE-LSP". The Ethernet PHY path messages are then sent towards the next hop node C. Two Ethernet PHY LSPs will be set up.

d. When node C receives the Ethernet PHY path messages which are used to support partial-rate FlexE-LSP from node B, it will first check if itself support partial-rate capability as a result of the "Partial-rate FlexE-LSP" carried in G-PID. Node C then sends the Resv message to node B to finish the set up of Ethernet PHYs LSP if it confirms the support of partial-rate capability.

e. When node B receives the Ethernet PHYs resv message from node C, it will first finish the set up of Ethernet PHYs LSP, then continue sending the FlexE path message towards next hop node C. These Ethernet PHY LSPs behave as a one hop FlexE link in the FlexE network.

f. When node C receives the FlexE path message, node B first block the FlexE path message, then checks if there are ODUFlex LSP available to carry the FlexE traffic. If no, node B first initiate the ODUFlex LSP set up and the bandwidth requested does not take the unavailable slots into consideration.

Considering the set up of ODUFlex path is not the focus of this draft, procedure of setting up ODUFlex paths are not going to be described in this draft. Node C will receive the Resv message from node D and confirm the successful set up of ODUFlex paths. The ODUFlex LSPs behave as a one hop FlexE link in the FlexE network.

g. When node C receives the ODUFlex Resv message from node D. It will first finish the set up of ODUFlex LSP, then continue sending the FlexE path message towards next hop node D. These ODUFlex LSPs behave as a one hop FlexE link in the FlexE network and this link carries all FlexE slots except unavailable slots.

h. When node D receives the FlexE path message, it will repeat the procedure in c, d, e. Node E will receive the FlexE path message sent from node B and it will construct the Resv message sent back to node B to finish the resource reservation along the path.

i. After node B receives the FlexE Resv message, it first finish the path set up and then continue the blocked FlexE client signalling procedure.

4. IANA Considerations

In this draft, two new encoding types "FlexE-LSP" and "Partial-rate FlexE-LSP" are assigned for FlexE LSP.

5. Security Considerations

TBD

6. Manageability Considerations

TBD

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YANG Models for the Northbound Interface of a Transport Network Controller: Requirements, Functions, and a List of YANG Models

draft-zhang-ccamp-transport-ctrlnorth-yang-00.txt

Abstract

A transport network is 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 equipment utilizing any of a number of different transport technologies such as the evolving optical transport infrastructure (Synchronous Optical Networking (SONET) / Synchronous Digital Hierarchy (SDH) and Optical Transport Network (OTN)) or packet transport as epitomized by the MPLS Transport Profile (MPLS-TP).

All transport networks have high benchmarks for reliability and operational simplicity. This suggests a common, technology-independent management/control paradigm that can be extended to represent and configure specific technology attributes.

This document describes the requirements facing transport networks in order to provide open interfaces for resource programmability and control/management automation. A list of existing and additional YANG models is provided to fulfill the functional requirements.

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Table of Contents

1. Introduction

A transport network is a server-layer network designed to provide connectivity services, or more advanced services like Virtual Private Networks (VPN) for a client-layer network to carry the client traffic opaquely across the server-layer network resources. It acts as a pipe provider for upper-layer networks, such as IP network and mobile networks.

Transport networks, such as Synchronous Optical Networking (SONET) / Synchronous Digital Hierarchy (SDH), Optical Transport Network (OTN), Wavelength Division Multiplexing (WDM), and flexi-grid networks, are often built using equipment from a single vendor and are managed using private interfaces to dedicated Element Management Systems (EMS) / Network Management Systems (NMS). All transport networks have high benchmarks for reliability and operational simplicity. This suggests a common, technology-independent management/control paradigm that is extended to represent and configure specific technology attributes.

The need of network providers to manage multi-vendor and multi-domain transport networks (where each domain is an island of equipment from a single supplier) has been further stressed by the expansion in network size. At the same time, applications such as data center interconnection require larger and more dynamic connectivity matrices. Therefore, transport networks face new challenges going beyond automatic provisioning of tunnel setup enabled by GMPLS (Generalized Multi-Protocol Label Switching) protocols to achieve automatic service provisioning, as well as address opportunities enabled by partitioning the network through the process of resource slicing. With lower operational expenditure (OPEX) and capital expenditure (CAPEX) as the usual objectives, open interfaces to transport networks are considered by network providers as a way to meet these requirements. The concept of Software Defined Networking (SDN) leverages these ideas.

The YANG language [RFC6020] is currently the data modeling language of choice within the IETF and has been adopted by a number of industry-wide open management and control initiatives. YANG may be used to model both configuration and operational states; it is vendor-neutral and supports extensible APIs for control and management of elements.

This document analyzes typical scenarios that need transport network control/management openness, and lists functions desired to enable deployment. Moreover, a list of YANG models and their relationships have been identified that can help facilitate the deployment and operation of transport network open interfaces. Note that some of the models discussed meet the requirements described, and are already being developed in the IETF. Thus, this document provides a reference of existing models, and provides information of the missing ones which need further work.

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 RFC-2119 [RFC2119].

3. 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 draft is defined in [ietf-netmod-rfc6087bis]. 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.

4. Functional Requirements

4.1. Scenarios

There are several scenarios where an open interface to access server-layer (transport) network resources would be useful. Here two typical scenarios are provided.

The first one is depicted as below (Figure 1):

```
        /--\   +------+                  +------+     /--\
       | 1  ~~~|  A   +------------------|  B   |~~~~~  3 |
        \--/   +-----++                  +--+---+     \--/
                     |                      |
                     |                      |
                     |                      |
                    ++-----+            +---+--+
                    |   F  +------------+  C   |
                    ++-----+            +--+---+
                     |                     |
                     |                     |
                     |                     |
                     |                     |
                     |                     |
                 +---+-+               +---+-+    /---\
                 |  E  +---------------+  D  |~~~~  4  |
        /--\~~~~~+-----+               +-----+    \---/
       | 2  |
        \--/

                   +----+                  /--\
                   |    |  Transport NE   |    |   DC
                   +----+                  \--/

                   -----   Transport Link   ~~~   Transport-DC link

        (a) Data Centers interconnected via a transport network


                           +----------------------+
                           | Data Center Network  |
                           |   Controller         |
                           +----------+-----------+
```

```
                                  |
                                  |
                                  |
                                  | Open Interface
                                  |
                                  |
                        +---------+----------+
                        |  Transport Network  |
                        |    Controller       |
                        +---------------------+
         (b) The controller architecture for data center interconnection
```

Figure 1: Scenario 1: Data centers interconnected via a transport network and the controller architecture

For the data center operator, assuming the objective is to trigger the transport network to provide connectivity on demand, the following capabilities, at a minimum, would be required on the open itnerface between the two contollers illustrated in Figure 1:

A: The ability to obtain information about a set of access points of the transport network facing the client side, including information such as access point identifiers, capabilities, etc.; for instance, transport-network-side end point identifiers related to the access link between DC1 and Transport NE A.

B: The capability to send a request for a service using the aforementioned access point information, as well as the ability to retrieve a list of service requests and their statuses. In this request, it should at least be possible to include source node, destination node, and requested bandwidth to request the transport network to set up tunnels/paths so as to provide the requested connectivitiy for the service request.

C: Note that in this case acquistion of the topology, be it physical or logical, of the transport network is not a compulsory requirement, but it may indeed be able to give data center providers more control over the transport resource usage. Furtheremore, the client controller can impose a virtual network of its own choice by requesting a slice of network resource with its choice of network parameters (such as network topology type, bandwidth etc.).

The second scenario, more complicated than the first, is depicted as below (Figure 2). In this example, we focus on the management and control via open interfaces for multi-domain networks with homogeneous technologies (such as OTN), but it can be extended further to multi-domain networks with heterogeneous technologies with higher complexity.

```
        +-------------------------------------------------+
        |              Orchestrator/Coordinator           |
        +---------+--------------+-------------------+----+
                  |              |                   |
                  |              |                   |
     +------------+--+           |        +----------+----------+
     | Controller 1  |           |        |   Controller 2      |
     +---------+-----+           |        +-------+-------------+
               #        +----------------+        #
               #Qx      | Controller 3   |        #
               #        +----------------+        #TL1
               #                #                 #
           ----+-----           #             ----+-----
      ____/          \____      #        ____/          \____
     |                    |     #       |                    |
    |                      |    #      |                      |
    |    Network Domain    +***********+   Network Domain     |
    |          1          |     #      |          2           |
     |____            ___|      #       |____             ___|
          \           /         #PCEP       \           /
           -----------          #            *----------
             *       *          #           *       *
              *       *         #          *       *
               *       *        #         *       *
                *       *       #        *       *
                 *       *      #       *       *
                  *       *     #      *       *
                   *       *----+-----*       *
                    *  ____/          \____  *
                     *|                   |*
                     |                     |
                     |    Network Domain    |
                     |          3          |
                      |____            ___|
                           \           /
                            ----------

                        *****  inter-domain links
                        -----  Open Interfaces
                        #####  Controller-device interfaces
```

Figure 2: Scenario 2: Multi-domain network control and management

For the second scenario, the orchestrator/coordinator controls and manages three distinct network domains, each controlled/managed by their domain controller. In order to orchestrate across domains/layers, the orchestrator needs its interface between domain controllers to be equipped with the following functions:

A: Access to the topologies reported by each domain controller, including cross-domain links for the purpose of planning and requesting the paths of end-to-end tunnels. Multiple technologies within a domain (i.e., a multi-layer network), this might be reflected in the reported topology. Depending on the abstraction level of the reported topology, the orchestrator has different control granularities.

B: The ability to set up, delete and modify tunnels, be it within one domain or across multiple domains. Furthermore, it should have the abilty to view the tunnels created within each domain as well as thouse that cross domains as reported by each domain controller.

4.2. Function Requirement Summary

For the open interface of a transport controller towards a northbound client, five functions are derived from the scenarios explained in the last section. They are summarized in the table below and we also match these functions with YANG models that are being developed in existing drafts.
Analysis and descriptions of whether and how these functions are supported by the YANG models are provided in more detail in Section 5.

Functions	Description	Related Existing YANG Models
Obtaining Access Point Info	Getting the necessary access points info	[TE-Topo]
Obtaining Topology	Getting the topology info	[TE-Topo], [WDM-Topo] [ODU-Topo]
Tunnel Operations	Tunnel Setup, Deletion Modification and Info Retrieval	[TE-Tunnel]

Service Request	Requesting connectivity service and retrieval the list of service request	[this I.D.]
Virtual Network Operations	Requesting a virtual network and related control operations, (e.g.,update, deletion)	[TE-Topo], [WDM topo] [ODU-Topo]

5. Function Analysis

5.1. Toplogy Related Functions

As shown in Section 4, the functions of obtaining access point information, obtaining topology, and imposing virtual network operations can take advantages of the same set of topology YANG models. These functions are briefly explained further in the following sub-sections.

5.1.1 Obtaining Access Point Info

For cases such as scenario 1, a client may have no interest in directly controlling network resources, but might want an automated open control interface for initiating service requests. In this case, a transport controller may provide the access point information. This information can then be used in service request sent over the open interface.

The TE Topology YANG model provided in [TE-topo] can be used to provide a list of links. If the remote node and termination point information is unknown, it is omitted from the reported information. If the client-side node and termination point information is obtained via configuration or a distributed discovery mechanism, then it can also be added into the reported information. Technology-specific details might also be needed to further express the constraints/attributes associated with the access points. Note that all of this information is usually read only.

5.1.2 Obtaining Topology

Refer to [TE-Topo] for explanations and examples on how to obtain the topology. For technology specific topology information, other models such as those provided in [WDM-Topo] and [ODU-Topo] maybe used.

5.1.3 Virtual Network Operations

There are two ways to request the creation of a virtual network. One is to define the topology explicitly using the model provided in the topology YANG drafts listed in Section 5.1.2.. The other way is to provide an estimated traffic information (a traffic matrix) and ask for a network controller of the provider network to provide a virtual network that can fulfill the demand. This second approach does not have a supporting model and need further work.

5.2. Tunnel Operations

Thecurrent [TE-Tunnel] provides a technology agnostic Traffic-Engieering (TE) device tunnel. The model included in that draft is currently being developed to make it generic for both controller and device usage. It is expected that the next version of this draft will provide such a generic TE tunnel model that can cater to the base requirementss for tunnel operations but it may need to be augmented to support controller-specific operations.

Futhermore, technology-specific augmentations of the base generic TE tunnel models are needed. For example, for Optical Channel (OCh) tunnels in WDM networks, information such as the lambda resource usage is needed. Similarly, for ODU tunnels, information such as the usage of tributary slots is needed.

5.3. Service Requests

The service model is an important model that enables automated operations between a client controller and a provider controller. The transport connectivity service model is different from the model of a tunnel since the transport connectivity service model hides technical details from a client.

A transport connectivity service model is provided below:

```
module: ietf-transport-service
   +--rw transport_service
   |  +--rw service* [service-id]
   |     +--rw service-id           uint32
   |     +--rw service-name?        string
   |     +--rw source
   |     |  +--rw node-id?   node-id
   |     |  +--rw tp-id?     tp-id
   |     +--rw destination
   |     |  +--rw node-id?   node-id
```

```
      |     |  +--rw tp-id?     tp-id
      |     +--rw service-type?        service-types
      |     +--rw supporting-tunnel* [name]
      |     |  +--rw name    string
      |     +--rw bandwidth            decimal64
      |     +--rw SLA?                 SLAtypes
      |     +--rw intended-policies
      |        +--rw schedule
      |           +--rw schedules
      |              +--rw schedule* [schedule-id]
      |                 +--rw schedule-id          uint32
      |                 +--rw start?               yang:date-and-time
      |                 +--rw schedule-duration?   string
      |                 +--rw repeat-interval?     string
      +--rw service-state
         +--ro service* [service-id]
            +--ro service-id           uint32
            +--ro service-name?        string
            +--ro source
            |  +--ro node-id?   node-id
            |  +--ro tp-id?     tp-id
            +--ro destination
            |  +--ro node-id?   node-id
            |  +--ro tp-id?     tp-id
            +--ro service-type?        service-types
            +--ro supporting-tunnel* [name]
            |  +--ro name    string
            +--ro bandwidth            decimal64
            +--ro SLA?                 SLAtypes
            +--ro applied-policies
            |  +--ro schedule
            |     +--ro schedules
            |        +--ro schedule* [schedule-id]
            |           +--ro schedule-id          uint32
            |           +--ro start?               yang:date-and-time
            |           +--ro schedule-duration?   string
            |           +--ro repeat-interval?     string
            +--ro status?              state-types
```

The corresponding YANG code is provided below:

```
<CODE BEGINS> file " ietf-transport-service@2016-3-7.yang"

module ietf-transport-service {
  yang-version 1;
  namespace "urn:ietf:params:xml:ns:yang:ietf_transport_service";
  prefix tser;
```

```
     import ietf-inet-types {
       prefix inet;
     }

     import ietf-schedule {
       prefix "sch";
     }

     organization "TBD";
     contact
       "WILL-BE-DEFINED-LATER";
     description
       "this module describes a service module that is essential
       API for a client to ask for a provider network for a path
       without the need to care about underlying technologies.
       Capability to specify constraints/policies are provided as
       optional features.";

     revision 2016-03-07 {
       description
         "Initial revision.";
         reference "to add the draft name";
     }


     typedef tp-id {  //client termination port
       type union {
         type uint32;
         type inet:ip-address; // IPv4 or IPv6 address
       }
       description
         "the client termination port of a transport device";
     }

     typedef node-id {  //client termination port
       type union {
         type uint32;
         type inet:ip-address; // IPv4 or IPv6 address
       }
       description
         "the node id of a transport device";
     }

     typedef service-types {
       type enumeration {
         enum "EPL" {
```

```
          value 0;
          description
          "EPL service";
        }
        enum "EVPL" {
          value 1;
          description
          "EVPL";
        }
        enum "EPLAN" {
          value 2;
          description
          "EPLAN";
        }
        enum "EVPLAN" {
          value 3;
          description
          "EVPLAN";
        }
      }
      description "the type of a service request";
    }

    typedef state-types{
      type enumeration {
        enum "NORMAL" {
          value 0;
          description
          "service is normal/up and running";
        }
        enum "DOWN" {
          value 1;
          description
          "service is down.";
        }
        enum "DEGRADED"{
          value 2;
          description
          "service is in degraded state.";
        }
      }
      description "the state of a service.";
    }

    typedef SLAtypes{
      type enumeration{
        enum "1+1+R"{
```

```
          value 0;
          description
          "A reroute will be provided after both the working and
          protection path fails.";
        }
        enum "1+1"{
          value 1;
          description
          "a protection path is provided.";
        }
        enum "Rerouting"{
          value 2;
          description
          "rerouting after the working path fails";
        }
        enum "unprotected"{
          value 3;
          description
          "no protection provided";
        }
      }
    }

    grouping service-basics {
      //later put all service under so that it can reused
      // in states.
      leaf service-id {
        type uint32;
        description "an unique identificaiton of a service.";
      }

      leaf service-name{
        type string;
        description "name for a service";
      }

      container source{
        leaf node-id {
          type node-id;
          description "node id";
        }
        leaf tp-id {
          type tp-id;
          description "TBD";
        }
        description "Service source information";
      }
```

```
       container destination{
         leaf node-id {
           type node-id;
           description "node id";
         }
         leaf tp-id {
           type tp-id;
           description "TBD";
         }
         description "Service destination information";
       }


       leaf service-type {
         type service-types;
         description "the type of a service request";
       }

       list supporting-tunnel{
         key "name";
         leaf name{
           type string;
           description "the name of a tunnel";
         }

         description "the list of tunnesl to support the list";
       }

       leaf bandwidth {
         type decimal64 {
           fraction-digits 2;
         }
         mandatory true;
         description "the bandwidth requested by a service.";
       }

       leaf SLA{
         type SLAtypes;
         description "the type of protection expected for this
         service";
       }
     }

     container transport_service {
       description
         "serves as a top-level container for a list of services";
```

```
      list service {
        key "service-id";
        description
          "an unique identifier of a service";

        uses service-basics;

        container intended-policies {
          container schedule {
            uses sch:schedules;
            description "to specify bandwidth scheduling
            information of this service.";
          }
          description "specify the policy associated with a
          service";
        }//end of policy
      }//end of service list
    }//service top container

    container service-state
    {
      list service {
        config false;
        key "service-id";
        description "operational state of a service";

        uses service-basics;

        container applied-policies{
          container schedule {
            uses sch:schedules;
            description "to specify bandwidth scheduling
            information of this service.";
          }
        }

        leaf status {
          type state-types;
          description "TBD";
        }
      }//end of a service state
    }//end of state
  }

  <CODE ENDS>
```

6. Security Considerations

Clearly modifying server-layer resources will have a significant impact on network infrastructure. More specifically they will provide the services and applications running across client-layers, which the server-layer is supporting. Therefore, security must be an important consideration when implementing the architecture, models and protocol mechanisms discussed in this document.

Communicating service and network information (including access point identifiers, capabilities, topologies, etc.) across external interfaces represents a security risk. Thus, mechanisms to encrypt or preserve the domain topology confidentiality should be used.

A key consideration are the external protocols (those shown as entering or leaving the orchestrator and controllers shown in Figure 2 (Scenario 2: Multi-domain network control and management)) which must be appropriately secured. This security should include authentication and authorization to control access to different functions that the orchestrator may perform to modify or create state in the server-layer, and the establishment and management of the orchestrator to controller relationship.

The orchestrator will contain significant data about the network domains, the services carried by each domain, and customer type information. Therefore, access to information held in the orchestrator must be secured. Since such access will be largely through external mechanisms, it may be pertinent to apply policy-based controls to restrict access and functions.

7. Manageability Considerations

The core objectives of this document are to assist in the deployment and operation of transport services across server-layer network infrastructure. The model-driven management/control principles, which are vendor-neutral and supported by extensible APIs, should be utilized.

The open models described in this document are based on YANG [RFC6020] and the RESTCONF [RESTCONF] messaging protocol, a REST-like protocol running over HTTP for accessing data defined in YANG, may also be used.

8. IANA Considerations

TBD.

9. Acknowledgements

Thank Igor Bryskin for useful discussions on relevant YANG models.

10. References

10.1. Normative References

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