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A YANG Data Model for Microwave Radio Link
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Abstract

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

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1. Introduction

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

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

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

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

1.1. Terminology and Definitions

The following terms are used in this document:

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

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

The following acronyms are used in this document:

ACM Adaptive Coding Modulation

ATPC Automatic Transmit Power Control

CM Coding Modulation

RLT Radio Link Terminal

RTPC Remote Transmit Power Control

XPIC Cross Polarization Interference Cancellation

MIMO Multiple-Input Multiple-Output

1.2. Tree Structure

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

2. Requirements Language

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

3. Microwave Radio Link YANG Data Model

3.1. YANG Tree

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

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

```
       |  +--ro available-min-acm?         identityref
       |  +--ro available-max-acm?         identityref
```

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

3.2. Explanation of the Microwave Data Model

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

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

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

4. Microwave Radio Link YANG Module

```
<CODE BEGINS> file "ietf-microwave-radio-link@2018-02-26.yang"

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

  import ietf-yang-types {
    prefix yang;
  }

  import ietf-interfaces {
    prefix if;
    reference "RFC7223bis";
  }

  import ietf-interface-protection {
    prefix ifprot;
  }
```

```
     import iana-if-type {
       prefix ianaift;
     }
```

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

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

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

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

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       authors of the code.  All rights reserved.";

     revision 2018-02-26 {
       description "Update with respect to the YANG Guideline";
       reference "RFC XXXX: A YANG Data Model for Microwave Radio Link";
     }

     /*
      * Features
      */

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

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

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

     /*
      * Interface identities
      */
```

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

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

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

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

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

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

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

/*
 * Coding and modulation identities
 */

identity coding-modulation {
```

```
        description
          "The coding and modulation schemes.";
      }
```

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

/*
 * TDM-type identities
 */

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

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

identity STM-1 {
  base tdm-type;
```

```
        description
          "STM-1 connection, 155,52 Mbit/s.";
      }
```

```
/*
 * Typedefs
 */

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

/*
 * Radio Link Terminal (RLT)
 */

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

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

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

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

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

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

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

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

    /*
     * Carrier Termination
     */

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

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

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

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

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

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

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

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

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

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

```
            }
```

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

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

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

        leaf atpc-upper-threshold  {
          when "../power-mode = 'atpc'";
          type power {
            range "-99..-30";
          }
          units "dBm";
          mandatory true;
          description
            "The upper threshold for the input power at far-end
```

```
            used in the ATPC mode.";
          reference "ETSI EN 302 217-1";
        }
```

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

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

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

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

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

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

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

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

        leaf actual-xpi {
          if-feature xpic;
          type decimal64 {
```

```
            fraction-digits 1;
            range "0..99";
          }
```

```
          units "dB";
          config false;
          description
            "The actual carrier to cross-polar interference.
             Only valid if XPIC is enabled. (0.1 dB resolution).";
          reference "ETSI TR 102 311";
        }

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

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

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

          leaf ber-alarm-threshold {
            type enumeration {
              enum "10e-9" {
                description "Threshold at 10e-9.";
              }
              enum "10e-8" {
                description "Threshold at 10e-8.";
              }
              enum "10e-7" {
                description "Threshold at 10e-7.";
              }
```

```
              enum "10e-6" {
                description "Threshold at 10e-6.";
              }
```

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

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

        leaf rf-loop {
          type enumeration {
            enum disabled {
```

```
            description "Disables the RF Loop.";
          }
```

```
            enum client {
              description
                "Loops the signal back to the client side.";
            }
            enum radio {
              description
                "Loops the signal back to the radio side.";
            }
          }
          default "disabled";
          description
            "Enable (client/radio) or disable (disabled)
             the RF loop, which loops the signal back to
             the client side or the radio side.";
        }

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

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

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

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

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

```
}
```

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

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

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

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

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

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

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

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

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

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

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

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

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

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

    /*
     * Radio Link Protection Groups
     */

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

      uses ifprot:protection-groups {

        refine protection-group/members {
          must "/if:interfaces/if:interface[if:name = current()]"
             + "/if:type = 'mrl:carrier-termination'" {
            description
```

```
               "The type of a protection member must be
                'carrier-termination'.";
           }
         }
```

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

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

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

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

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

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

        leaf-list members {
          type if:interface-ref;
          must "/if:interfaces/if:interface[if:name = current()]"
            + "/if:type = 'mrl:carrier-termination'" {
            description
              "The type of a member must be 'carrier-termination'.";
          }
          min-elements 2;
```

```
            max-elements 2;
```

```
          description
            "Association to XPIC pairs used in the radio link
             terminal.";
        }
      }
    }

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

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

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

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

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

<CODE ENDS>

5. Interface Protection YANG Module

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

```
<CODE BEGINS> file "ietf-interface-protection@2018-02-26.yang"

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

  import ietf-interfaces {
    prefix if;
    reference "RFC7223bis";
  }

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

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

  description
    "This is a module for the entities in
    a generic interface protection mechanism.
    Copyright (c) 2018 IETF Trust and the persons identified as
    authors of the code.  All rights reserved.";

  revision 2018-02-26 {
    description "Update with respect to the YANG Guideline";
    reference "RFC XXXX: A YANG Data Model for Microwave Radio Link";
  }

  /*
   * Protection architecture type identities
   */

  identity protection-architecture-type {
    description
      "protection architecture type";
```

```
      reference "ITU-T Rec. G.808.1";
    }
```

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

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

     /*
      * Protection states identities
      */

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

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

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

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

     /*
      * protection-external-commands identities
      */

     identity protection-external-commands{
       description
         "Protection external commands for trouble shooting
```

```
          purpose.";
        reference "ITU-T Rec. G.808.1";
      }
```

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

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

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

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

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

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

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

     /*
      * Protection Groups
      */

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

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

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

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

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

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

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

        leaf revertive-wait-to-restore {
          when "../operation-type = 'revertive'";
          type uint16;
          units "seconds";
          default "0";
          description
            "The time to wait before switching back to the working
```

```
            interface if operation-type is revertive.";
          reference "ITU-T Rec. G.808.1";
        }
```

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

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

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

  <CODE ENDS>
```

6. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC5246].

The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

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

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

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

/if:interfaces/if:interface/selected-max-acm,
/if:interfaces/if:interface/if-loop, and
/if:interfaces/if:interface/rf-loop:

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

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

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

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

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

7. IANA Considerations

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

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

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

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

```
Name: ietf-microwave-radio-link
Namespace: urn:ietf:params:xml:ns:yang:ietf-microwave-radio-link
Prefix: mrl
```

Reference: RFC xxxx

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

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

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

A.1 1+0 instance

Figure A-1 shows a 1+0 example.

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

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

  \--- Microwave Node ---/          \--- Microwave Node ---/
```

Figure A-1 1+0 example

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

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

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

A.2 2+0 instance

Figure A-2 shows a 2+0 example.

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

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

     \--- Microwave Node ---/          \--- Microwave Node ---/]
```

Figure A-2 2+0 example

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

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

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

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

]

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