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## A YANG Data Model for Microwave Radio Link

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### Abstract

This document defines a YANG data model in order to control and manage the radio link interfaces, and the connectivity to packet (typically Ethernet) interfaces in a microwave/millimeter wave node.

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## 1. Terminology and Definitions

The following terms are used in this document:

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

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

The following acronyms are used in this document:

ACM Adaptive Coding Modulation  
ATPC Automatic Transmit Power Control  
CM Coding Modulation  
CT Carrier Termination  
RLT Radio Link Terminal  
RTPC Remote Transmit Power Control  
XPIC Cross Polarization Interference Cancellation



## 2. 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. The data model includes configuration and state data.

The design of the data model follows the framework for management and control of microwave and millimeter wave interface parameters defined in [mw-fmwk]. 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 RFC 7223 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 RFC 7223 as a basis.

The designed YANG data model uses 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 [mw-fmwk].

## 3. YANG Data Model (Tree Structure)



```

module: ietf-microwave-radio-link
  +--rw radio-link-protection-groups
  |   +--rw radio-link-protection-group* [name]
  |   |   +--rw name                               string
  |   |   +--rw protection-architecture-type?     identityref
  |   |   +--rw protection-operation-type?        enumeration
  |   |   +--rw working-entity*                   if:interface-ref
  |   |   +--rw revertive-wait-to-restore?        uint16
  |   |   +--rw radio-link-protection-members*    if:interface-ref
  |   |   +---x protection-external-commands
  |   |   |   +---w input
  |   |   |   +---w protection-external-command?  identityref
  |   +--ro radio-link-protection-groups-state
  |   |   +--ro radio-link-protection-group* [name]
  |   |   |   +--ro name                           string
  |   |   |   +--ro protection-status?             identityref
  |   +--rw xpic-pairs {xpic}?
  |   |   +--rw xpic-pair* [name]
  |   |   |   +--rw name                           string
  |   |   |   +--rw enabled?                       boolean
  |   |   |   +--rw xpic-members*                  if:interface-ref
  |   +--rw mimo-groups {mimo}?
  |   |   +--rw mimo-group* [name]
  |   |   |   +--rw name                           string
  |   |   |   +--rw enabled?                       boolean
  |   |   |   +--rw mimo-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
                                                /radio-link-protection-group/name
    +--rw xpic-pairs*                            -> /xpic-pairs/xpic-pair/name {xpic}?
    +--rw mimo-group?                            -> /mimo-groups/mimo-group/name {mimo}?
    +--rw tdm-connections* [tdm-type] {tdm}?
    |   +--rw tdm-type                           identityref
    |   +--rw tdm-connections                     unit16
  augment /if:interfaces/if:interface:
    +--rw carrier-id?                            string
    +--rw tx-enabled?                            boolean
    +--rw tx-frequency                           uint32
    +--rw rx-frequency?                          uint32

```



```

+--rw rx-frequency-config?          boolean
+--rw duplex-distance                uint32
+--rw channel-separation             decimal64
+--rw polarization?                 enumeration
+--rw power-mode                     enumeration
+--rw selected-output-power          power
+--rw atpc-lower-threshold            power
+--rw atpc-upper-threshold           power
+--rw coding-modulation-mode         enumeration
+--rw selected-cm                    identityref
+--rw selected-min-acm                identityref
+--rw selected-max-acm                identityref
+--rw if-loop?                       enumeration
+--rw rf-loop?                       enumeration
+--rw ct-performance-thresholds
  +--rw received-level-alarm-threshold? power
  +--rw transmitted-level-alarm-threshold? power
  +--rw ber-alarm-threshold?          enumeration
augment /if:interfaces-state/if:interface:
+--ro tx-oper-status?                enumeration
+--ro actual-transmitted-level?       power
+--ro actual-received-level?         power
+--ro actual-tx-cm?                  identityref
+--ro actual-snr?                    decimal64
+--ro actual-xpi?                    decimal64 {xpic}?
+--ro capabilities
  +--ro min-tx-frequency?             uint32
  +--ro max-tx-frequency?             uint32
  +--ro min-rx-frequency?             uint32
  +--ro max-rx-frequency?             uint32
  +--ro available-min-output-power?   power
  +--ro available-max-output-power?   power
  +--ro available-min-acm?             identityref
  +--ro available-max-acm?             identityref
augment /if:interfaces-state/if:interface/if:statistics:
+--ro bbe?                            yang:counter32
+--ro es?                              yang:counter32
+--ro ses?                             yang:counter32
+--ro uas?                             yang:counter32
+--ro min-rltm?                        power
+--ro max-rltm?                        power
+--ro min-tltm?                        power
+--ro max-tltm?                        power

```



## 4. YANG Module

```
<CODE BEGINS> file "ietf-microwave-radio-link.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;
  }

  import iana-if-type {
    prefix ianaift;
  }

  organization
    "IETF CCAMP Working Group";
  contact
    "jonas.ahlberg@ericsson.com
    amy.yemin@huawei.com
    Xi.Li@neclab.eu
    cjbc@it.uc3m.es
    k-kawada@ah.jp.nec.com";

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

  revision 2016-12-22 {
    description
      "Draft revision covering a complete scope for
      configuration and state data for radio link
      interfaces.";

    reference "";
  }
}
```



```
revision 2016-10-29 {
  description
    "Draft revision.";
  reference "";
}

/*
 * Features
 */

feature xpic {
  description
    "Indicates that the device supports XPIC.";
}

feature mimo {
  description
    "Indicates that the device supports MIMO.";
}

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.";
}

/*
 * Protection architecture type identities
 */
identity protection-architecture-type {
  description
    "protection architecture type";
}

identity one-plus-one-type {
  base protection-architecture-type;
  description
    "One carrier termination and
     one protecting carrier termination.";
}

identity one-to-n-type {
  base protection-architecture-type;
  description
    "One carrier termination protecting
     n other carrier terminations.";
}
```



```
/*
 * Protection states identities
 */

identity protection-states {
  description
    "Identities describing the status of the protection,
    in a group of carrier terminations configured in
    a radio link 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.";
}

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



```
/*
 * 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) - Configuration data nodes
 */
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:radio-link-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.";
}

leaf mimo-group {
  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.";
}

list tdm-connections {
  if-feature tdm;
  key "tdm-type";
  description
    "A list stating the number of TDM connections of a
    specified tdm-type that is 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 - Configuration data nodes
 */

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



```
leaf rx-frequency {
  type uint32;
  units "kHz";
  description
    "Selected receiver frequency.
    Mandatory and writeable when rx-frequency-config=true.
    Otherwise read-only and calculated from tx-frequency
    and duplex-distance.";
}

leaf rx-frequency-config {
  type boolean;
  default "true";
  description
    "Enable (true) or disable (false) direct
    configuration of rx-frequency and instead
    using a defined duplex distance.";
}

leaf duplex-distance {
  when "../rx-frequency-config = 'false'";
  type uint32;
  units "kHz";
  mandatory true;
  description
    "Distance between Tx & Rx frequencies.
    Used to calculate rx-frequency when
    rx-frequency-config=false.";
}

leaf channel-separation {
  type decimal64 {
    fraction-digits 1;
  }
  units "MHz";
  mandatory true;
  description
    "The amount of bandwidth allocated to a carrier.";
}

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).";
        }
        enum atpc {
            description "Automatic Transmit Power Control
                (ATPC).";
        }
    }
    mandatory true;
    description
        "A choice of Remote Transmit Power Control (RTPC)
            or Automatic Transmit Power Control (ATPC).;"
}

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

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.";
  }

  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.";
  }

  leaf coding-modulation-mode {
    type enumeration {
      enum fixed {
        description "Fixed coding/modulation.";
      }
      enum adaptive {
        description "Adaptive coding/modulation.";
      }
    }
    mandatory true;
    description
      "A selection of fixed or
      adaptive coding/modulation mode.";
  }

  leaf selected-cm {
    when "../coding-modulation-mode = 'fixed'";
    type identityref {
      base coding-modulation;
    }
    mandatory true;
    description
      "Selected fixed 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 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 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
      "Specification of at which received power level an alarm
       should be raised.";
  }

  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.";
  }
}
```



```
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.";
}
}
}

/*
 * Radio Link Terminal - Operational state data nodes
 * Currently nothing in addition to the general
 * interface-state model.
 */

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



```
augment "/if:interfaces-state/if:interface" {
  when "if:type = 'mrl: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" {
        description "Transmitter is off.";
      }
      enum "on" {
        description "Transmitter is on.";
      }
      enum "standby" {
        description "Transmitter is in standby.";
      }
    }
    description
      "Shows the operative status of the transmitter.";
  }

  leaf actual-transmitted-level {
    type power {
      range "-99..40";
    }
    units "dBm";
    description
      "Actual transmitted power level (0.1 dBm resolution).";
  }

  leaf actual-received-level {
    type power {
      range "-99..-20";
    }
    units "dBm";
    description
      "Actual received power level (0.1 dBm resolution).";
  }

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



```
leaf actual-snr {
  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 {
  if-feature xpica;
  type decimal64 {
    fraction-digits 1;
    range "0..99";
  }
  units "dB";
  description
    "The actual carrier to cross-polar interference.
    Only valid if XPICA is enabled. (0.1 dB 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 available-min-output-power {
      type power;
      units "dBm";
      description
        "The minimum output power supported.";
    }

    leaf available-max-output-power {
      type power;
      units "dBm";
      description
        "The maximum output power supported.";
    }

    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.";
    }
  }
}
```



```
augment "/if:interfaces-state/if:interface/if:statistics" {
  when "../if:type = 'mrl: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 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 min-rltm {
      type power {
        range "-99..-20";
      }
      units "dBm";
      description
        "Minimum received power level since last reset.";
    }

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

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

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

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

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.";
}
```



```
list radio-link-protection-group {
  key "name";
  description
    "List of protected groups of carrier terminations
    in a radio link.";

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

  leaf protection-architecture-type {
    type identityref{
      base protection-architecture-type;
    }
    default "one-plus-one-type";
    description
      "The type of protection architecture
      used, e.g. one carrier termination
      protecting one carrier termination.";
  }

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



```
leaf-list working-entity {
  when "../protection-operation-type = 'revertive'";
  type if:interface-ref;
  must "/if:interfaces/if:interface[if:name = current()]"
    + "/if:type = 'mrl:carrier-termination'" {
    description
      "The type of a working-entity must be
      'carrier-termination'.";
  }
  min-elements 1;
  description
    "The carrier terminations over which the
    traffic normally should be transported
    over when there is no need to use the
    protecting carrier termination.";
}

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

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



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

/*
 * Radio Link Protection - Operational state data nodes
 */
container radio-link-protection-groups-state {
  config false;
  description
    "State data for radio link protected groups
     of carrier terminations in a radio link.";
  list radio-link-protection-group {
    key "name";
    description
      "List of protected groups of carrier
       terminations in a radio link.";

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

    leaf protection-status {
      type identityref {
        base protection-states;
      }
      description
        "Status of the protection, in a group of
         carrier terminations configured in a
         radio link protection mode.";
    }
  }
}
}
```



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

container xpic-pairs {
  if-feature xpic;
  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 enabled {
      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 = 'mrl: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 {
  if-feature mimo;
  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 enabled {
      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 = 'mrl: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. Security Considerations

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

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

The security considerations of [RFC7223] also apply to this document.

## 6. IANA Considerations

TBD.

## 7. References

### 7.1. Normative References

[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>>.

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[RFC6242] Wasserman, M., "Using the NETCONF Protocol  
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