

Internet Engineering Task Force (IETF)
Request for Comments: 8561
Category: Standards Track
ISSN: 2070-1721

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June 2019

A YANG Data Model for Microwave Radio Link

Abstract

This document defines a YANG data model for control and management of 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 for other interface types as well.

Status of This Memo

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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 Time-Division Multiplexing (TDM) interfaces in a microwave/millimeter wave node. The ETSI EN 302 217 series defines the characteristics and requirements of microwave/millimeter wave equipment and antennas. Specifically, ETSI EN 302 217-2 [EN302217-2] specifies the essential parameters for systems operating from 1.4 GHz to 86 GHz. The data model includes configuration and state data according to the new Network Management Datastore Architecture [RFC8342].

The design of the data model follows the framework for management and control of microwave and millimeter wave interface parameters defined in [RFC8432]. This framework identifies the need and the scope of the YANG data model, 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, it 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 [MICROWAVE-RADIO-LINK], and it augments [RFC8343] 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 [RFC8343] 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 also available for other interface types.

The designed YANG data model uses established microwave equipment and radio standards, such as ETSI EN 302 217-2; the IETF Radio Link Model [MICROWAVE-RADIO-LINK]; and the ONF Microwave Model [ONF-model], as the basis for the definition of the detailed leafs/parameters, and it proposes new ones to cover identified gaps, which are analyzed in [RFC8432].

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 is 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 Transmitter Power Control

BBE: Background Block Error

BER: Bit Error Ratio

BPSK: Binary Phase-Shift Keying

CM: Coding Modulation

CT: Carrier Termination

ES: Errored Seconds

IF: Intermediate Frequency

MIMO: Multiple Input Multiple Output

RF: Radio Frequency

RLT: Radio Link Terminal

QAM: Quadrature Amplitude Modulation

QPSK: Quadrature Phase-Shift Keying

RTPC: Remote Transmit Power Control

SES: Severely Errored Seconds

TDM: Time-Division Multiplexing

UAS: Unavailable Seconds

XPIC: Cross Polarization Interference Cancellation

1.2. Tree Structure

A simplified graphical representation of the data model is used in Section 2.1 of this document. The meaning of the symbols in these diagrams is defined in [RFC8340].

2. Microwave Radio Link YANG Data Model

2.1. YANG Tree

```

module: ietf-microwave-radio-link
  +--rw radio-link-protection-groups
  |   +--rw protection-group* [name]
  |   |   +--rw name                string
  |   |   +--rw protection-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
  |   |   +--ro status?            identityref
  |   |   +---x manual-switch-working
  |   |   +---x manual-switch-protection
  |   |   +---x forced-switch
  |   |   +---x lockout-of-protection
  |   |   +---x freeze
  |   |   +---x exercise
  |   |   +---x clear
  |   +--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}?
  +--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 (freq-or-distance)
|   +--:(rx-frequency)
|   |   +--rw rx-frequency?          uint32
|   +--:(duplex-distance)
|   |   +--rw duplex-distance?      int32
+--ro actual-rx-frequency?  uint32
+--ro actual-duplex-distance? uint32
+--rw channel-separation   uint32
+--rw polarization?       enumeration
+--rw (power-mode)
|   +--:(rtpc)
|   |   +--rw rtpc
|   |   |   +--rw maximum-nominal-power    power
|   +--:(atpc)
|   |   +--rw atpc
|   |   |   +--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)
|   +--:(single)
|   |   +--rw single
|   |   |   +--rw selected-cm          identityref
|   +--:(adaptive)
|   |   +--rw adaptive
|   |   |   +--rw selected-min-acm     identityref
|   |   |   +--rw selected-max-acm     identityref
+--ro actual-tx-cm?             identityref
+--ro actual-snr?               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

```

2.2. Explanation of the Microwave Data Model

The leaves in the Interface Management Module augmented by RLT and 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", and "out-errors" are not within the scope of the microwave radio link domain and therefore are not applicable for RLT and CT.

3. Microwave Radio Link YANG Data Model

This module imports typedefs and modules from [RFC6991], [RFC8343] and [RFC7224], and it references [TR102311], [EN302217-1], [EN301129], and [G.826].

```

<CODE BEGINS> file "ietf-microwave-radio-link@2019-06-19.yang"

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

```

```
import ietf-yang-types {
  prefix yang;
  reference
    "RFC 6991";
}
import iana-if-type {
  prefix ianaift;
}
import ietf-interfaces {
  prefix if;
  reference
    "RFC 8343";
}
import ietf-interface-protection {
  prefix ifprot;
  reference
    "RFC 8561";
}
import ietf-microwave-types {
  prefix mw-types;
  reference
    "RFC 8561";
}

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

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  authors of the code. All rights reserved.

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```


This version of this YANG module is part of RFC 8561; see the RFC itself for full legal notices.";

```
revision 2019-06-19 {
  description
    "Initial revision.";
  reference
    "RFC 8561: 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.";
}

/*
 * Typedefs
 */

typedef power {
  type decimal64 {
    fraction-digits 1;
  }
  description
    "Type used for the power values in the data nodes
    for configuration or status.";
}
```

```

/*
 * Radio Link Terminal (RLT)
 */

augment "/if:interfaces/if:interface" {
  when "derived-from-or-self(if:type, "
    + "'ianaift:microwaveRadioLinkTerminal')";
  description
    "Addition of data nodes for the radio link terminal to
    the standard Interface data model, for interfaces of
    the type 'microwaveRadioLinkTerminal'.";
  leaf id {
    type string;
    description
      "Descriptive identity of the radio link terminal used by
      far-end RLT to check that it's connected to the correct
      near-end RLT. Does not need to be configured if this
      check is not used.";
  }
  leaf mode {
    type identityref {
      base mw-types: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 represents the number of bonded carrier terminations.
      Y represents the number of protecting carrier
      terminations.";
  }
  leaf-list carrier-terminations {
    type if:interface-ref;
    must "derived-from-or-self(/if:interfaces/if:interface"
      + "[if:name = current()]"
      + "/if:type, 'ianaift:microwaveCarrierTermination')" {
      description
        "The type of interface must be
        'microwaveCarrierTermination'.";
    }
    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 xplic-pairs {
  if-feature "xplic";
  type leafref {
    path "/mrl:xplic-pairs/mrl:xplic-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 mw-types: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 "derived-from-or-self(if:type, "
        + "'ianaift:microwaveCarrierTermination')";
    description
        "Addition of data nodes for carrier termination to
        the standard Interface data model, for interfaces
        of the type 'microwaveCarrierTermination'.";
    leaf carrier-id {
        type string;
        default "A";
        description
            "ID of the carrier (e.g., A, B, C, or D).
            Used in XPIC and 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. Left as
            default value when MIMO and XPIC are not in use.";
    }
    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.";
}
choice freq-or-distance {
    leaf rx-frequency {
        type uint32;
        units "kHz";
        description
            "Selected receiver frequency.";
    }
    leaf duplex-distance {
        type int32;
        units "kHz";
        description
            "Distance between transmitter and receiver frequencies.";
    }
}
mandatory true;
description
    "A choice to configure rx-frequency directly or compute
    it as duplex-distance subtracted from tx-frequency.";
}
leaf actual-rx-frequency {
    type uint32;
    units "kHz";
    config false;
    description
        "Computed receiver frequency.";
}
leaf actual-duplex-distance {
    type uint32;
    units "kHz";
    config false;
```

```
    description
      "Computed distance between Tx and Rx frequencies.";
  }
  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.";
  }
  choice power-mode {
    container rtpc {
      description
        "Remote Transmit Power Control (RTPC).";
      reference
        "ETSI EN 302 217-1";
      leaf maximum-nominal-power {
        type power {
          range "-99..99";
        }
        units "dBm";
        mandatory true;
        description
          "Selected output power.";
      }
    }
  }
}
```

```

        reference
            "ETSI EN 302 217-1";
    }
}
container atpc {
    description
        "Automatic Transmitter Power Control (ATPC).";
    reference
        "ETSI EN 302 217-1";
    leaf maximum-nominal-power {
        type power {
            range "-99..99";
        }
        units "dBm";
        mandatory true;
        description
            "Selected maximum output power. Minimum output
            power is the same as the system capability,
            minimum-power.";
        reference
            "ETSI EN 302 217-1";
    }
    leaf atpc-lower-threshold {
        type power {
            range "-99..-20";
        }
        units "dBm";
        must 'current() <= ../atpc-upper-threshold';
        mandatory true;
        description
            "The lower threshold for the input power at the
            far end, which is used in the ATPC mode.";
        reference
            "ETSI EN 302 217-1";
    }
    leaf atpc-upper-threshold {
        type power {
            range "-99..-20";
        }
        units "dBm";
        mandatory true;
        description
            "The upper threshold for the input power at the
            far end, which is used in the ATPC mode.";
        reference
            "ETSI EN 302 217-1";
    }
}
}

```

```
    mandatory true;
    description
      "A choice of RTPC or ATPC.";
  }
  leaf actual-transmitted-level {
    type power {
      range "-99..99";
    }
    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";
  }
  choice coding-modulation-mode {
    container single {
      description
        "A single modulation order only.";
      reference
        "ETSI EN 302 217-1";
      leaf selected-cm {
        type identityref {
          base mw-types:coding-modulation;
        }
        mandatory true;
        description
          "Selected the single coding/modulation.";
      }
    }
    container adaptive {
      description
        "Adaptive coding/modulation.";
      reference
        "ETSI EN 302 217-1";
    }
  }
}
```



```
leaf selected-min-acm {
  type identityref {
    base mw-types:coding-modulation;
  }
  mandatory true;
  description
    "Selected minimum coding/modulation.
    Adaptive coding/modulation shall not go
    below this value.";
}
leaf selected-max-acm {
  type identityref {
    base mw-types:coding-modulation;
  }
  mandatory true;
  description
    "Selected maximum coding/modulation.
    Adaptive coding/modulation shall not go
    above this value.";
}
}
mandatory true;
description
  "A selection of single or
  adaptive coding/modulation mode.";
}
leaf actual-tx-cm {
  type identityref {
    base mw-types:coding-modulation;
  }
  config false;
  description
    "Actual coding/modulation in transmitting direction.";
}
leaf actual-snrir {
  type decimal64 {
    fraction-digits 1;
    range "0..99";
  }
  units "dB";
  config false;
  description
    "Actual signal to noise plus the interference ratio
    (0.1 dB resolution).";
}
leaf actual-xpi {
  if-feature "xplic";
  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..-20";
    }
    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..99";
    }
    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 1e-9 {
        description
          "Threshold at 1e-9 (10^-9).";
      }
      enum 1e-8 {
        description
          "Threshold at 1e-8 (10^-8).";
      }
    }
  }
}

```

```
    }
    enum 1e-7 {
      description
        "Threshold at 1e-7 (10^-7).";
    }
    enum 1e-6 {
      description
        "Threshold at 1e-6 (10^-6).";
    }
    enum 1e-5 {
      description
        "Threshold at 1e-5 (10^-5).";
    }
    enum 1e-4 {
      description
        "Threshold at 1e-4 (10^-4).";
    }
    enum 1e-3 {
      description
        "Threshold at 1e-3 (10^-3).";
    }
    enum 1e-2 {
      description
        "Threshold at 1e-2 (10^-2).";
    }
    enum 1e-1 {
      description
        "Threshold at 1e-1 (10^-1).";
    }
  }
  default "1e-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 mw-types:coding-modulation;
      }
      description
        "Minimum coding-modulation possible to use.";
    }
    leaf available-max-acm {
      type identityref {
        base mw-types: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 (BBEs). A BBE is an
    errored block not occurring as part of Severely Errored
    Seconds (SES). Discontinuities in the value of this
    counter can occur at re-initialization of the management
    system and at other times as indicated by the value of
    'discontinuity-time' in ietf-interfaces.";
  reference
    "ITU-T G.826";
}
leaf es {
  type yang:counter32;
  units "seconds";
  description
    "Number of Errored Seconds (ES). An ES is a one-second
    period with one or more errored blocks or at least one
    defect. Discontinuities in the value of this counter
    can occur at re-initialization of the management system
    and at other times as indicated by the value of
    'discontinuity-time' in ietf-interfaces.";
  reference
    "ITU-T G.826";
}
leaf ses {
  type yang:counter32;
  units "seconds";
  description
    "Number of SES. SES is a one-second period that contains
    equal or more than 30% errored blocks or at least
    one defect. SES is a subset of ES. Discontinuities in
    the value of this counter can occur at re-initialization
    of the management system and at other times as indicated
    by the value of 'discontinuity-time' in ietf-interfaces.";
  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.
```

```

        Discontinuities in the value of this counter can occur
        at re-initialization of the management system and at
        other times as indicated by the value of
        'discontinuity-time' in ietf-interfaces.";
    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. Discontinuities in the
            value of this counter can occur at re-initialization
            of the management system and at other times as
            indicated by the value of 'discontinuity-time' in
            ietf-interfaces.";
        reference
            "ETSI EN 301 129";
    }
    leaf max-rltm {
        type power {
            range "-99..-20";
        }
        units "dBm";
        description
            "Maximum received power level. Discontinuities in the
            value of this counter can occur at re-initialization
            of the management system and at other times as
            indicated by the value of 'discontinuity-time' in
            ietf-interfaces.";
        reference
            "ETSI EN 301 129";
    }
    leaf min-tltm {
        type power {
            range "-99..99";
        }
        units "dBm";
    }
}

```

```

    description
      "Minimum transmitted power level. Discontinuities
      in the value of this counter can occur at
      re-initialization of the management system and
      at other times as indicated by the value of
      'discontinuity-time' in ietf-interfaces.";
    reference
      "ETSI EN 301 129";
  }
  leaf max-tltn {
    type power {
      range "-99..99";
    }
    units "dBm";
    description
      "Maximum transmitted power level. Discontinuities
      in the value of this counter can occur at
      re-initialization of the management system and
      at other times as indicated by the value of
      'discontinuity-time' in ietf-interfaces.";
    reference
      "ETSI EN 301 129";
  }
}
}
}
/*
 * Radio Link Protection Groups
 */

container radio-link-protection-groups {
  description
    "Configuration of radio link protected groups 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 "derived-from-or-self(/if:interfaces/if:interface"
        + "[if:name = current()]"
        + "/if:type, 'ianaift:microwaveCarrierTermination')" {
        description
          "The type of a protection member must be
          'microwaveCarrierTermination'.";
      }
    }
  }
  refine "protection-group/working-entity" {
    must "derived-from-or-self(/if:interfaces/if:interface"
      + "[if:name = current()]"

```



```

    + "/if:type, 'ianaift:microwaveCarrierTermination')" {
      description
        "The type of a working-entity must be
        'microwaveCarrierTermination'.";
    }
  }
}

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

container xpic-pairs {
  if-feature "xplic";
  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 "derived-from-or-self(/if:interfaces/if:interface"
        + "[if:name = current()]"
        + "/if:type, 'ianaift:microwaveCarrierTermination')" {
        description
          "The type of a member must be
          'microwaveCarrierTermination'.";
      }
    }
    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 "derived-from-or-self(/if:interfaces/if:interface"
                + "[if:name = current()]"
                + "/if:type, 'ianaift:microwaveCarrierTermination')";
            description
                "The type of a member must be
                'microwaveCarrierTermination'.";
        }
        min-elements 2;
        description
            "Association to a MIMO group if used in the radio
            link terminal.";
    }
}
}
}

```

<CODE ENDS>

4. Interface Protection YANG Data Model

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 model in order to make it also available for other interface types.

This module imports modules from [RFC8343], and it references [G.808.1].

```
<CODE BEGINS> file "ietf-interface-protection@2019-06-19.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
      "RFC 8343";
  }

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

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    Marko Vaupotic (Marko.Vaupotic@aviatnet.com)";
  description
    "This is a module for the entities in
    a generic interface protection mechanism.

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  authors of the code. All rights reserved.

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  (http://trustee.ietf.org/license-info).
```

This version of this YANG module is part of RFC 8561; see the RFC itself for full legal notices.";

```
revision 2019-06-19 {
  description
    "Initial revision.";
  reference
    "RFC 8561: A YANG Data Model for Microwave Radio Link";
}

/*
 * Protection architecture type identities
 */

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

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

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

/*
 * Protection states identities
 */

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

```
    }

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

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

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

    /*
     * Protection Groups
     */

    grouping protection-groups {
      description
        "Configuration of protected groups of interfaces
        providing protection for each other. More than one
        protected group per higher-layer interface is allowed.";
      list protection-group {
        key "name";
        description
          "List of protected groups of interfaces
          in a higher-layer interface.";
        leaf name {
          type string;
          description
            "Name used for identification of the protection group.";
        }
        leaf protection-architecture-type {
          type identityref {
            base protection-architecture-type;
          }
          default "ifprot:one-plus-one-type";
          description
            "The type of protection architecture used, e.g., one
            interface protecting one or several other interfaces.";
        }
      }
    }
  }
}
```

```
reference
  "ITU-T G.808.1";
}
leaf-list members {
  type if:interface-ref;
  min-elements 2;
  description
    "Association to a group of interfaces configured for
    protection and used by a higher-layer interface.";
}
leaf operation-type {
  type enumeration {
    enum non-revertive {
      description
        "In non-revertive operation, the traffic does not
        return to the working interface if the switch requests
        are terminated.";
      reference
        "ITU-T G.808.1";
    }
    enum revertive {
      description
        "In revertive operation, the traffic always
        returns to (or remains on) the working interface
        if the switch requests are terminated.";
      reference
        "ITU-T G.808.1";
    }
  }
  default "non-revertive";
  description
    "The type of protection operation, i.e., revertive
    or non-revertive operation.";
}
leaf-list working-entity {
  when "../operation-type = 'revertive'";
  type if:interface-ref;
  min-elements 1;
  description
    "The interfaces that the traffic normally should
    be transported over when there is no need to use the
    protecting interface.";
}
leaf revertive-wait-to-restore {
  when "../operation-type = 'revertive'";
  type uint16;
  units "seconds";
  default "0";
}
```

```
description
  "The time to wait before switching back to the working
  interface if operation-type is revertive.";
reference
  "ITU-T G.808.1";
}
leaf hold-off-timer {
  type uint16;
  units "milliseconds";
  default "0";
  description
    "Time interval after the detection of a fault and its
    confirmation as a condition requiring the protection-
    switching procedure.";
  reference
    "ITU-T G.808.1";
}
leaf status {
  type identityref {
    base protection-states;
  }
  config false;
  description
    "Status of the protection in a group of interfaces
    configured in a protection mode.";
  reference
    "ITU-T G.808.1";
}
action manual-switch-working {
  description
    "A switch action initiated by an operator command.
    It switches a normal traffic signal to the working
    transport entity.";
  reference
    "ITU-T G.808.1";
}
action manual-switch-protection {
  description
    "A switch action initiated by an operator command.
    It switches a normal traffic signal to the protection
    transport entity.";
  reference
    "ITU-T G.808.1";
}
action forced-switch {
  description
    "A switch action initiated by an operator command.
    It switches a normal traffic signal to the protection
```

```
    transport entity and forces it to remain on that
    entity even when criteria for switching back to
    the original entity are fulfilled.";
  reference
    "ITU-T G.808.1";
}
action lockout-of-protection {
  description
    "A switch action temporarily disables access to the
    protection transport entity for all signals.";
  reference
    "ITU-T G.808.1";
}
action freeze {
  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 Automatic Protection-Switching (APS) messages
    are ignored.";
  reference
    "ITU-T G.808.1";
}
action exercise {
  description
    "A switch action to test if the APS communication is
    operating correctly. It is lower priority than any 'real'
    switch request.";
  reference
    "ITU-T G.808.1";
}
action clear {
  description
    "An action clears all switch commands.";
  reference
    "ITU-T G.808.1";
}
}
}
}
<CODE ENDS>
```


5. Microwave Types YANG Data Model

This module defines a collection of common data types using the YANG data modeling language. These common types are designed to be imported by other modules defined in the microwave area.

```
<CODE BEGINS> file "ietf-microwave-types@2019-06-19.yang"
```

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

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

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    Marko Vaupotic (Marko.Vaupotic@aviatnet.com)";
  description
    "This module contains a collection of YANG data types
    considered generally useful for microwave interfaces.

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    authors of the code. All rights reserved.

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    set forth in Section 4.c of the IETF Trust's Legal Provisions
    Relating to IETF Documents
    (http://trustee.ietf.org/license-info).

    This version of this YANG module is part of RFC 8561; see
    the RFC itself for full legal notices.";

  revision 2019-06-19 {
    description
      "Initial revision.";
    reference
      "RFC 8561: A YANG Data Model for Microwave Radio Link";
  }
}
```

```
/*
 * 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 represents the number of bonded carrier terminations.
    Y represents 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 {
  base coding-modulation;
  description
    "Half BPSK coding and modulation scheme.";
}
```

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

identity qam-4096-light {
  base qam-4096;
  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.";
}
}
```

<CODE ENDS>

6. Security Considerations

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

The Network Configuration Access Control Model (NACM) [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in these YANG data models 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 microwaveRadioLinkTerminal:

```
/if:interfaces/if:interface/mode,  
/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 data nodes represent the configuration of the radio link terminal, and they 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 microwaveCarrierTermination:

```
/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/rtpc/maximum-nominal-power,
```



```
/if:interfaces/if:interface/atpc/maximum-nominal-power,  
/if:interfaces/if:interface/atpc/atpc-lower-threshold,  
/if:interfaces/if:interface/atpc/atpc-upper-threshold,  
/if:interfaces/if:interface/single/selected-cm,  
/if:interfaces/if:interface/adaptive/selected-min-acm,  
/if:interfaces/if:interface/adaptive/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 they 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 data node represents the configuration of the protection of carrier terminations. Unauthorized access to this data node could interrupt the ability to forward traffic or remove the ability to perform a necessary protection switch.

XPIC:

```
/xpic-pairs:
```

This data node represents the XPIC configuration of a pair of carriers. Unauthorized access to this data node could interrupt the ability to forward traffic.

MIMO:

```
/mimo-groups:
```

This data node represents the MIMO configuration of multiple carriers. Unauthorized access to this data node could interrupt the ability to forward traffic.

Some of the RPC operations in this YANG data model may be considered sensitive or vulnerable in some network environments. It is thus important to control access to these operations. These are the operations and their sensitivity/vulnerability:

Radio link protection:

```
/radio-link-protection-groups/protection-group/manual-switch-working,  
/radio-link-protection-groups/protection-group/  
                                manual-switch-protection,  
/radio-link-protection-groups/protection-group/forced-switch,  
/radio-link-protection-groups/protection-group/lockout-of-protection,  
/radio-link-protection-groups/protection-group/freeze,  
/radio-link-protection-groups/protection-group/exercise, and  
/radio-link-protection-groups/protection-group/clear
```

These data nodes represent actions that might have an impact on 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.

The security considerations of [RFC8343] also apply to this document.

7. IANA Considerations

IANA has assigned 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.
```

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

IANA has recorded YANG module names in the "YANG Module Names" registry [RFC6020] as follows:

Name: ietf-microwave-radio-link
 Maintained by IANA?: N
 Namespace: urn:ietf:params:xml:ns:yang:ietf-microwave-radio-link
 Prefix: mrl
 Reference: RFC 8561

Name: ietf-interface-protection
 Maintained by IANA?: N
 Namespace: urn:ietf:params:xml:ns:yang:ietf-interface-protection
 Prefix: ifprot
 Reference: RFC 8561

Name: ietf-microwave-types
 Maintained by IANA?: N
 Namespace: urn:ietf:params:xml:ns:yang:ietf-microwave-types
 Prefix: mw-types
 Reference: RFC 8561

IANA has registered the following ifTypes in "ifType definitions" under [IANA-SMI]:

Decimal	Name	Description
295	microwaveCarrierTermination	air interface of a single microwave carrier
296	microwaveRadioLinkTerminal	radio link interface for one or several aggregated microwave carriers

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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 instances using the YANG data model defined in this document. The examples are not intended as a complete module for 1+0 and 2+0 configuration.

A.1. 1+0 Instance

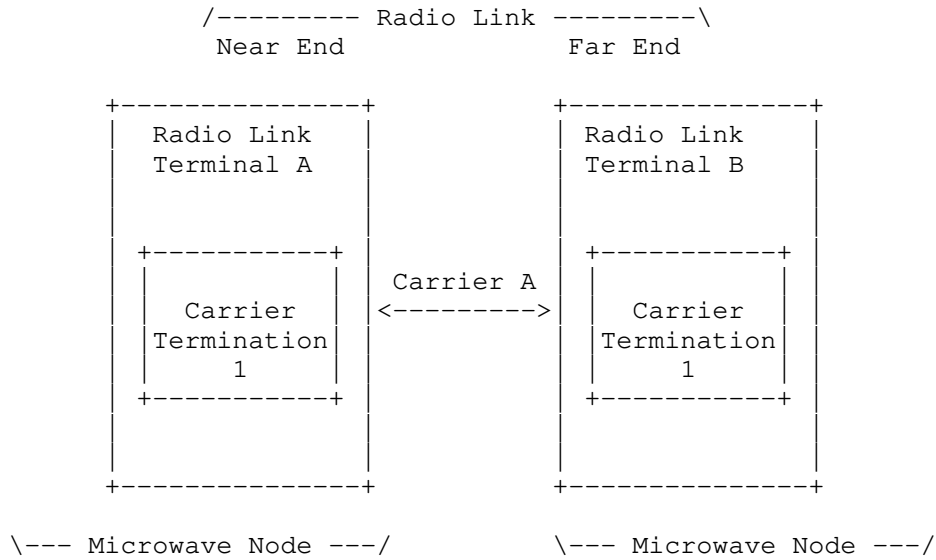


Figure 1: 1+0 Example

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

```
"interface": [  
  {  
    "name": "RLT-A",  
    "description": "Radio Link Terminal A",  
    "type": "microwaveRadioLinkTerminal",  
    "id": "RLT-A",  
    "mode": "one-plus-zero",  
    "carrier-terminations": [  
      "RLT-A:CT-1"  
    ],  
    "tdm-connections": [  
      "tdm-type": "E1",  
      "tdm-connections": "4"  
    ]  
  },  
  {  
    "name": "RLT-A:CT-1",  
    "description": "Carrier Termination 1",  
    "type": "microwaveCarrierTermination",  
    "carrier-id": "A",  
    "tx-enabled": true,  
    "tx-frequency": 10728000,  
    "duplex-distance": 644000,  
    "channel-separation": 28000,  
    "polarization": not-specified,  
    "rtpc": {  
      "maximum-nominal-power": 20  
    },  
    "single": {  
      "selected-cm": "qam-512"  
    }  
  }  
]
```


A.2. 2+0 Instance

Figure 2 shows a 2+0 example.

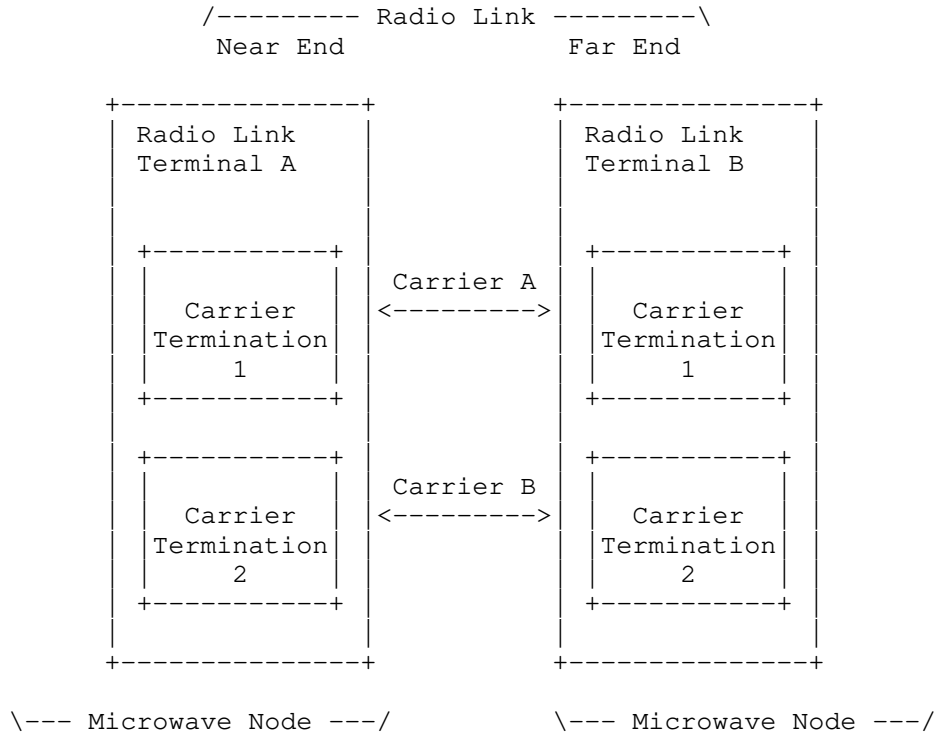


Figure 2: 2+0 Example

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

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

```
    "tdm-connections": [
      "tdm-type": "E1",
      "tdm-connections": "4"
    ]
  },
  {
    "name": "RLT-A:CT-1",
    "description": "Carrier Termination 1",
    "type": "microwaveCarrierTermination",
    "carrier-id": "A",
    "tx-enabled": true,
    "tx-frequency": 10728000,
    "duplex-distance": 644000,
    "channel-separation": 28000,
    "polarization": not-specified,
    "rtpc": {
      "maximum-nominal-power": 20
    },
    "single": {
      "selected-cm": "qam-512"
    }
  },
  {
    "name": "RLT-A:CT-2",
    "description": "Carrier Termination 2",
    "type": "microwaveCarrierTermination",
    "carrier-id": "B",
    "tx-enabled": true,
    "tx-oper-status": on,
    "tx-frequency": 10618000,
    "duplex-distance": 644000,
    "channel-separation": 28000,
    "polarization": not-specified,
    "rtpc": {
      "maximum-nominal-power": 20
    },
    "single": {
      "selected-cm": "qam-512"
    }
  }
]
```

A.3. 2+0 XPIC Instance

The following instance shows the XPIC configuration of the Near End node.

```
"interface": [
  {
    "name": "RLT-A",
    "description": "Radio Link Terminal A",
    "type": "microwaveRadioLinkTerminal",
    "id": "RLT-A",
    "mode": "two-plus-zero",
    "carrier-terminations": [
      "RLT-A:CT-1",
      "RLT-A:CT-2"
    ],
    "xpic-pairs": [
      "RLT-A:CT-1",
      "RLT-A:CT-2"
    ],
    "tdm-connections": [
      "tdm-type": "E1",
      "tdm-connections": "4"
    ]
  },
  {
    "name": "RLT-A:CT-1",
    "description": "Carrier Termination 1",
    "type": "microwaveCarrierTermination",
    "carrier-id": "A",
    "tx-enabled": true,
    "tx-frequency": 10728000,
    "duplex-distance": 644000,
    "channel-separation": 28000,
    "polarization": not-specified,
    "rtpc": {
      "maximum-nominal-power": 20
    },
    "single": {
      "selected-cm": "qam-512"
    }
  }
],
```

```
{
  "name": "RLT-A:CT-2",
  "description": "Carrier Termination 2",
  "type": "microwaveCarrierTermination",
  "carrier-id": "B",
  "tx-enabled": true,
  "tx-oper-status": on,
  "tx-frequency": 10618000,
  "duplex-distance": 644000,
  "channel-separation": 28000,
  "polarization": not-specified,
  "rtpc": {
    "maximum-nominal-power": 20
  },
  "single": {
    "selected-cm": "qam-512"
  }
}
```

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