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A YANG Data Model for Microwave Topology
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Abstract

This document defines a YANG data model to describe the topologies of microwave/millimeter.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP14 [RFC2119] [RFC8174] when, and only when, they appear in all captials, as shown here.

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Table of Contents

1. Terminology and Definitions	2
2. Introduction	3
3. YANG Data Model (Tree Structure)	3
3.1. The YANG Tree	3
3.2. Relationship with microwave interface YANG model	6
3.3. Relationship with client topology model	7
3.4. Model applicability to other technology	7
4. YANG Module	7
5. Security Considerations	18
6. IANA Considerations	19
7. References	20
7.1. Normative References	20
7.2. Informative References	21
Appendix A. Appendix A Examples of microwave topology	21
A.1. Appendix A.1 A topology with single microwave radio link	21
A.2. Appendix A.2 A topology with microwave radio links bundling	23
Appendix B. Contributors	26
Authors' Addresses	26

1. Terminology and Definitions

The following acronyms are used in this document:

PNC Provisioning Network Controller

MDSC Multi Domain Service Coordinator

2. Introduction

This document defines a YANG data model to describe the topologies of microwave/millimeter(hereafter microwave is used to simplify the text). The microwave topology model augments the TE topology model defines in [I-D.ietf-teas-yang-te-topo].

The microwave topology model is expected to be used between a Provisioning Network Controller(PNC) and a Multi Domain Service Coordinator(MDSC) ([RFC8453]). Possible use cases of microwave topology models include:

1. The microwave link frequency could be used to understand the current frequency usage, enabling a whole view of the network topology information, and as an input for network frequency planning.
2. The microwave radio link could change its bandwidth according to the environments under the adaptive modulation mode, e.g., the bandwidth will degrade when there's a heavy rain. To get to know of current microwave link bandwidth is important for path computation and service provisioning across different technologies/networks.
3. Due to bandwidth changing feature, availability is normally used to describe the microwave radio link characteristic. [RFC8330] defines a mechanism to report bandwidth-availability information through OSPF-TE. It's also necessary to include the information in the YANG data model to optimize the path/route computation.

3. YANG Data Model (Tree Structure)

3.1. The YANG Tree

The tree format defined in [RFC8340] is used for the YANG data model tree representation.

```
module: ietf-microwave-topology
  augment /nw:networks/nw:network/nw:network-types/tet:te-topology:
    +--rw mw-topology!
  augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-attributes:
    +--rw mw-channels* [mw-channel-frequency mw-channel-id]
      +--rw mw-channel-id                               uint32
      +--rw mw-channel-frequency                         uint32
      +--rw mw-channel-separation?                       uint32
      +--ro mw-channel-nominal-bandwidth?                uint64
      +--ro mw-channel-current-bandwidth?                uint64
```

```
    +---rw mw-channel-availability* [availability]
    |   +---rw availability          decimal64
    |   +---ro channel-bandwidth?   uint64
    +---rw interface-root {root-radio-if}?
augment /nw:networks/nw:network/nw:node/nt:termination-point/tet:te
/tet:interface-switching-capability/tet:max-lsp-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +---ro mw-bandwidth?   uint64
    +---ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nw:node/tet:te/tet:te-node-attributes
/tet:connectivity-matrices/tet:path-constraints/tet:te-bandwidth
/tet:technology:
  +--: (mw)
    +---ro mw-bandwidth?   uint64
    +---ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nw:node/tet:te/tet:te-node-attributes
/tet:connectivity-matrices/tet:connectivity-matrix
/tet:path-constraints/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +---ro mw-bandwidth?   uint64
    +---ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nw:node/tet:te
/tet:information-source-entry/tet:connectivity-matrices
/tet:path-constraints/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +---ro mw-bandwidth?   uint64
    +---ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nw:node/tet:te
/tet:information-source-entry/tet:connectivity-matrices
/tet:connectivity-matrix/tet:path-constraints/tet:te-bandwidth
/tet:technology:
  +--: (mw)
    +---ro mw-bandwidth?   uint64
    +---ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nw:node/tet:te
/tet:tunnel-termination-point/tet:client-layer-adaptation
/tet:switching-capability/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +---ro mw-bandwidth?   uint64
    +---ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nw:node/tet:te
/tet:tunnel-termination-point/tet:local-link-connectivities
/tet:path-constraints/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +---ro mw-bandwidth?   uint64
    +---ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nw:node/tet:te
```

```
/tet:tunnel-termination-point/tet:local-link-connectivities
/tet:local-link-connectivity/tet:path-constraints
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:te-link-attributes/tet:interface-switching-capability
/tet:max-lsp-bandwidth/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:te-link-attributes/tet:max-link-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:te-link-attributes/tet:max-resv-link-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:te-link-attributes/tet:unreserved-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:information-source-entry
/tet:interface-switching-capability/tet:max-lsp-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:information-source-entry/tet:max-link-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:information-source-entry/tet:max-resv-link-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
```

```

    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/nw:network/nt:link/tet:te
/tet:information-source-entry/tet:unreserved-bandwidth
/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/tet:te/tet:templates/tet:link-template
/tet:te-link-attributes/tet:interface-switching-capability
/tet:max-lsp-bandwidth/tet:te-bandwidth/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/tet:te/tet:templates/tet:link-template
/tet:te-link-attributes/tet:max-link-bandwidth/tet:te-bandwidth
/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/tet:te/tet:templates/tet:link-template
/tet:te-link-attributes/tet:max-resv-link-bandwidth/tet:te-bandwidth
/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64
augment /nw:networks/tet:te/tet:templates/tet:link-template
/tet:te-link-attributes/tet:unreserved-bandwidth/tet:te-bandwidth
/tet:technology:
  +--: (mw)
    +--ro mw-bandwidth?   uint64
    +--ro mw-unreserved-bandwidth uint64

```

3.2. Relationship with microwave interface YANG model

The microwave topology model is expected to be used between a PNC and a MDSC. [I-D.ietf-ccamp-mw-yang] defines an interface YANG model for microwave radio link which is used between the PNC and the physical device for device configuration. The PNC is able to convert the information received from the topology model into the interface model. For example, link in the topology model represent the connection between the Radio Link Terminations in the interface model, channels in the topology model represent the connections between Carrier Terminations in the interface model. Thus the channel frequency in the topology model is mapped to the tx-frequency of the Carrier Termination in the interface model.

If the purpose is to access more information of the microwave interface YANG model through the microwave topology model, a schema mount mechanism could be used, see the "interface-root" in the microwave topology model. [RFC8528] defines a mechanism to add the schema trees defined by a set of YANG modules onto a mount point defined in the schema tree in some YANG module. The current defined schema mount mechanism allows mounting of complete data models only. If complete mounting of the microwave interface YANG model is not necessary, a deviation model could be created to remove unneeded schema in the microwave interface model, and be mounted to the topology model.

3.3. Relationship with client topology model

Ethernet is the most common client signal over microwave link. The Ethernet topology is an overlay TE topology on microwave topology. When an ETH service is transported by a single microwave radio link, the ETH link is supported by the microwave link in underlay microwave topology. Appendix A.1 shows some JSON example of Ethernet link over single microwave link with one microwave channel. When an ETH service is transported over two microwave radio links, the ETH link is supported by the microwave link with two microwave channels in underlay microwave topology. Appendix A.2 shows some JSON example of Ethernet link over two microwave links.

3.4. Model applicability to other technology

TBA

4. YANG Module

```
<CODE BEGINS> file "ietf-microwave-topology@2019-02-27.yang"
```

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

  prefix "mwtopo";

  import ietf-network {
    prefix "nw";
    reference "RFC 8345: A YANG Data Model for Network
              Topologies";
  }

  import ietf-network-topology {
    prefix "nt";
  }
}
```

```
        reference "RFC 8345: A YANG Data Model for Network Topologies";
    }

// Note to RFC Editor: please replace YYYY with the number assigned
// to draft-ietf-teas-yang-te-topo
import ietf-te-topology {
    prefix "tet";
    reference "RFC xxxx: YANG Data Model for Traffic Engineering
              (TE) Topologies";
}

/*
*import ietf-routing-types {
*  prefix "rt-types";
* }
*/

import ietf-yang-schema-mount {
    prefix yangmnt;
    reference "RFC 8528: YANG Schema Mount";
}

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// Note to RFC Editor: replace XXXX with actual RFC number and
// remove this note.
description
  "This is a module for microwave topology.
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  authors of the code. All rights reserved.
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```


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This version of this YANG module is part of RFC XXXX
(<https://tools.ietf.org/html/rfcXXXX>); see the RFC itself for
full legal notices.";

```
revision 2019-02-27 {
  description
    "Update microwave link key.";
  reference "";
}

revision 2019-01-03 {
  description
    "Align with the TE topology YANG model.";
  reference "";
}

revision 2018-10-22 {
  description
    "change the type of serveral data nodes.";
  reference "";
}

revision 2018-06-30 {
  description
    "Updated version to add mount point to the interface model.";
  reference "";
}

revision 2018-03-05 {
  description
    "Initial version.";
  reference "";
}

feature root-radio-if{
  description
    "This feature means that root for microwave radio
    interface model is supported.";
}

/*
 * Groupings
 */
grouping mw-bandwidth {
  description "Microwave bandwidth attributes";
```

```
leaf mw-bandwidth {
    type uint64;
    units "Kbps";
    config false;
    description "Microwave nominal bandwidth. Calculation
of microwave nominal bandwidth is implementation specific.
For example, if there's only one channel in the mw-channels
list, the microwave nominal bandwidth is equal to the
channel bandwidth. If there's two channels in the mw-channels
list, depending on the configuration of the channels, the
microwave nominal bandwidth is the sum of channel
bandwidth(2+0), or just one channel bandwidth
(1+1 with protection).";
}

    leaf mw-unreserved-bandwidth {
        type uint64;
        units "Kbps";
        config false;
        description "The unreserved bandwidth of the link is
mw-bandwidth minus occupied bandwidth
on mw link";
    }
}

grouping mw-link-attributes {
    description "Microwave link attributes.";
    list mw-channels {
        key "mw-channel-frequency mw-channel-id";
        description "List of microwave channels supporting the link.";
        uses mw-channel-attributes;
    }
}

grouping mw-channel-attributes {
    description "Microwave channel attributes";

    leaf mw-channel-id {
        type string;
        description "Microwave channel identifier";
    }

    leaf mw-channel-frequency {
        type uint32;
        units "kHz";
        description "Microwave channel frequency";
    }
}
```

```
leaf mw-channel-separation {
  type uint32;
  units "kHz";
  description
    "The distance between adjacent channels
     in a radio frequency channel arrangement
     used in this link";
  reference "ETSI EN 302 217-1";
}

leaf mw-channel-nominal-bandwidth {
  type uint64;
  units "Kbps";
  config false;
  description "The nominal channel bandwidth";
}

leaf mw-channel-current-bandwidth {
  type uint64;
  units "Kbps";
  config false;
  description "The current channel bandwidth";
}

list mw-channel-availability{
  key "availability";
  description
    "List of availability and corresponding
     channel bandwidth";

  leaf availability {
    type decimal64 {
      fraction-digits 4;
      range "0..99.9999";
    }
    description "Availability level";
  }

  leaf channel-bandwidth {
    type uint64;
    units "Kbps";
    config false;
    description
      "The channel bandwidth corresponding
       to the availability level";
  }
}
```

```
    container "interface-root" {
    if-feature root-radio-if;
    description
      "Container for mount point.";
    yangmnt:mount-point "interface-root" {
      description
        "Root for microwave radio interface model.
        It could contain an interface instance.";
    }
  }
}

/*
 * Data nodes
 */
augment "/nw:networks/nw:network/nw:network-types/"
  + "tet:te-topology" {
  container mw-topology {
    presence "indicates a topology type of microwave.";
    description "Microwave topology type";
  }
  description "augment network types to include microwave network";
}

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes" {
  when "../..../nw:network-types/tet:te-topology/"
    + "mwtopo:mw-topology" {
    description "This augment is only valid for microwave.";
  }
  description "Microwave link augmentation";

  uses mw-link-attributes;
}

/*
 * Augment TE bandwidth
 */

/* Augment maximum LSP bandwidth of link terminationpoint (LTP) */
augment "/nw:networks/nw:network/nw:node/nt:termination-point/"
  + "tet:te/"
  + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "mwtopo:mw-topology" {
    description "Augment microwave TE bandwidth";
  }
}
```

```

    }
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}

/* Augment bandwidth path constraints of connectivity-matrices */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "mwtopo:mw-topology" {
        description "Augment microwave TE bandwidth";
    }
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}

/* Augment bandwidth path constraints of connectivity-matrix */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:te-node-attributes/tet:connectivity-matrices/"
    + "tet:connectivity-matrix/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "mwtopo:mw-topology" {
        description "Augment microwave TE bandwidth";
    }
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}

/* Augment bandwidth path constraints of connectivity-matrices
 * information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
    + "tet:information-source-entry/tet:connectivity-matrices/"
    + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
    when "../..../..../..../nw:network-types/tet:te-topology/"
        + "mwtopo:mw-topology" {
        description "Augment microwave TE bandwidth";
    }
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}

```

```

}

/* Augment bandwidth path constraints of connectivity-matrix
 * information-source */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:information-source-entry/tet:connectivity-matrices/"
  + "tet:connectivity-matrix/"
  + "tet:path-constraints/tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
  description "Augment microwave TE bandwidth";
}
description "microwave bandwidth.";
case mw {
  uses mw-bandwidth;
}
}

/* Augment client bandwidth of tunnel termination point (TTP) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:client-layer-adaptation/tet:switching-capability/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
  description "Augment microwave TE bandwidth";
}
description "microwave bandwidth.";
case mw {
  uses mw-bandwidth;
}
}

/* Augment bandwidth path constraints of local-link-connectivities */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/tet:path-constraints/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
  description "Augment microwave TE bandwidth";
}
description "microwave bandwidth.";
case mw {
  uses mw-bandwidth;
}
}

```

```

/* Augment bandwidth path constraints of
*local-link-connectivity (LLC) */
augment "/nw:networks/nw:network/nw:node/tet:te/"
  + "tet:tunnel-termination-point/"
  + "tet:local-link-connectivities/"
  + "tet:local-link-connectivity/tet:path-constraints/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "mwtopo:mw-topology" {
    description "Augment microwave TE bandwidth";
  }
  description "microwave bandwidth.";
  case mw {
    uses mw-bandwidth;
  }
}

/* Augment maximum LSP bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:interface-switching-capability/tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "mwtopo:mw-topology" {
    description "Augment microwave TE bandwidth";
  }
  description "microwave bandwidth.";
  case mw {
    uses mw-bandwidth;
  }
}

/* Augment maximum bandwidth of TE link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
  when "../..../nw:network-types/tet:te-topology/"
    + "mwtopo:mw-topology" {
    description "Augment microwave TE bandwidth";
  }
  description "microwave bandwidth.";
  case mw {
    uses mw-bandwidth;
  }
}

/* Augment maximum reservable bandwidth of TE link */

```

```

augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:max-resv-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
  description "Augment microwave TE bandwidth";
}
description "microwave bandwidth.";
case mw {
  uses mw-bandwidth;
}
}

/* Augment unreserved bandwidth of TE Link */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:te-link-attributes/"
  + "tet:unreserved-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
  description "Augment microwave TE bandwidth";
}
description "microwave bandwidth.";
case mw {
  uses mw-bandwidth;
}
}

/* Augment maximum LSP bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:interface-switching-capability/"
  + "tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
  description "Augment microwave TE bandwidth";
}
description "microwave bandwidth.";
case mw {
  uses mw-bandwidth;
}
}

/* Augment maximum bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:max-link-bandwidth/"

```



```
    + "tet:te-bandwidth/tet:technology" {
when "../..../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
    description "Augment microwave TE bandwidth";
  }
  description "microwave bandwidth.";
  case mw {
    uses mw-bandwidth;
  }
}

/* Augment maximum reservable bandwidth of TE link
* information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:max-resv-link-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
    description "Augment microwave TE bandwidth";
  }
  description "microwave bandwidth.";
  case mw {
    uses mw-bandwidth;
  }
}

/* Augment unreserved bandwidth of TE link information-source */
augment "/nw:networks/nw:network/nt:link/tet:te/"
  + "tet:information-source-entry/"
  + "tet:unreserved-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
when "../..../..../nw:network-types/tet:te-topology/"
  + "mwtopo:mw-topology" {
    description "Augment microwave TE bandwidth";
  }
  description "microwave bandwidth.";
  case mw {
    uses mw-bandwidth;
  }
}

/* Augment maximum LSP bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
  + "tet:link-template/tet:te-link-attributes/"
  + "tet:interface-switching-capability/"
  + "tet:max-lsp-bandwidth/"
  + "tet:te-bandwidth/tet:technology" {
```

```
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}

/* Augment maximum bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:max-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}

/* Augment maximum reservable bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:max-resv-link-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}

/* Augment unreserved bandwidth of TE link template */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:unreserved-bandwidth/"
    + "tet:te-bandwidth/tet:technology" {
    description "microwave bandwidth.";
    case mw {
        uses mw-bandwidth;
    }
}
}
<CODE ENDS>
```

5. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040][RFC8040]. The lowest

NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

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

TBD.(list subtrees and data nodes and state why they are sensitive)

Some of the readable data nodes in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or notification) to these data nodes. These are the subtrees and data nodes and their sensitivity/vulnerability:

TBD.(list subtrees and data nodes and state why they are sensitive)

6. IANA Considerations

IANA is asked to assign a new URI from the "IETF XML Registry" [RFC3688].

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

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

Name: ietf-microwave-topology
Namespace: urn:ietf:params:xml:ns:yang:ietf-microwave-topology
Prefix: mwtopo
Reference: RFC xxxx

7. References

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7.2. Informative References

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Appendix A. Appendix A Examples of microwave topology

A.1. Appendix A.1 A topology with single microwave radio link

Microwave is a transport technology which can be used to transport client services, such as ETH. When an ETH service is transported by a single microwave radio link, the topology could be shown as the Figure 3. Note that the figure just shows an example, there might be other possibilities to demonstrate the topology.

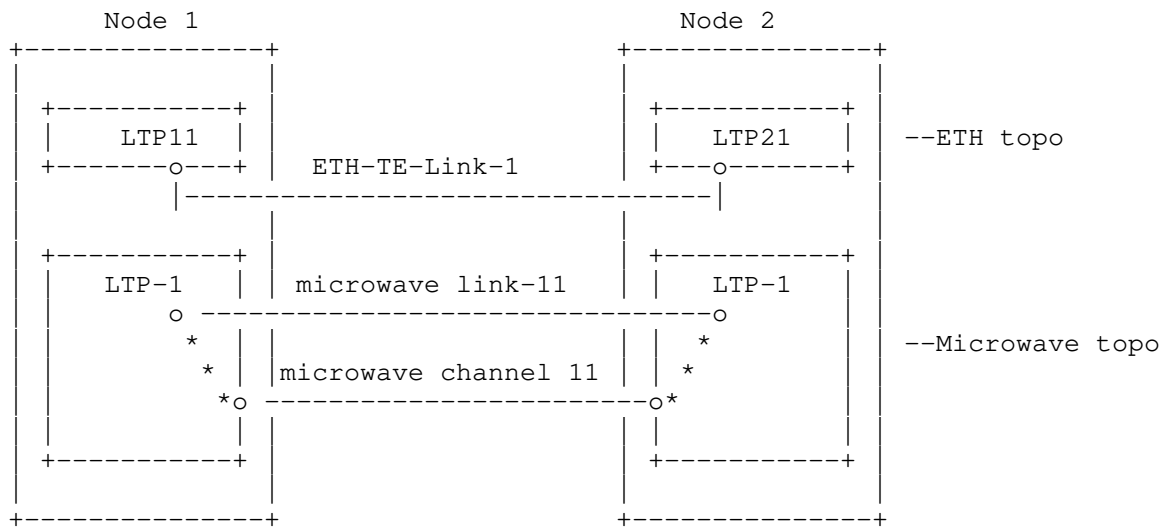


Figure 3: ETH transported on a single microwave radio link

In the above ETH topology, the ETH-TE-link is encoded in JSON as below:

```
...
"ietf-network-topology:link": [
  {
    "link-id": "N1,LTP11,N2,LTP21",
    "source": {
      "source-node": "N1",
      "source-tp": "LTP11"
    }
    "destination": {
      "dest-node": "N2",
      "dest-tp": "LTP21"
    }
    "supporting-link": {
      "network-ref": "mw-topo",
      "link-ref": "mw-link-11"
    }
  }
]
```

Note that the example above just shows the particular ETH link, not the full ETH topology.

In the microwave topology, the microwave link is encoded in JSON as below:

```

...
"ietf-network-topology:link": [
  {
    "link-id": "N1,LTP-1,N2,LTP-1",
    "source": {
      "source-node": "N1",
      "source-tp": "LTP-1"
    }
    "destination": {
      "dest-node": "N2",
      "dest-tp": "LTP-1"
    }
  }
]

"ietf-te-topology:link/te/te-link-attributes": [
  {
    "mw-channels":{
      "ietf-microwave-topology:mw-channel-id": "1",
      "ietf-microwave-topology:mw-channel-frequency": 10728000,
      "ietf-microwave-topology:mw-channel-separation": "28000",
      "ietf-microwave-topology:mw-channel-nominal-bandwidth":
        "1000",
      "ietf-microwave-topology:mw-channel-current-bandwidth":
        "1000",
      "ietf-microwave-topology:mw-channel-availability":{
        "availability":"99.99",
        "channel-bandwidth": "1000"
      }
    }
  }
]

"ietf-te-topology:node/te/interface-switching-capability
/max-lsp-bandwidth/te-bandwidth/technology":{
  "mw-bandwidth":"1000"
}

```

A.2. Appendix A.2 A topology with microwave radio links bundling

When a ETH service is transported over two microwave radio links (2+0 configuration), the topologies could be shown as in Figure 4. Note that the figure just shows one example, there might be other possibilities to demonstrate the topology.

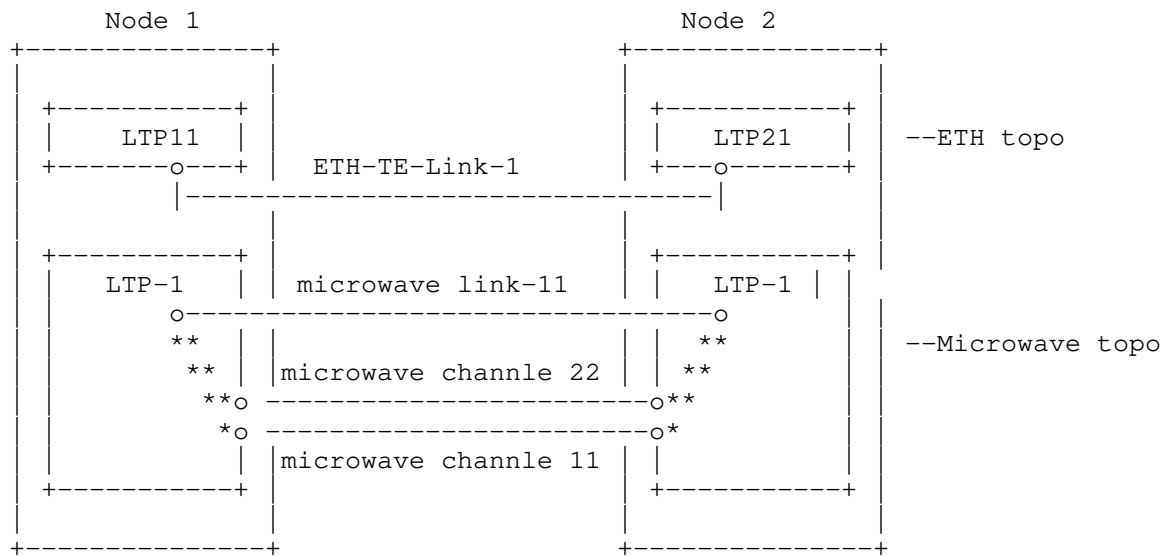


Figure 4: ETH transported on two microwave radio links

In the ETH topology, the ETH-TE-link is encoded in JSON as below:

```
...
"ietf-network-topology:link": [
  {
    "link-id": "N1,LTP11,N2,LTP21",
    "source": {
      "source-node": "N1",
      "source-tp": "LTP11"
    }
    "destination": {
      "dest-node": "N2",
      "dest-tp": "LTP21"
    }
    "supporting-link": {
      "network-ref": "mw-topo",
      "link-ref": "mw-link-11"
    }
  }
]
```

Note that the example above just shows the specific ETH link, not the full ETH topology.

In the microwave topology, the microwave link is encoded in JSON as below:

```
...

"ietf-network-topology:link": [
  {
    "link-id": "N1,LTP-1,N2,LTP-1",
    "source": {
      "source-node": "N1",
      "source-tp": "LTP-1"
    }
    "destination": {
      "dest-node": "N2",
      "dest-tp": "LTP-1"
    }
  }
]

"ietf-te-topology:link/te/te-link-attributes": [
  {
    "mw-channels":
    {
      "ietf-microwave-topology:mw-channel-id": "1",
      "ietf-microwave-topology:mw-channel-frequency": 10728000,
      "ietf-microwave-topology:mw-channel-separation": "28000",
      "ietf-microwave-topology:mw-channel-nominal-bandwidth":
      "1000",
      "ietf-microwave-topology:mw-channel-current-bandwidth":
      "1000",
      "ietf-microwave-topology:mw-channel-availability":{
        "availability":"99.99",
        "channel-bandwidth": "1000"
      }
    }

    {
      "ietf-microwave-topology:mw-channel-id": "2",
      "ietf-microwave-topology:mw-channel-frequency": 10756000,
      "ietf-microwave-topology:mw-channel-separation": "28000",
      "ietf-microwave-topology:mw-channel-nominal-bandwidth":
      "1000",
      "ietf-microwave-topology:mw-channel-current-bandwidth":
      "1000",
      "ietf-microwave-topology:mw-channel-availability":{
        "availability":"99.99",
        "channel-bandwidth": "1000"
      }
    }
  }
]
```

```
        }  
      }  
    ]  
  
    "ietf-te-topology:node/te/interface-switching-capability  
      /max-lsp-bandwidth/te-bandwidth/technology":{  
      "mw-bandwidth":"2000"  
    }  
  }
```

Note that the example above just shows the microwave component links, it doesn't show the full microwave topology.

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