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A Yang Data Model for Impairment-Aware WSON Optical Networks

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Abstract

This document provides a YANG data model for the impairment-aware TE topology in wavelength switched optical networks (WSONs).

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Table of Contents

1. Introduction....2
  1.1. Terminology....3
  1.2. Tree diagram....3
  1.3. Prefixes in Data Node Names....4
2. YANG Model (Tree Structure)....4
3. IETF-WSON-Topology YANG Model....6
4. Security Considerations....16
5. IANA Considerations....16
6. Acknowledgments....16
7. References....17
  7.1. Normative References....17
  7.2. Informative References....17
8. Contributors....18
Authors' Addresses....18

1. Introduction

In order to provision an optical connection (an optical path) through a WSON, a combination of path continuity, resource availability, and impairment constraints must be met to determine viable and optimal paths through the network. The determination of appropriate paths is known as Impairment-Aware Routing and Wavelength Assignment (IA-RWA) [RFC6566].

This document provides a YANG data model for the impairment-aware Traffic Engineering (TE) topology in wavelength switched optical networks (WSONs). The YANG model described in this document is a WSON technology-specific Yang model based on the information model developed in [RFC7446] and the two encoding documents [RFC7581] and [RFC7579] that developed protocol independent encodings based on [RFC7446].

The intent of this document is to provide a Yang data model, which can be utilized by an MDSC to collect states of WSON impairment data

from the Transport PNCs to enable impairment-aware optical path computation according to the ACTN Architecture [RFC8453]. The communication between controllers is done via a NETCONF [RFC8341].

This document augments the generic TE topology draft [TE-TOPO] and reuses groupings via importing other modules such as ietf-wson-topology and ietf-te-wson-types defined in [WSON-TOPO].

This document defines one YANG module: ietf-wson-impairment-topology (Section 3) according to the new Network Management Datastore Architecture [RFC8342].

1.1. Terminology

Refer to [RFC4847] and [RFC5253] for the key terms used in this document.

The following terms are defined in [RFC7950] and are not redefined here:

o client

o server

o augment

o data model

o data node

The following terms are defined in [RFC6241] and are not redefined here:

o configuration data

o state data

The terminology for describing YANG data models is found in [RFC7950].

1.2. Tree diagram

A simplified graphical representation of the data model is used in Section 2 of this this document. The meaning of the symbols in these diagrams is defined in [RFC8340].

1.3. Prefixes in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules, as shown in Table 1.

Prefix	YANG module	Reference
wson-imp-topo	ietf-wson-impairment-topology	[RFC XXXX]

Table 1: Prefixes and corresponding YANG modules

Note: The RFC Editor will replace XXXX with the number assigned to the RFC once this draft becomes an RFC.

2. YANG Model (Tree Structure)

```
module: ietf-wson-impairment-topology
  augment /nw:networks/nw:network/nw:network-types/tet:te-topology:
    +--rw wson-impairment-topology!
  augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-attributes:
    +--ro power?   int32
  augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-
attributes/tet:underlay/tet:primary-path/tet:path-
element/tet:type/tet:label/tet:label-hop/tet:te-label/tet:technology:
    +--:(wson-imp-topo)
       +--rw (grid-type)?
       |  +--:(dwdm)
       |  |  +--ro channel-freq?         decimal64
       |  +--:(cwdm)
       |     +--ro channel-wavelength?   uint32
       +--ro bit-rate?             decimal64
       +--ro BER?                  decimal64
       +--ro pmd?                  decimal64
       +--ro cd?                   decimal64
       +--ro osnr?                 decimal64
       +--ro q-factor?             decimal64
  augment /nw:networks/nw:network/nt:link/tet:te/tet:te-link-
attributes/tet:underlay/tet:backup-path/tet:path-
element/tet:type/tet:label/tet:label-hop/tet:te-label/tet:technology:
    +--:(wson-imp-topo)
       +--rw (grid-type)?
```

```
          |  +--:(dwdm)
          |  |  +--ro channel-freq?         decimal64
          |  +--:(cwdm)
          |     +--ro channel-wavelength?   uint32
          +--ro bit-rate?             decimal64
          +--ro BER?                  decimal64
          +--ro pmd?                  decimal64
          +--ro cd?                   decimal64
          +--ro osnr?                 decimal64
          +--ro q-factor?             decimal64
     augment /nw:networks/tet:te/tet:templates/tet:link-template/tet:te-link-
   attributes/tet:underlay/tet:primary-path/tet:path-
   element/tet:type/tet:label/tet:label-hop/tet:te-label/tet:technology:
       +--:(wson-imp-topo)
          +--rw (grid-type)?
          |  +--:(dwdm)
          |  |  +--ro channel-freq?         decimal64
          |  +--:(cwdm)
          |     +--ro channel-wavelength?   uint32
          +--ro bit-rate?             decimal64
          +--ro BER?                  decimal64
          +--ro pmd?                  decimal64
          +--ro cd?                   decimal64
          +--ro osnr?                 decimal64
          +--ro q-factor?             decimal64
     augment /nw:networks/tet:te/tet:templates/tet:link-template/tet:te-link-
   attributes/tet:underlay/tet:backup-path/tet:path-
   element/tet:type/tet:label/tet:label-hop/tet:te-label/tet:technology:
       +--:(wson-imp-topo)
          +--rw (grid-type)?
          |  +--:(dwdm)
          |  |  +--ro channel-freq?         decimal64
          |  +--:(cwdm)
          |     +--ro channel-wavelength?   uint32
          +--ro bit-rate?             decimal64
          +--ro BER?                  decimal64
          +--ro pmd?                  decimal64
          +--ro cd?                   decimal64
          +--ro osnr?                 decimal64
          +--ro q-factor?             decimal64
     augment /nw:networks/nw:network/nw:node/tet:te/tet:te-node-attributes:
       +--rw wson-node
          +--rw node-type?   identityref
     augment /nw:networks/nw:network/nw:node/tet:te/tet:tunnel-termination-
point:
       +--ro available-modulation*   identityref
       +--ro modulation-enabled?     boolean
       +--ro modulation-type?        identityref
```

```
       +--ro available-FEC*          identityref
       +--ro FEC-enabled?            boolean
```

```
       +--ro FEC-type?               identityref
       +--ro FEC-code-rate?          decimal64
       +--ro FEC-threshold?          decimal64
     augment /nw:networks/nw:network/nw:node/tet:te/tet:tunnel-termination-
point:
       +--ro transponder-list* [carrier-id]
          +--ro carrier-id    uint32
```

3. IETF-WSON-Topology YANG Model

```
<CODE BEGINS> file "ietf-wson-impairment-topology@2018-08-31.yang"

module   ietf-wson-impairment-topology {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-wson-impairment-topology";

  prefix "wson-imp-topo";

  import ietf-network {
    prefix "nw";
  }

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

  import ietf-te-topology {
    prefix "tet";
  }

  import ietf-wson-topology {
    prefix "wson";
  }

  import ietf-te-wson-types {
    prefix "te-wson-types";
  }

  organization
    "IETF CCAMP Working Group";

  contact
    "Editor:   Young Lee  <leeyoung@huawei.com>";

  description
   "This module contains a collection of YANG definitions for
```

```
   Impairment-aware RWA WSON.

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   authors of the code.  All rights reserved.

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

  revision 2018-08-31{
   description
      "version 0.";
      reference
        "RFC XXX: A Yang Data Model for Impairment-aware WSON Optical Networks
";
  }

  identity modulation {
    description "base identity for modulation type";
  }
  identity QPSK {
   base modulation;
   description
      "QPSK (Quadrature Phase Shift Keying) modulation";
  }
  identity DP_QPSK {
    base modulation;
    description
     "DP-QPSK (Dual Polarization Quadrature
      Phase Shift Keying) modulation";
  }
  identity QAM16 {
    base modulation;
   description
     "QAM16 (Quadrature Amplitude Modulation
      - 4 bits per symbol) modulation";
  }
  identity  DP_QAM16 {
    base modulation;
    description
     "DP-QAM16 (Dual Polarization Quadrature Amplitude Modulation
     - 4 bits per symbol) modulation";
  }
  identity DC_DP_QAM16 {
    base modulation;
```

```
    description
     "DC DP-QAM16 (Dual Polarization Quadrature Amplitude Modulation
     - 4 bits per symbol) modulation";
  }


  identity FEC {
    description
     "Enumeration that defines the type of
      Forward Error Correction";
  }
  identity reed-solomon {
    base FEC;
   description
     "Reed-Solomon error correction";
  }
  identity hamming-code {
    base FEC;
   description
     "Hamming Code error correction";
  }
  identity golay {
    base FEC;
   description "Golay error correction";
  }


  grouping wson-label {
    description
      "Generic label for WSON links and paths";
    choice grid-type {
      description
        "Label for DWDM or CWDM grid";
      case dwdm {
        leaf channel-freq {
          type decimal64 {
            fraction-digits 5;
          }
          units THz;
        config false;
          description
            "The DWDM frequency in THz, e.g. 193.12500";
          reference
            "RFC6205";
        }
      }
      case cwdm {
```

```
        leaf channel-wavelength {
          type uint32;
          units nm;
        config false;
          description
            "The CWDM wavelength in nanometer, e.g. 1511";
          reference
            "RFC6205";
        }
      }
    }
  }


  grouping transponder-attributes {
   description "Configuration of an optical transponder";
   leaf-list available-modulation {
      type identityref {
        base modulation;
      }
      config false;
      description
         "List determining all the available modulations";
   }
   leaf modulation-enabled {
      type boolean;
      config false;
      description
         "Determines whether the modulation is enabled or not";
   }
   leaf modulation-type {
      type identityref {
        base modulation;
      }
      config false;
      description
         "Modulation type of the transponder";
   }
   leaf-list available-FEC {
      type identityref {
        base FEC;
      }
      config false;
      description "List determining all the available FEC";
   }
   leaf FEC-enabled {
      type boolean;
```

```
      config false;
      description
         "Determines whether the FEC is enabled or not";
   }
   leaf FEC-type {
      type identityref {
        base FEC;
      }
      config false;
      description
         "FEC type of the transponder";
   }
   leaf FEC-code-rate {
      type decimal64 {
        fraction-digits 8;
        range "0..max";
      }
      config false;
      description "FEC-code-rate";
   }
   leaf FEC-threshold {
      type decimal64 {
        fraction-digits 8;
        range "0..max";
      }
      config false;
      description "Threshold on the BER, for which FEC is able to correct
errors";
   }
  }

  grouping sliceable-transponder-attributes {
   description
      "Configuration of a sliceable transponder.";
   list transponder-list {
      key "carrier-id";
      config false;
      description "List of carriers";
      leaf carrier-id {
         type uint32;
         config false;
         description "Identifier of the carrier";
      }
   }
  }

  grouping wson-node-attributes {
   description "WSON node attributes";
```

```
   container wson-node {
      description "WSON node attrtibutes.";
      leaf node-type {
       type identityref {
         base te-wson-types:wson-node-type;
       }
       description "WSON node type.";
      }
   }
  }

  grouping wson-fiber-data {
   description "WSON link (fiber) attributes with impairment data";
     leaf power {
      type int32;
      units "dBm";
      config false;
      description "Input Power Level of the receiver side of the link";
      }
  }

  grouping wson-impairement-data {
   description "WSON impairment data per wavelength";
     leaf bit-rate {
       type decimal64 {
         fraction-digits 8;
         range "0..max";
       }
       units "Gbit/s";
      config false;
       description "Gross bit rate";
     }
     leaf BER {
       type decimal64 {
        fraction-digits 18;
          range "0..max";
        }
        config false;
        description "BER";
     }
     leaf pmd {
       type decimal64 {
        fraction-digits 8;
        range "0..max";
       }
       units "ps/(km)^0.5";
       config false;
```

```
        description "Polarization Mode Dispersion";
     }
     leaf cd {
       type decimal64 {
        fraction-digits 5;
       }
       units "ps/nm/km";
       config false;
       description "Cromatic Dispersion";
     }
     leaf osnr {
       type decimal64 {
        fraction-digits 5;
       }
       units "dB";
       config false;
       description "osnr";
     }
     leaf q-factor {
       type decimal64 {
        fraction-digits 5;
       }
       units "dB";
       config false;
       description "q-factor";
     }
  }

  /*
  grouping wson-ttp-attributes {
    description
      "WSON tunnel termination point (e.g.tranponder) attributes";
      leaf-list available-operational-mode {
        type te-wson-types:operational-mode;
        description "List of all vendor-specific supported
        mode identifiers";
      }

      leaf operational-mode {
        type te-wson-types:operational-mode;
        description "Vendor-specific mode identifier";
      }
  }
  */

/* Data nodes */
```

```
  augment "/nw:networks/nw:network/nw:network-types"
    + "/tet:te-topology" {
    description "wson-impairment topology augmented";
    container wson-impairment-topology {
      presence "indicates an impairment-aware topology of wson";
      description
       "Container to identify impairment-aware wson topology type";
    }
  }

  augment "/nw:networks/nw:network/nt:link/tet:te"
    + "/tet:te-link-attributes"   {
    when "/nw:networks/nw:network/nw:network-types"
      +"/tet:te-topology/wson-imp-topo:wson-impairment-topology" {
      description
        "This augment is only valid for WSON Impairment.";
    }
    description "WSON Link augmentation for impairment data.";
    uses wson-fiber-data;
  }

    /* Augment label hop of underlay primary path of TE link */
  augment "/nw:networks/nw:network/nt:link/tet:te/"
        + "tet:te-link-attributes/"
        + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
        + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../../../../../../../../"
       + "nw:network-types/tet:te-topology/"
       + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
    description "WSON label.";
    case wson-imp-topo {
      uses wson-label;
     uses wson-impairement-data;
    }
  }

  /* Augment label hop of underlay backup path of TE link */
  augment "/nw:networks/nw:network/nt:link/tet:te/"
        + "tet:te-link-attributes/"
        + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
        + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
    when "../../../../../../../../"
       + "nw:network-types/tet:te-topology/"
       + "wson:wson-topology" {
      description "Augment WSON TE label";
```

```
    }
    description "WSON label.";
    case wson-imp-topo {
      uses wson-label;
     uses wson-impairement-data;
    }
  }
    /* Augment label hop of underlay primary path of TE link template */
  augment "/nw:networks/tet:te/tet:templates/"
        + "tet:link-template/tet:te-link-attributes/"
        + "tet:underlay/tet:primary-path/tet:path-element/tet:type/"
        + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
/*
    when "../../../../../../../../../"
       + "nw:network-types/tet:te-topology/"
       + "wson:wson-topology" {
          description "Augment WSON TE label";
    }
*/
    description "WSON label.";
    case wson-imp-topo {
      uses wson-label;
     uses wson-impairement-data;
    }
  }

  /* Augment label hop of underlay backup path of TE link template */
  augment "/nw:networks/tet:te/tet:templates/"
        + "tet:link-template/tet:te-link-attributes/"
        + "tet:underlay/tet:backup-path/tet:path-element/tet:type/"
        + "tet:label/tet:label-hop/tet:te-label/tet:technology" {
/*
    when "../../../../../../../../../"
       + "nw:network-types/tet:te-topology/"
       + "wson:wson-topology" {
      description "Augment WSON TE label";
    }
*/
    description "WSON label.";
    case wson-imp-topo {
      uses wson-label;
     uses wson-impairement-data;
    }
  }
```

```
  augment "/nw:networks/nw:network/nw:node/tet:te"
    + "/tet:te-node-attributes" {
    when "/nw:networks/nw:network/nw:network-types"
      +"/tet:te-topology/wson:wson-topology" {
      description
        "This augment is only valid for WSON.";
    }
    description "WSON Node augmentation.";
    uses wson-node-attributes;
  }


  augment "/nw:networks/nw:network/nw:node/tet:te"
    + "/tet:tunnel-termination-point" {
    when "/nw:networks/nw:network/nw:network-types"
      +"/tet:te-topology/wson-imp-topo:wson-impairment-topology" {
      description
        "This augment is only valid for Impairment WSON with non-sliceable
        transponder model";
    }
    description
      "WSON tunnel termination point
      augmentation for non-sliceabletransponder model.";

   /* uses wson-ttp-attributes; */
    uses transponder-attributes;
  }

  augment "/nw:networks/nw:network/nw:node/tet:te"
    + "/tet:tunnel-termination-point" {
    when "/nw:networks/nw:network/nw:network-types"
      +"/tet:te-topology/wson-imp-topo:wson-impairment-topology" {
      description
        "This augment is only valid for Impairment WSON with sliceable
        transponder model";
    }
    description
      "WSON tunnel termination point augmentation for sliceabletransponder
model.";
    uses sliceable-transponder-attributes;
  }
}
<CODE ENDS>
```

4. Security Considerations

The configuration, state, and action data defined in this document are designed to be accessed via a management protocol with a secure transport layer, such as NETCONF [RFC6241]. The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF users to a preconfigured subset of all available NETCONF protocol operations and content.

A number of configuration data nodes defined in this document are read-only; however, these data nodes may be considered sensitive or vulnerable in some network environments.

5. IANA Considerations

This document registers the following namespace URIs in the IETF XML registry [RFC3688]:

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

This document registers the following YANG modules in the YANG Module Names registry [RFC7950]:

```
---------------------------------------------------------------------
name:      ietf-wson-impairment-topology
namespace: urn:ietf:params:xml:ns:yang:ietf-wson-impairment-
topology

reference: RFC XXXX (TDB)
---------------------------------------------------------------------
```

6. Acknowledgments

This document was prepared using 2-Word-v2.0.template.dot.

7. References

7.1. Normative References

7.2. Informative References

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, June 2011.

[RFC6566] Y. Lee, G. Bernstein, D. Li, G. Martinelli, "A Framework for the Control of Wavelength Switched Optical Networks (WSONs) with Impairments", RFC 6566, March 2012.

[RFC7446] Y. Lee, G. Bernstein, D. Li, W. Imajuku, "Routing and Wavelength Assignment Information Model for Wavelength Switched Optical Networks", RFC 7446, Feburary 2015.

[RFC7579] G. Bernstein, Y. Lee, D. Li, W. Imajuku, "General Network Element Constraint Encoding for GMPLS Controlled Networks", RFC 7579, June 2015.

[RFC7581] G. Bernstein, Y. Lee, D. Li, W. Imajuku, "Routing and Wavelength Assignment Information Encoding for Wavelength Switched Optical Networks", RFC 7581, June 2015.

[RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, August 2016.

[RFC8341] Bierman, A. and M. Bjorklund, "Network Configuration Access Control Model", RFC 8341, March 2018.

[RFC8342] Bjorklund, M., Schoenwaelder, J., Shafer, P., Watsen, K., and R. Wilton, "Network Management Datastore Architecture (NMDA)", RFC 8342, March 2018.

[TE-TOPO] X. Liu, et al., "YANG Data Model for TE Topologies", work in progress: draft-ietf-teas-yang-te-topo.

[RFC8453] Ceccarelli, D. and Y. Lee, "Framework for Abstraction and Control of Traffic Engineered Networks", RFC 8453, August 2018.

8. Contributors

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