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YANG Data Models for requesting Path Computation in WDM Optical Networks
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Abstract

This document provides a mechanism to request path computation in Wavelength-Division Multiplexing (WDM) optical networks composed of Wavelength Switched Optical Networks (WSO) and Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) switched technologies. This model augments the Remote Procedure Calls (RPCs) defined in RFC YYYY.

[RFC EDITOR NOTE: Please replace RFC YYYY with the RFC number of draft-ietf-teas-yang-path-computation once it has been published.]

About This Document

This note is to be removed before publishing as an RFC.

The latest revision of this draft can be found at <https://ietf-ccamp-wg.github.io/ietf-ccamp-optical-path-computation/draft-ietf-ccamp-optical-path-computation-yang.html>. Status information for this document may be found at <https://datatracker.ietf.org/doc/draft-ietf-ccamp-optical-path-computation-yang/>.

Discussion of this document takes place on the Common Control and Measurement Plane Working Group mailing list (<mailto:ccamp@ietf.org>), which is archived at <https://mailarchive.ietf.org/arch/browse/ccamp/>. Subscribe at <https://www.ietf.org/mailman/listinfo/ccamp/>.

Source for this draft and an issue tracker can be found at <https://github.com/ietf-ccamp-wg/ietf-ccamp-optical-path-computation>.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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Table of Contents

1. Introduction	3
1.1. Terminology and Notations	3
1.2. Tree Diagram	4
1.3. Prefix in Data Node Names	4
2. YANG Data Models for WDM Path Computation	4
2.1. YANG Models Overview	4
2.2. Attributes Augmentation	5
2.3. Bandwidth Augmentation	5
2.4. Label Augmentations	5
3. WDM Path Computation Tree Diagrams	6
4. YANG Models for WDM Path Computation	17
5. Manageability Considerations	27
6. Security Considerations	27
7. IANA Considerations	27
8. References	28
8.1. Normative References	28
8.2. Informative References	29
Appendix A. Change Log	30
Acknowledgments	30
Contributors	31

Authors' Addresses	31
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1. Introduction

[I-D.ietf-teas-yang-path-computation] describes key use cases, where a client needs to request underlying Software-Defined Network (SDN) controllers for path computation. In some of these use cases, the underlying SDN controller can control a single-layer optical technologies, including Optical Transport Network (OTN), Wavelength Switched Optical Networks (WSO), Flexi-grid, and multi-layer Optical network.

This document defines YANG data models, which augment the generic Path Computation RPC defined in [I-D.ietf-teas-yang-path-computation], with technology-specific augmentations required to request path computation to an underlying Optical SDN controller. These models allow a client to delegate path computation tasks to the underlying Optical SDN controller without having to obtain optical-layer information from the controller and performing feasible path computation itself. This is especially helpful in cases where computing optically-feasible paths require knowledge of physical-layer states, such as optical impairments, which are visible only to the Optical controller.

1.1. Terminology and Notations

Refer to [RFC7446] and [RFC7581] for the key terms used in this document. The following terms are defined in [RFC7950] and are not redefined here:

- * client
- * server
- * augment
- * data model
- * data node

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

- * configuration data
- * 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 3 of this document. The meaning of the symbols in these diagrams is defined in [RFC8340].

1.3. Prefix 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
l0-types	ietf-layer0-types	[RFCZZZZ]
te	ietf-te	[RFCKKKK]
tepc	ietf-te-path-computation	[RFCYYYY]
wdm-pc	ietf-wdm-path-computation	RFCXXXX

Table 1: Prefixes and corresponding YANG modules

RFC Editor Note: Please replace XXXX with the RFC number assigned to this document. Please replace ZZZZ with the RFC number assigned to [I-D.ietf-ccamp-rfc9093-bis]. Please replace KKKK with the RFC number assigned to [I-D.ietf-teas-yang-te]. Please replace YYYY with the RFC number assigned to [I-D.ietf-teas-yang-path-computation]. Please remove this note.

2. YANG Data Models for WDM Path Computation

2.1. YANG Models Overview

The YANG data models for requesting WDM path computation are defined as augmentations of the generic Path Computation RPC defined in [I-D.ietf-teas-yang-path-computation], as shown in Figure 1.

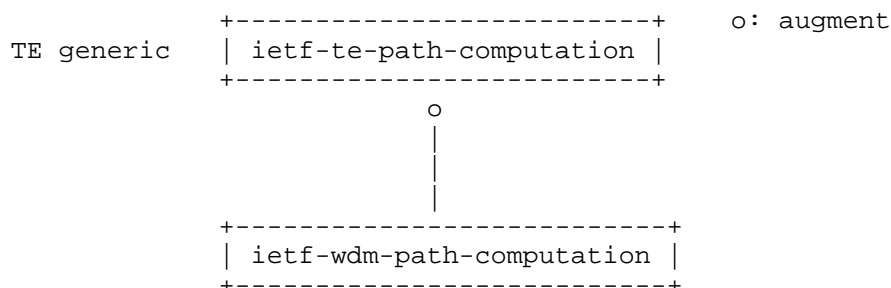


Figure 1: Relationship between WDM and TE path computation models

The entities and Traffic Engineering (TE) attributes, such as requested path and tunnel attributes, defined in [I-D.ietf-teas-yang-path-computation], are still applicable when requesting WDM path computation and the models defined in this document only specifies the additional technology-specific attributes/information, using the attributes defined in [I-D.ietf-ccamp-rfc9093-bis].

2.2. Attributes Augmentation

The common characteristics for layer 0 (WSON and Flexi-grid) path computation are under definition in [I-D.ietf-ccamp-rfc9093-bis] and re-used in the `ietf-wdm-path-computation` YANG models.

2.3. Bandwidth Augmentation

As described in Section 4.2 of [RFC7699], there is some overlap between bandwidth and label in layer0.

The WSON and flexi-grid label resource information described in Section 2.4, is sufficient to describe also the spectrum resources within WSON and flexi-grid networks. Therefore, the model does not define any augmentation for the `te-bandwidth` containers defined in [I-D.ietf-teas-yang-path-computation].

2.4. Label Augmentations

The models augment all the occurrences of the `label-restriction` list with WSON and Flexi-grid technology-specific attributes using the `l0-label-range-info` and `flexi-grid-label-range-info` groupings defined in [I-D.ietf-ccamp-rfc9093-bis].

Moreover, the models augment all the occurrences of the `te-label` container with the WSON, Flexi-grid and OTN technology-specific attributes using the `wson-label-start-end`, `wson-label-hop`, `wson-label-step`, `flexi-grid-label-start-end`, `flexi-grid-label-hop` and `flexi-grid-label-step` defined in [I-D.ietf-ccamp-rfc9093-bis].

3. WDM Path Computation Tree Diagrams

Figure 2 below shows the tree diagram of the YANG data model defined in module `ietf-wdm-path-computation.yang`.

module: `ietf-wdm-path-computation`

```

augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:tunnel-attributes:
    +-- wdm-constraint
      +-- transceiver-constraint
        | +-- operational-modes*          string
        | +-- tx-tune-constraints
        | | +-- min-central-frequency?    frequency-thz
        | | +-- max-central-frequency?    frequency-thz
        | | +-- transceiver-tunability?   frequency-ghz
        | +-- line-coding-bitrate*        identityref
        | +-- tx-channel-power?           10-types:power-dbm
        | +-- preferred-rx-channel-power?  10-types:power-dbm
      +-- gsnr-extra-margin?              snr
      +-- use-regen?                      boolean
      +-- wavelength-conversion?          boolean
      +-- wavelength-assignment?          identityref
      +-- guard-band-size?                10-types:frequency-thz
      +-- matching-fwd-rev-wavelength?    boolean
      +-- allow-retuning?                 boolean
      +-- delta-power?                    10-types:power-ratio
    augment /te:tunnels-path-compute/te:input/te:path-compute-info
      /tepc:path-request/tepc:optimizations/tepc:algorithm
      /tepc:metric/tepc:optimization-metric
      /tepc:explicit-route-exclude-objects
      /tepc:route-object-exclude-object/tepc:type
      /tepc:numbered-node-hop:
        +-- path-in-transceiver
          | +-- transponder-id?    uint32
          | +-- transceivers* [lane-id]
          | | +-- lane-id          uint8
          | | +-- transceiver-id?  uint32
          | | +-- operational-modes* string
          | | +-- tx-tune-constraints
          | | | +-- min-central-frequency?    frequency-thz
          | | | +-- max-central-frequency?    frequency-thz

```

```

|         | +-- transceiver-tunability? frequency-ghz
|         | +-- line-coding-bitrate*      identityref
|         | +-- tx-channel-power?         10-types:power-dbm
|         | +-- preferred-rx-channel-power? 10-types:power-dbm
+-- path-out-transceiver
  +-- transponder-id? uint32
  +-- transceivers* [lane-id]
    +-- lane-id          uint8
    +-- transceiver-id?  uint32
    +-- operational-modes* string
    +-- tx-tune-constraints
      | +-- min-central-frequency? frequency-thz
      | +-- max-central-frequency? frequency-thz
      | +-- transceiver-tunability? frequency-ghz
    +-- line-coding-bitrate* identityref
    +-- tx-channel-power?     10-types:power-dbm
    +-- preferred-rx-channel-power? 10-types:power-dbm
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:path-request/tepc:optimizations/tepc:algorithm
  /tepc:metric/tepc:optimization-metric
  /tepc:explicit-route-exclude-objects
  /tepc:route-object-exclude-object/tepc:type:
+--:(oms-element)
  +-- oms-element-uid? string
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:path-request/tepc:optimizations/tepc:algorithm
  /tepc:metric/tepc:optimization-metric
  /tepc:explicit-route-include-objects
  /tepc:route-object-include-object/tepc:type
  /tepc:numbered-node-hop:
+-- path-in-transceiver
  +-- transponder-id? uint32
  +-- transceivers* [lane-id]
    +-- lane-id          uint8
    +-- transceiver-id?  uint32
    +-- operational-modes* string
    +-- tx-tune-constraints
      | +-- min-central-frequency? frequency-thz
      | +-- max-central-frequency? frequency-thz
      | +-- transceiver-tunability? frequency-ghz
    +-- line-coding-bitrate* identityref
    +-- tx-channel-power?     10-types:power-dbm
    +-- preferred-rx-channel-power? 10-types:power-dbm
+-- path-out-transceiver
  +-- transponder-id? uint32
  +-- transceivers* [lane-id]
    +-- lane-id          uint8
    +-- transceiver-id?  uint32

```

```

    +-- operational-modes*          string
    +-- tx-tune-constraints
    |   +-- min-central-frequency?  frequency-thz
    |   +-- max-central-frequency?  frequency-thz
    |   +-- transceiver-tunability? frequency-ghz
    +-- line-coding-bitrate*        identityref
    +-- tx-channel-power?           10-types:power-dbm
    +-- preferred-rx-channel-power?  10-types:power-dbm
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:optimizations/tepc:algorithm
    /tepc:metric/tepc:optimization-metric
    /tepc:explicit-route-include-objects
    /tepc:route-object-include-object/tepc:type:
+--:(oms-element)
    +-- oms-element-uid?  string
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:explicit-route-objects
    /tepc:route-object-exclude-always/tepc:type
    /tepc:numbered-node-hop:
+-- path-in-transceiver
|   +-- transponder-id?  uint32
|   +-- transceivers* [lane-id]
|   |   +-- lane-id          uint8
|   |   +-- transceiver-id?  uint32
|   |   +-- operational-modes* string
|   |   +-- tx-tune-constraints
|   |   |   +-- min-central-frequency?  frequency-thz
|   |   |   +-- max-central-frequency?  frequency-thz
|   |   |   +-- transceiver-tunability? frequency-ghz
|   |   +-- line-coding-bitrate*        identityref
|   |   +-- tx-channel-power?           10-types:power-dbm
|   |   +-- preferred-rx-channel-power?  10-types:power-dbm
+-- path-out-transceiver
    +-- transponder-id?  uint32
    +-- transceivers* [lane-id]
    |   +-- lane-id          uint8
    |   +-- transceiver-id?  uint32
    |   +-- operational-modes* string
    |   +-- tx-tune-constraints
    |   |   +-- min-central-frequency?  frequency-thz
    |   |   +-- max-central-frequency?  frequency-thz
    |   |   +-- transceiver-tunability? frequency-ghz
    |   +-- line-coding-bitrate*        identityref
    |   +-- tx-channel-power?           10-types:power-dbm
    |   +-- preferred-rx-channel-power?  10-types:power-dbm
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:explicit-route-objects
    /tepc:route-object-exclude-always/tepc:type:

```



```

+--:(oms-element)
  +-- oms-element-uid?  string
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:path-request/tepc:explicit-route-objects
  /tepc:route-object-include-exclude/tepc:type
  /tepc:numbered-node-hop:
+-- path-in-transceiver
|   +-- transponder-id?  uint32
|   +-- transceivers* [lane-id]
|       +-- lane-id                uint8
|       +-- transceiver-id?        uint32
|       +-- operational-modes*      string
|       +-- tx-tune-constraints
|           +-- min-central-frequency?  frequency-thz
|           +-- max-central-frequency?  frequency-thz
|           +-- transceiver-tunability? frequency-ghz
|       +-- line-coding-bitrate*      identityref
|       +-- tx-channel-power?         10-types:power-dbm
|       +-- preferred-rx-channel-power? 10-types:power-dbm
+-- path-out-transceiver
|   +-- transponder-id?  uint32
|   +-- transceivers* [lane-id]
|       +-- lane-id                uint8
|       +-- transceiver-id?        uint32
|       +-- operational-modes*      string
|       +-- tx-tune-constraints
|           +-- min-central-frequency?  frequency-thz
|           +-- max-central-frequency?  frequency-thz
|           +-- transceiver-tunability? frequency-ghz
|       +-- line-coding-bitrate*      identityref
|       +-- tx-channel-power?         10-types:power-dbm
|       +-- preferred-rx-channel-power? 10-types:power-dbm
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:path-request/tepc:explicit-route-objects
  /tepc:route-object-include-exclude/tepc:type:
+--:(oms-element)
  +-- oms-element-uid?  string
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:synchronization/tepc:exclude-objects/tepc:excludes
  /tepc:type/tepc:numbered-node-hop:
+-- path-in-transceiver
|   +-- transponder-id?  uint32
|   +-- transceivers* [lane-id]
|       +-- lane-id                uint8
|       +-- transceiver-id?        uint32
|       +-- operational-modes*      string
|       +-- tx-tune-constraints
|           +-- min-central-frequency?  frequency-thz

```

```

|         |   +-- max-central-frequency?      frequency-thz
|         |   +-- transceiver-tunability?    frequency-ghz
|         |   +-- line-coding-bitrate*       identityref
|         |   +-- tx-channel-power?          10-types:power-dbm
|         |   +-- preferred-rx-channel-power? 10-types:power-dbm
+-- path-out-transceiver
  +-- transponder-id?   uint32
  +-- transceivers* [lane-id]
    +-- lane-id                uint8
    +-- transceiver-id?       uint32
    +-- operational-modes*     string
    +-- tx-tune-constraints
      |   +-- min-central-frequency?      frequency-thz
      |   +-- max-central-frequency?      frequency-thz
      |   +-- transceiver-tunability?    frequency-ghz
      +-- line-coding-bitrate*       identityref
      +-- tx-channel-power?          10-types:power-dbm
      +-- preferred-rx-channel-power? 10-types:power-dbm
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:synchronization/tepc:exclude-objects/tepc:excludes
  /tepc:type:
  +--:(oms-element)
    +-- oms-element-uid?   string
augment /te:tunnels-path-compute/te:output/te:path-compute-result
  /tepc:response/tepc:computed-paths-properties
  /tepc:computed-path-properties/tepc:path-properties:
  +--ro estimated-gsnr?      snr
  +--ro estimated-eol-gsnr?  snr
  +--ro estimated-lowest-gsnr? snr
augment /te:tunnels-path-compute/te:output/te:path-compute-result
  /tepc:response/tepc:computed-paths-properties
  /tepc:computed-path-properties/tepc:path-properties
  /tepc:path-route-objects/tepc:path-route-object/tepc:type
  /tepc:numbered-node-hop:
+--ro path-in-transceiver
|   +--ro transponder-id?   uint32
|   +--ro transceivers* [lane-id]
|     +--ro lane-id                uint8
|     +--ro transceiver-id?       uint32
|     +--ro operational-modes*     string
|     +--ro tx-tune-constraints
|       |   +--ro min-central-frequency?      frequency-thz
|       |   +--ro max-central-frequency?      frequency-thz
|       |   +--ro transceiver-tunability?    frequency-ghz
|       +--ro line-coding-bitrate*       identityref
|       +--ro tx-channel-power?          10-types:power-dbm
|       +--ro preferred-rx-channel-power? 10-types:power-dbm
+--ro path-out-transceiver

```

```

    +--ro transponder-id?    uint32
    +--ro transceivers* [lane-id]
        +--ro lane-id                uint8
        +--ro transceiver-id?        uint32
        +--ro operational-modes*      string
        +--ro tx-tune-constraints
            | +--ro min-central-frequency?    frequency-thz
            | +--ro max-central-frequency?    frequency-thz
            | +--ro transceiver-tunability?    frequency-ghz
        +--ro line-coding-bitrate*      identityref
        +--ro tx-channel-power?          10-types:power-dbm
        +--ro preferred-rx-channel-power? 10-types:power-dbm
augment /te:tunnels-path-compute/te:output/te:path-compute-result
    /tepc:response/tepc:computed-paths-properties
    /tepc:computed-path-properties/tepc:path-properties
    /tepc:path-route-objects/tepc:path-route-object
    /tepc:type:
+--:(oms-element)
    +--ro oms-element-uid?    string
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:path-in-segment
    /tepc:label-restrictions/tepc:label-restriction:
+-- grid-type?    identityref
+-- priority?     uint8
+-- flexi-grid
    +-- slot-width-granularity?    identityref
    +-- min-slot-width-factor?     uint16
    +-- max-slot-width-factor?     uint16
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:path-out-segment
    /tepc:label-restrictions/tepc:label-restriction:
+-- grid-type?    identityref
+-- priority?     uint8
+-- flexi-grid
    +-- slot-width-granularity?    identityref
    +-- min-slot-width-factor?     uint16
    +-- max-slot-width-factor?     uint16
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:optimizations/tepc:algorithm
    /tepc:metric/tepc:optimization-metric
    /tepc:explicit-route-exclude-objects
    /tepc:route-object-exclude-object/tepc:type/tepc:label
    /tepc:label-hop/tepc:te-label/tepc:technology:
+--:(wdm)
    +-- (grid-type)?
        +--:(fixed-dwdm)
            | +-- (fixed-single-or-super-channel)?
            | +--:(single)

```

```

|         | +-- dwdm-n?                10-types:dwdm-n
|         +--:(multi)
|         +-- subcarrier-dwdm-n*      10-types:dwdm-n
+--:(cwdm)
| +-- cwdm-n?                10-types:cwdm-n
+--:(flexi-grid)
+-- (single-or-super-channel)?
+--:(single)
| +-- flexi-n?                10-types:flexi-n
| +-- flexi-m?                10-types:flexi-m
x--:(super)
| x-- subcarrier-flexi-n* [flexi-n]
|   +-- flexi-n      10-types:flexi-n
|   +-- flexi-m?    10-types:flexi-m
+--:(multi)
+-- frequency-slots
+-- frequency-slot* [flexi-n]
+-- flexi-n      10-types:flexi-n
+-- flexi-m?    10-types:flexi-m
augment /te:tunnels-path-compute/te:input/te:path-compute-info
/tepc:path-request/tepc:optimizations/tepc:algorithm
/tepc:metric/tepc:optimization-metric
/tepc:explicit-route-include-objects
/tepc:route-object-include-object/tepc:type/tepc:label
/tepc:label-hop/tepc:te-label/tepc:technology:
+--:(wdm)
+-- (grid-type)?
+--:(fixed-dwdm)
| +-- (fixed-single-or-super-channel)?
| +--:(single)
| | +-- dwdm-n?                10-types:dwdm-n
| +--:(multi)
| | +-- subcarrier-dwdm-n*      10-types:dwdm-n
+--:(cwdm)
| +-- cwdm-n?                10-types:cwdm-n
+--:(flexi-grid)
+-- (single-or-super-channel)?
+--:(single)
| +-- flexi-n?                10-types:flexi-n
| +-- flexi-m?                10-types:flexi-m
x--:(super)
| x-- subcarrier-flexi-n* [flexi-n]
|   +-- flexi-n      10-types:flexi-n
|   +-- flexi-m?    10-types:flexi-m
+--:(multi)
+-- frequency-slots
+-- frequency-slot* [flexi-n]
+-- flexi-n      10-types:flexi-n

```

```

        +-- flexi-m? 10-types:flexi-m
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:path-request/tepc:explicit-route-objects
  /tepc:route-object-exclude-always/tepc:type/tepc:label
  /tepc:label-hop/tepc:te-label/tepc:technology:
+--:(wdm)
  +-- (grid-type)?
    +--:(fixed-dwdm)
      | +-- (fixed-single-or-super-channel)?
      |   +--:(single)
      |     | +-- dwdm-n? 10-types:dwdm-n
      |     +--:(multi)
      |       +-- subcarrier-dwdm-n* 10-types:dwdm-n
    +--:(cwdm)
      | +-- cwdm-n? 10-types:cwdm-n
    +--:(flexi-grid)
      +-- (single-or-super-channel)?
        +--:(single)
          | +-- flexi-n? 10-types:flexi-n
          | +-- flexi-m? 10-types:flexi-m
        x--:(super)
          | x-- subcarrier-flexi-n* [flexi-n]
          |   +-- flexi-n 10-types:flexi-n
          |   +-- flexi-m? 10-types:flexi-m
        +--:(multi)
          +-- frequency-slots
            +-- frequency-slot* [flexi-n]
            +-- flexi-n 10-types:flexi-n
            +-- flexi-m? 10-types:flexi-m
augment /te:tunnels-path-compute/te:input/te:path-compute-info
  /tepc:path-request/tepc:explicit-route-objects
  /tepc:route-object-include-exclude/tepc:type/tepc:label
  /tepc:label-hop/tepc:te-label/tepc:technology:
+--:(wdm)
  +-- (grid-type)?
    +--:(fixed-dwdm)
      | +-- (fixed-single-or-super-channel)?
      |   +--:(single)
      |     | +-- dwdm-n? 10-types:dwdm-n
      |     +--:(multi)
      |       +-- subcarrier-dwdm-n* 10-types:dwdm-n
    +--:(cwdm)
      | +-- cwdm-n? 10-types:cwdm-n
    +--:(flexi-grid)
      +-- (single-or-super-channel)?
        +--:(single)
          | +-- flexi-n? 10-types:flexi-n
          | +-- flexi-m? 10-types:flexi-m

```

```

    x--:(super)
    |   x-- subcarrier-flexi-n* [flexi-n]
    |   +-- flexi-n      10-types:flexi-n
    |   +-- flexi-m?    10-types:flexi-m
    +--:(multi)
    +-- frequency-slots
    +-- frequency-slot* [flexi-n]
    +-- flexi-n      10-types:flexi-n
    +-- flexi-m?    10-types:flexi-m
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:path-in-segment
    /tepc:label-restrictions/tepc:label-restriction
    /tepc:label-start/tepc:te-label/tepc:technology:
+--:(wdm)
+-- (grid-type)?
+--:(fixed-dwdm)
|   +-- dwdm-n?    10-types:dwdm-n
+--:(cwdm)
|   +-- cwdm-n?    10-types:cwdm-n
+--:(flexi-grid)
+-- flexi-n?    10-types:flexi-n
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:path-in-segment
    /tepc:label-restrictions/tepc:label-restriction
    /tepc:label-end/tepc:te-label/tepc:technology:
+--:(wdm)
+-- (grid-type)?
+--:(fixed-dwdm)
|   +-- dwdm-n?    10-types:dwdm-n
+--:(cwdm)
|   +-- cwdm-n?    10-types:cwdm-n
+--:(flexi-grid)
+-- flexi-n?    10-types:flexi-n
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:path-in-segment
    /tepc:label-restrictions/tepc:label-restriction
    /tepc:label-step/tepc:technology:
+--:(wdm)
+-- (l0-grid-type)?
+--:(fixed-dwdm)
|   +-- wson-dwdm-channel-spacing?    identityref
+--:(cwdm)
|   +-- wson-cwdm-channel-spacing?    identityref
+--:(flexi-grid)
+-- flexi-grid-channel-spacing?    identityref
+-- flexi-ncfg?                    identityref
+-- flexi-n-step?                    uint8
augment /te:tunnels-path-compute/te:input/te:path-compute-info

```

```

    /tepc:path-request/tepc:path-out-segment
    /tepc:label-restrictions/tepc:label-restriction
    /tepc:label-start/tepc:te-label/tepc:technology:
+---:(wdm)
+--- (grid-type)?
+---:(fixed-dwdm)
|   +--- dwdm-n?      10-types:dwdm-n
+---:(cwdm)
|   +--- cwdm-n?      10-types:cwdm-n
+---:(flexi-grid)
+--- flexi-n?         10-types:flexi-n
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:path-out-segment
    /tepc:label-restrictions/tepc:label-restriction
    /tepc:label-end/tepc:te-label/tepc:technology:
+---:(wdm)
+--- (grid-type)?
+---:(fixed-dwdm)
|   +--- dwdm-n?      10-types:dwdm-n
+---:(cwdm)
|   +--- cwdm-n?      10-types:cwdm-n
+---:(flexi-grid)
+--- flexi-n?         10-types:flexi-n
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:path-request/tepc:path-out-segment
    /tepc:label-restrictions/tepc:label-restriction
    /tepc:label-step/tepc:technology:
+---:(wdm)
+--- (l0-grid-type)?
+---:(fixed-dwdm)
|   +--- wson-dwdm-channel-spacing?  identityref
+---:(cwdm)
|   +--- wson-cwdm-channel-spacing?  identityref
+---:(flexi-grid)
+--- flexi-grid-channel-spacing?     identityref
+--- flexi-ncfg?                     identityref
+--- flexi-n-step?                   uint8
augment /te:tunnels-path-compute/te:input/te:path-compute-info
    /tepc:synchronization/tepc:exclude-objects/tepc:excludes
    /tepc:type/tepc:label/tepc:label-hop/tepc:te-label
    /tepc:technology:
+---:(wdm)
+--- (grid-type)?
+---:(fixed-dwdm)
|   +--- (fixed-single-or-super-channel)?
|   +---:(single)
|   |   +--- dwdm-n?                  10-types:dwdm-n
|   +---:(multi)

```

```

|           +-- subcarrier-dwdm-n*      10-types:dwdm-n
+--:(cwdm)
|   +-- cwdm-n?                        10-types:cwdm-n
+--:(flexi-grid)
    +-- (single-or-super-channel)?
        +--:(single)
            |   +-- flexi-n?            10-types:flexi-n
            |   +-- flexi-m?            10-types:flexi-m
        x--:(super)
            |   x-- subcarrier-flexi-n* [flexi-n]
            |   |   +-- flexi-n      10-types:flexi-n
            |   |   +-- flexi-m?    10-types:flexi-m
        +--:(multi)
            +-- frequency-slots
                +-- frequency-slot* [flexi-n]
                    +-- flexi-n      10-types:flexi-n
                    +-- flexi-m?    10-types:flexi-m
augment /te:tunnels-path-compute/te:output/te:path-compute-result
    /tepc:response/tepc:computed-paths-properties
    /tepc:computed-path-properties/tepc:path-properties
    /tepc:path-route-objects/tepc:path-route-object/tepc:type
    /tepc:label/tepc:label-hop/tepc:te-label/tepc:technology:
+--:(wdm)
    +--ro (grid-type)?
        +--:(fixed-dwdm)
            |   +--ro (fixed-single-or-super-channel)?
            |   |   +--:(single)
            |   |   |   +--ro dwdm-n?      10-types:dwdm-n
            |   |   +--:(multi)
            |   |   |   +--ro subcarrier-dwdm-n* 10-types:dwdm-n
        +--:(cwdm)
            |   +--ro cwdm-n?            10-types:cwdm-n
        +--:(flexi-grid)
            +--ro (single-or-super-channel)?
                +--:(single)
                    |   +--ro flexi-n?      10-types:flexi-n
                    |   +--ro flexi-m?      10-types:flexi-m
                x--:(super)
                    |   x--ro subcarrier-flexi-n* [flexi-n]
                    |   |   +--ro flexi-n      10-types:flexi-n
                    |   |   +--ro flexi-m?    10-types:flexi-m
                +--:(multi)
                    +--ro frequency-slots
                        +--ro frequency-slot* [flexi-n]
                            +--ro flexi-n      10-types:flexi-n
                            +--ro flexi-m?    10-types:flexi-m

```

Figure 2: WDM path computation tree diagram

4. YANG Models for WDM Path Computation

```
<CODE BEGINS> file "ietf-wdm-path-computation@2024-02-29.yang"
module ietf-wdm-path-computation {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-wdm-path-computation";
  prefix "wdm-pc";

  import ietf-te-path-computation {
    prefix "tepc";
    reference
      "I-D.ietf-teas-yang-path-computation-22: Yang model
       for requesting Path Computation.";
  }

  import ietf-te {
    prefix "te";
    reference
      "I-D.ietf-teas-yang-te-36: A YANG Data Model for Traffic
       Engineering Tunnels and Interfaces.";
  }

  import ietf-layer0-types {
    prefix "l0-types";
    reference
      "I-D.ietf-ccamp-rfc9093-bis: A YANG Data Model for Layer 0
       Types.";
  }

  import ietf-wdm-tunnel {
    prefix "wdm-tnl";
    reference
      "I-D.ietf-wdm-tunnel: A YANG Data Model for WDM Tunnels.";
  }

  organization
    "IETF CCAMP Working Group";
  contact
    "WG Web:    <http://tools.ietf.org/wg/ccamp/>
     WG List:   <mailto:ccamp@ietf.org>

     Editor:    Aihua Guo
                <mailto:aihuaguo.ietf@gmail.com>

     Editor:    Italo Busi
                <mailto:italo.busi@huawei.com>
```

Editor: Sergio Belotti
<mailto:sergio.belotti@nokia.com>;

description

"This module defines a model for requesting
WDM Path Computation.

The model fully conforms to the Network Management
Datastore Architecture (NMDA).

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identified as authors of the code. All rights reserved.

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to the license terms contained in, the Revised BSD License
set forth in Section 4.c of the IETF Trust's Legal Provisions
Relating to IETF Documents
(<https://trustee.ietf.org/license-info>).

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

```
revision "2024-02-29" {
  description
    "Initial version.";
  reference
    "RFC XXXX: YANG Data Models for requesting Path Computation
    in Optical Networks.";
  // RFC Ed.: replace XXXX with actual RFC number, update date
  // information and remove this note
}

/*
 * Data nodes
 */

/*
 * Augment tunnel attributes
 */
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:tunnel-attributes" {
  description
    "Augment with WDM tunnel-specific constraints.";

  uses wdm-tnl:wdm-constraint;
}
```

```
/*
 * Augment path computation request
 */

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:optimizations/tepc:algorithm/"
  + "tepc:metric/tepc:optimization-metric/"
  + "tepc:explicit-route-exclude-objects/"
  + "tepc:route-object-exclude-object/tepc:type/"
  + "tepc:numbered-node-hop" {
  description
    "Augment with transceiver configurations.";

  uses wdm-tnl:path-transceiver-config;
}

//???
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:optimizations/tepc:algorithm/"
  + "tepc:metric/tepc:optimization-metric/"
  + "tepc:explicit-route-exclude-objects/"
  + "tepc:route-object-exclude-object/tepc:type" {
  description
    "Augment the route hop for the optimization of the explicit
    route objects excluded by the path computation of the requested
    path.";
  case oms-element {
    leaf oms-element-uid {
      type string;
      description
        "The unique id of the OMS element.";
    }
    description
      "The OMS element route hop type";
  }
}

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:optimizations/tepc:algorithm/"
  + "tepc:metric/tepc:optimization-metric/"
  + "tepc:explicit-route-include-objects/"
  + "tepc:route-object-include-object/tepc:type/"
  + "tepc:numbered-node-hop" {
  description
    "Augment with transceiver configurations.";

  uses wdm-tnl:path-transceiver-config;
}
```

```
//???
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:optimizations/tepc:algorithm/"
  + "tepc:metric/tepc:optimization-metric/"
  + "tepc:explicit-route-include-objects/"
  + "tepc:route-object-include-object/tepc:type" {
  description
    "Augment the route hop for the optimization of the explicit
    route objects included by the path computation of the requested
    path.";
  case oms-element {
    leaf oms-element-uid {
      type string;
      description
        "The unique id of the OMS element.";
    }
    description
      "The OMS element route hop type";
  }
}

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:explicit-route-objects/"
  + "tepc:route-object-exclude-always/tepc:type/"
  + "tepc:numbered-node-hop" {
  description
    "Augment with transceiver configurations.";

  uses wdm-tnl:path-transceiver-config;
}

//???
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:explicit-route-objects/"
  + "tepc:route-object-exclude-always/tepc:type" {
  description
    "Augment the route hop for the explicit route objects always
    excluded by the path computation of the requested path.";
  case oms-element {
    leaf oms-element-uid {
      type string;
      description
        "The unique id of the OMS element.";
    }
    description
      "The OMS element route hop type";
  }
}
```

```
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:explicit-route-objects/"
  + "tepc:route-object-include-exclude/tepc:type/"
  + "tepc:numbered-node-hop" {
  description
    "Augment with transceiver configurations.";

  uses wdm-tnl:path-transceiver-config;
}

//???
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:explicit-route-objects/"
  + "tepc:route-object-include-exclude/tepc:type" {
  description
    "Augment the route hop for the explicit route objects included
    or excluded by the path computation of the requested path.";
  case oms-element {
    leaf oms-element-uid {
      type string;
      description
        "The unique id of the OMS element.";
    }
    description
      "The OMS element route hop type";
  }
}

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:synchronization/tepc:exclude-objects/tepc:excludes/"
  + "tepc:type/tepc:numbered-node-hop" {
  description
    "Augment with transceiver configurations.";

  uses wdm-tnl:path-transceiver-config;
}

//???
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:synchronization/tepc:exclude-objects/tepc:excludes/"
  + "tepc:type" {
  description
    "Augment the route hop for the explicit route objects to always
    exclude from synchronized path computation.";
  case oms-element {
    leaf oms-element-uid {
      type string;
      description
```

```

        "The unique id of the OMS element.";
    }
    description
        "The OMS element route hop type";
    }
}

/*
 * Augment path computation response
 */

augment "/te:tunnels-path-compute/te:output/"
    + "te:path-compute-result/tepc:response/"
    + "tepc:computed-paths-properties/"
    + "tepc:computed-path-properties/tepc:path-properties" {
    description
        "Augment with additional properties for WDM paths.";

    uses l0-types:l0-path-properties;
}

augment "/te:tunnels-path-compute/te:output/"
    + "te:path-compute-result/tepc:response/"
    + "tepc:computed-paths-properties/"
    + "tepc:computed-path-properties/tepc:path-properties/"
    + "tepc:path-route-objects/tepc:path-route-object/"
    + "tepc:type/tepc:numbered-node-hop" {
    description
        "Augment with transceiver configurations.";

    uses wdm-tnl:path-transceiver-config;
}

//???
augment "/te:tunnels-path-compute/te:output/"
    + "te:path-compute-result/tepc:response/"
    + "tepc:computed-paths-properties/"
    + "tepc:computed-path-properties/tepc:path-properties/"
    + "tepc:path-route-objects/tepc:path-route-object/"
    + "tepc:type" {
    description
        "Augment the route hop for the route object of the computed
        path.";
    case oms-element {
        leaf oms-element-uid {
            type string;
            description

```

```
        "The unique id of the OMS element.";
    }
    description
        "The OMS element route hop type";
    }
}

/*
 * Augment TE label range information
 */

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
    + "tepc:path-request/tepc:path-in-segment/"
    + "tepc:label-restrictions/tepc:label-restriction" {
    description
        "Augment TE label range information for the ingress segment
        of the requested path.";
    uses l0-types:wdm-label-range-info;
}

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
    + "tepc:path-request/tepc:path-out-segment/"
    + "tepc:label-restrictions/tepc:label-restriction" {
    description
        "Augment TE label range information for the egress segment
        of the requested path.";
    uses l0-types:wdm-label-range-info;
}

/*
 * Augment TE label.
 */

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
    + "tepc:path-request/tepc:optimizations/tepc:algorithm/"
    + "tepc:metric/tepc:optimization-metric/"
    + "tepc:explicit-route-exclude-objects/"
    + "tepc:route-object-exclude-object/tepc:type/tepc:label/"
    + "tepc:label-hop/tepc:te-label/tepc:technology" {
    description
        "Augment TE label hop for the optimization of the explicit
        route objects excluded by the path computation of the requested
        path.";
    case wdm {
        uses l0-types:wdm-label-hop;
    }
}
```

```
augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:optimizations/tepc:algorithm/"
  + "tepc:metric/tepc:optimization-metric/"
  + "tepc:explicit-route-include-objects/"
  + "tepc:route-object-include-object/tepc:type/tepc:label/"
  + "tepc:label-hop/tepc:te-label/tepc:technology" {
  description
    "Augment TE label hop for the optimization of the explicit
    route objects included by the path computation of the requested
    path.";
  case wdm {
    uses l0-types:wdm-label-hop;
  }
}

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:explicit-route-objects/"
  + "tepc:route-object-exclude-always/tepc:type/tepc:label/"
  + "tepc:label-hop/tepc:te-label/tepc:technology" {
  description
    "Augment TE label hop for the explicit route objects always
    excluded by the path computation of the requested path.";
  case wdm {
    uses l0-types:wdm-label-hop;
  }
}

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:explicit-route-objects/"
  + "tepc:route-object-include-exclude/tepc:type/tepc:label/"
  + "tepc:label-hop/tepc:te-label/tepc:technology" {
  description
    "Augment TE label hop for the explicit route objects included
    or excluded by the path computation of the requested path.";
  case wdm {
    uses l0-types:wdm-label-hop;
  }
}

augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
  + "tepc:path-request/tepc:path-in-segment/"
  + "tepc:label-restrictions/tepc:label-restriction/"
  + "tepc:label-start/tepc:te-label/tepc:technology" {
  description
    "Augment TE label range start for the ingress segment
    of the requested path.";
  case wdm {
    uses l0-types:wdm-label-start-end;
```



```
    }  
  }  
  
  augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"  
    + "tepc:path-request/tepc:path-in-segment/"  
    + "tepc:label-restrictions/tepc:label-restriction/"  
    + "tepc:label-end/tepc:te-label/tepc:technology" {  
    description  
      "Augment TE label range end for the ingress segment  
      of the requested path.";  
    case wdm {  
      uses l0-types:wdm-label-start-end;  
    }  
  }  
  
  augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"  
    + "tepc:path-request/tepc:path-in-segment/"  
    + "tepc:label-restrictions/tepc:label-restriction/"  
    + "tepc:label-step/tepc:technology" {  
    description  
      "Augment TE label range step for the ingress segment  
      of the requested path.";  
    case wdm {  
      uses l0-types:wdm-label-step;  
    }  
  }  
  
  augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"  
    + "tepc:path-request/tepc:path-out-segment/"  
    + "tepc:label-restrictions/tepc:label-restriction/"  
    + "tepc:label-start/tepc:te-label/tepc:technology" {  
    description  
      "Augment TE label range start for the egress segment  
      of the requested path.";  
    case wdm {  
      uses l0-types:wdm-label-start-end;  
    }  
  }  
  
  augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"  
    + "tepc:path-request/tepc:path-out-segment/"  
    + "tepc:label-restrictions/tepc:label-restriction/"  
    + "tepc:label-end/tepc:te-label/tepc:technology" {  
    description  
      "Augment TE label range end for the egress segment  
      of the requested path.";  
    case wdm {  
      uses l0-types:wdm-label-start-end;  
    }  
  }
```

```

    }
  }

  augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
    + "tepc:path-request/tepc:path-out-segment/"
    + "tepc:label-restrictions/tepc:label-restriction/"
    + "tepc:label-step/tepc:technology" {
    description
      "Augment TE label range end for the egress segment
      of the requested path.";
    case wdm {
      uses l0-types:wdm-label-step;
    }
  }

  augment "/te:tunnels-path-compute/te:input/te:path-compute-info/"
    + "tepc:synchronization/tepc:exclude-objects/tepc:excludes/"
    + "tepc:type/tepc:label/tepc:label-hop/"
    + "tepc:te-label/tepc:technology" {
    description
      "Augment TE label hop for the explicit route objects to always
      exclude from synchronized path computation.";
    case wdm {
      uses l0-types:wdm-label-hop;
    }
  }

  augment "/te:tunnels-path-compute/te:output/"
    + "te:path-compute-result/tepc:response/"
    + "tepc:computed-paths-properties/"
    + "tepc:computed-path-properties/tepc:path-properties/"
    + "tepc:path-route-objects/tepc:path-route-object/"
    + "tepc:type/tepc:label/"
    + "tepc:label-hop/tepc:te-label/tepc:technology" {
    description
      "Augment TE label hop for the route object of the computed
      path.";
    case wdm {
      uses l0-types:wdm-label-hop;
    }
  }
}
<CODE ENDS>

```

Figure 3: WDM path computation YANG module

5. Manageability Considerations

This document provides a method for requesting path computations for WSON and Flexi-Grid tunnels. Consideration of mechanisms to gather and collate information required for the path computations will be necessary. Furthermore, storing path computation requests and responses and triggering actions will also need to be carefully managed and secured.

Future versions of this document will contain additional information.

6. Security Considerations

The YANG module defined in this document will be accessed via the NETCONF protocol [RFC6241] or RESTCONF protocol [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 to particular NETCONF or RESTCONF users to a pre-configured subset of all available NETCONF or RESTCONF protocol operations and content.

Some of the RPC operations defined in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus essential to control access to these operations.

Operations defined in this document, and their sensitivities and possible vulnerabilities, will be discussed further in future versions of this document.

7. IANA Considerations

This document registers the following URIs in the "ns" subregistry within the "IETF XML registry" [RFC3688].

URI: urn:ietf:params:xml:ns:yang:ietf-wdm-path-computation
Registrant Contact: The IESG.
XML: N/A, the requested URI is an XML namespace.

This document registers the following YANG module in the "YANG Module Names" registry [RFC7950].

```
name:      ietf-wdm-path-computation
namespace: urn:ietf:params:xml:ns:yang:ietf-wson-path-computation
prefix:    wdm-pc
reference:  this document
```

8. References

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8.2. Informative References

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Appendix A. Change Log

The initial YANG data model requesting path computation in optical networks was draft-gbb-ccamp-optical-path-computation-yang-00. This document included path computation request capabilities for WSON, Flexi-Grid and OTN technologies. However, it was proposed at IETF 113 (March 25, 2022) to split the initial document into separate documents for WDM (WSON and Flexi-Grid) and OTN technologies, as each technology may be developed and implemented separately.

The WDM technology capabilities were kept in this document, and the OTN capabilities were moved into [I-D.draft-gbb-ccamp-otn-path-computation-yang].

Editors note, please remove this appendix before publication.

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