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A YANG Data Model for Flexi-Grid Tunnels
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Abstract

This document defines a YANG model for managing flexi-grid optical tunnels (media-channels), complementing the information provided by the flexi-grid topology model.

The YANG data model defined in this document conforms to the Network Management Datastore Architecture (NMDA).

Status of This Memo

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Internet-Draft

Flexi-Grid YANG

July 2022

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[1.](#) Introduction

Transport networks are evolving from current DWDM systems towards elastic optical networks, based on flexi-grid transmission and switching technologies [[RFC7698](#)]. Such technology aims at increasing both transport network scalability and flexibility, allowing the optimization of bandwidth usage.

While [[I-D.ietf-ccamp-flexigrid-yang](#)] focuses on flexi-grid objects such as nodes, transponders and links, this document presents a YANG [[RFC7950](#)] model for the flexi-grid tunnel (media-channel). This YANG

module defines the whole path from a source transponder or node to the destination through a number of intermediate nodes in the flexi-grid network.

This document identifies the flexi-grid tunne components, parameters and their values, characterizes the features and the performances of the flexi-grid elements. An application example is provided towards the end of the document to better understand their utility.

2. Terminology

Refer to [[RFC7446](#)] and [[RFC7699](#)] 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](#)].

3. Flexi-Grid Tunnel Overview

The present model defines a flexi-grid tunnel mainly composed of:

- * source address
- * source flexi-grid port
- * source flexi-grid transponder
- * destination address
- * destination flexi-grid port
- * destination flexi-grid transponder

- * list of links that defines the path
- * other optical attributes

Each path can be a tunnel (only defined by source and destination node) or a network tunnel (additionally needs source and destination transponders). Therefore, all the attributes are optional to support both situations.

This is achieved by a combination of the traffic engineering tunnel attributes explained in [[I-D.ietf-teas-yang-te](#)] and augments when necessary. For instance, source address, source flexi-grid transponder, destination address and destination flexi-grid transponder attributes are directly taken from tunnel, whereas other attributes such as source flexi-grid port, destination flexi-grid port are defined, as they are specific for flexi-grid.

[4.](#) Example of Use

In order to explain how this model is used, the following example is provided. An optical network usually has multiple transponders, switches (nodes) and links. Figure 1 shows a simple topology, where two physical paths interconnect two optical transponders.

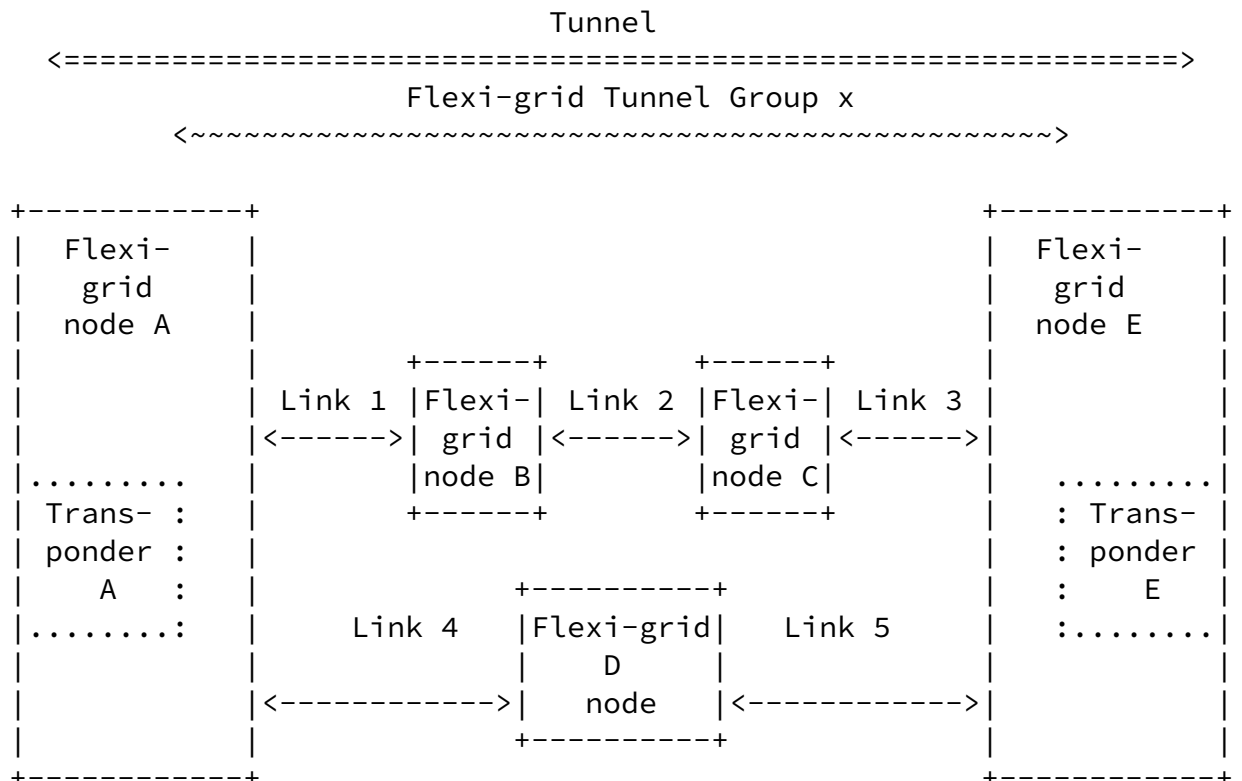


Figure 1: Topology Example

To configure a network tunnel to interconnect transponders A and E, first of all we have to populate the flexi-grid topology YANG model with all elements in the network:

- * We define the transponders within nodes A and E as tunnel termination points (TTPs) and provide their internal local link connectivity towards the node interfaces. We also provide nodes A and B identifiers, addresses and interfaces.
- * We do the same for the nodes B, C and D, providing their identifiers, addresses and interfaces, as well as the internal connectivity matrix between interfaces.
- * Then, we also define the links 1 to 5 that interconnect nodes, indicating which flexi-grid labels are available.
- * Other information, such as the slot frequency and granularity are also provided.

After the nodes, links and transponders have been defined using [[I-D.ietf-ccamp-flexigrid-yang](#)] we can configure the tunnel from the information we have stored in the flexi-grid topology, by querying which elements are available, and planning the resources that have to be provided on each situation. Note that every element in the flexi-grid topology has a reference, and this is the way in which they are called in the tunnel.

- * Depending on the case, it is possible to define either the source and destination node ports, or the source and destination node and transponder. In our case, we would define a network tunnel, with source transponder A and source node B, and destination transponder E and destination node C. Thus, we are going to follow path x.

- * Then, for each link in the path x , we indicate which channel we are going to use, providing information about the slots, and what nodes are connected.
- * Finally, the flexi-grid topology has to be updated with each element usage status each time a tunnel is created or torn down.

5. YANG Model for Flexi-Grid Tunnel

5.1. YANG Tree

```

module: ietf-flexi-grid-tunnel

augment /te:te/te:tunnels/te:tunnel:
  +--rw fec-type?          identityref
  +--rw termination-type? identityref
  +--rw bit-stuffing?      boolean
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-in-segment
  /te:label-restrictions/te:label-restriction:
  +--rw grid-type?      identityref
  +--rw priority?      uint8
  +--rw flexi-grid
    +--rw slot-width-granularity? identityref
    +--rw min-slot-width-factor?  uint16
    +--rw max-slot-width-factor?  uint16
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-out-segment
  /te:label-restrictions/te:label-restriction:
  +--rw grid-type?      identityref
  +--rw priority?      uint8
  +--rw flexi-grid
    +--rw slot-width-granularity? identityref

```

```

  +--rw min-slot-width-factor?  uint16
  +--rw max-slot-width-factor?  uint16
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
  /te:primary-path/te:path-in-segment/te:label-restrictions
  /te:label-restriction:
  +--rw grid-type?      identityref
  +--rw priority?      uint8
  +--rw flexi-grid

```

```

    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?    uint16
    +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
    /te:primary-path/te:path-out-segment
    /te:label-restrictions/te:label-restriction:
+--rw grid-type?      identityref
+--rw priority?       uint8
+--rw flexi-grid
    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?    uint16
    +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
    /te:primary-path/te:primary-reverse-path
    /te:path-in-segment/te:label-restrictions
    /te:label-restriction:
+--rw grid-type?      identityref
+--rw priority?       uint8
+--rw flexi-grid
    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?    uint16
    +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
    /te:primary-path/te:primary-reverse-path
    /te:path-out-segment/te:label-restrictions
    /te:label-restriction:
+--rw grid-type?      identityref
+--rw priority?       uint8
+--rw flexi-grid
    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?    uint16
    +--rw max-slot-width-factor?    uint16
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:path-in-segment
    /te:label-restrictions/te:label-restriction:
+--rw grid-type?      identityref
+--rw priority?       uint8
+--rw flexi-grid
    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?    uint16

```



```

augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:path-out-segment
    /te:label-restrictions/te:label-restriction:
+--rw grid-type?      identityref
+--rw priority?      uint8
+--rw flexi-grid
    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?   uint16
    +--rw max-slot-width-factor?   uint16
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
    /te:secondary-reverse-path/te:path-in-segment
    /te:label-restrictions/te:label-restriction:
+--rw grid-type?      identityref
+--rw priority?      uint8
+--rw flexi-grid
    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?   uint16
    +--rw max-slot-width-factor?   uint16
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
    /te:secondary-reverse-path/te:path-out-segment
    /te:label-restrictions/te:label-restriction:
+--rw grid-type?      identityref
+--rw priority?      uint8
+--rw flexi-grid
    +--rw slot-width-granularity?  identityref
    +--rw min-slot-width-factor?   uint16
    +--rw max-slot-width-factor?   uint16
augment /te:te/te:globals/te:named-path-constraints
    /te:named-path-constraint
    /te:explicit-route-objects-always
    /te:route-object-exclude-always/te:type/te:label
    /te:label-hop/te:te-label/te:technology:
+--:(flexi-grid)
    +--rw (single-or-super-channel)?
        +--:(single)
        |   +--rw flexi-n?          l0-types:flexi-n
        |   +--rw flexi-m?          l0-types:flexi-m
        +--:(super)
            +--rw subcarrier-flexi-n* [flexi-n]
                +--rw flexi-n      l0-types:flexi-n
                +--rw flexi-m?     l0-types:flexi-m
augment /te:te/te:globals/te:named-path-constraints
    /te:named-path-constraint
    /te:explicit-route-objects-always
    /te:route-object-include-exclude/te:type/te:label
    /te:label-hop/te:te-label/te:technology:
+--:(flexi-grid)

```

```

    +--rw (single-or-super-channel)?
      +--:(single)
        | +--rw flexi-n?          l0-types:flexi-n
        | +--rw flexi-m?          l0-types:flexi-m
      +--:(super)
        +--rw subcarrier-flexi-n* [flexi-n]
          +--rw flexi-n          l0-types:flexi-n
          +--rw flexi-m?         l0-types:flexi-m
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-in-segment
  /te:label-restrictions/te:label-restriction
  /te:label-start/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-in-segment
  /te:label-restrictions/te:label-restriction/te:label-end
  /te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-in-segment
  /te:label-restrictions/te:label-restriction/te:label-step
  /te:technology:
+--:(flexi-grid)
  +--rw flexi-grid-channel-spacing?  identityref
  +--rw flexi-n-step?                 uint8
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-out-segment
  /te:label-restrictions/te:label-restriction
  /te:label-start/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-out-segment
  /te:label-restrictions/te:label-restriction/te:label-end
  /te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:globals/te:named-path-constraints
  /te:named-path-constraint/te:path-out-segment
  /te:label-restrictions/te:label-restriction/te:label-step
  /te:technology:
+--:(flexi-grid)
  +--rw flexi-grid-channel-spacing?  identityref
  +--rw flexi-n-step?                 uint8

```

```
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:optimizations/te:algorithm/te:metric
```

```
        /te:optimization-metric/te:explicit-route-exclude-objects
        /te:route-object-exclude-object/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +--rw (single-or-super-channel)?
    +---:(single)
      | +--rw flexi-n?          l0-types:flexi-n
      | +--rw flexi-m?          l0-types:flexi-m
    +---:(super)
      +--rw subcarrier-flexi-n* [flexi-n]
        +--rw flexi-n          l0-types:flexi-n
        +--rw flexi-m?         l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:optimizations/te:algorithm/te:metric
        /te:optimization-metric/te:explicit-route-include-objects
        /te:route-object-include-object/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +--rw (single-or-super-channel)?
    +---:(single)
      | +--rw flexi-n?          l0-types:flexi-n
      | +--rw flexi-m?          l0-types:flexi-m
    +---:(super)
      +--rw subcarrier-flexi-n* [flexi-n]
        +--rw flexi-n          l0-types:flexi-n
        +--rw flexi-m?         l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:explicit-route-objects-always
        /te:route-object-exclude-always/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +--rw (single-or-super-channel)?
    +---:(single)
      | +--rw flexi-n?          l0-types:flexi-n
      | +--rw flexi-m?          l0-types:flexi-m
    +---:(super)
      +--rw subcarrier-flexi-n* [flexi-n]
        +--rw flexi-n          l0-types:flexi-n
        +--rw flexi-m?         l0-types:flexi-m
```

```

augment /te:te/te:tunnels/te:tunnel/te:primary-paths
  /te:primary-path/te:explicit-route-objects-always
  /te:route-object-include-exclude/te:type/te:label
  /te:label-hop/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw (single-or-super-channel)?
    +--:(single)
    |   +--rw flexi-n?           l0-types:flexi-n
    |   +--rw flexi-m?           l0-types:flexi-m

```

```

+--:(super)
  +--rw subcarrier-flexi-n* [flexi-n]
    +--rw flexi-n           l0-types:flexi-n
    +--rw flexi-m?         l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
  /te:primary-path/te:path-in-segment/te:label-restrictions
  /te:label-restriction/te:label-start/te:te-label
  /te:technology:
+--:(flexi-grid)
  +--rw flexi-n?           l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
  /te:primary-path/te:path-in-segment/te:label-restrictions
  /te:label-restriction/te:label-end/te:te-label
  /te:technology:
+--:(flexi-grid)
  +--rw flexi-n?           l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
  /te:primary-path/te:path-in-segment/te:label-restrictions
  /te:label-restriction/te:label-step/te:technology:
+--:(flexi-grid)
  +--rw flexi-grid-channel-spacing?  identityref
  +--rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
  /te:primary-path/te:path-out-segment
  /te:label-restrictions/te:label-restriction
  /te:label-start/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?           l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
  /te:primary-path/te:path-out-segment
  /te:label-restrictions/te:label-restriction/te:label-end
  /te:te-label/te:technology:

```

```

+---:(flexi-grid)
  +---rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:path-out-segment
        /te:label-restrictions/te:label-restriction/te:label-step
        /te:technology:
+---:(flexi-grid)
  +---rw flexi-grid-channel-spacing?  identityref
  +---rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:computed-paths-properties
        /te:computed-path-properties/te:path-properties
        /te:path-route-objects/te:path-route-object/te:type
        /te:label/te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +---ro (single-or-super-channel)?

```

```

+---:(single)
| +---ro flexi-n?          l0-types:flexi-n
| +---ro flexi-m?          l0-types:flexi-m
+---:(super)
  +---ro subcarrier-flexi-n* [flexi-n]
  +---ro flexi-n    l0-types:flexi-n
  +---ro flexi-m?  l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path/te:optimizations
        /te:algorithm/te:metric/te:optimization-metric
        /te:explicit-route-exclude-objects
        /te:route-object-exclude-object/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +---rw (single-or-super-channel)?
  +---:(single)
  | +---rw flexi-n?          l0-types:flexi-n
  | +---rw flexi-m?          l0-types:flexi-m
  +---:(super)
  +---rw subcarrier-flexi-n* [flexi-n]
  +---rw flexi-n    l0-types:flexi-n
  +---rw flexi-m?  l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path/te:optimizations
        /te:algorithm/te:metric/te:optimization-metric

```

```

        /te:explicit-route-include-objects
        /te:route-object-include-object/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +---rw (single-or-super-channel)?
  +---:(single)
  |   +---rw flexi-n?           l0-types:flexi-n
  |   +---rw flexi-m?           l0-types:flexi-m
  +---:(super)
  +---rw subcarrier-flexi-n* [flexi-n]
  +---rw flexi-n      l0-types:flexi-n
  +---rw flexi-m?    l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path
        /te:explicit-route-objects-always
        /te:route-object-exclude-always/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +---rw (single-or-super-channel)?
  +---:(single)
  |   +---rw flexi-n?           l0-types:flexi-n
  |   +---rw flexi-m?           l0-types:flexi-m
  +---:(super)

```

```

  +---rw subcarrier-flexi-n* [flexi-n]
  +---rw flexi-n      l0-types:flexi-n
  +---rw flexi-m?    l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path
        /te:explicit-route-objects-always
        /te:route-object-include-exclude/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
  +---rw (single-or-super-channel)?
  +---:(single)
  |   +---rw flexi-n?           l0-types:flexi-n
  |   +---rw flexi-m?           l0-types:flexi-m
  +---:(super)
  +---rw subcarrier-flexi-n* [flexi-n]
  +---rw flexi-n      l0-types:flexi-n
  +---rw flexi-m?    l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:primary-paths

```

```

        /te:primary-path/te:primary-reverse-path
        /te:path-in-segment/te:label-restrictions
        /te:label-restriction/te:label-start/te:te-label
        /te:technology:
+---:(flexi-grid)
    +--rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path
        /te:path-in-segment/te:label-restrictions
        /te:label-restriction/te:label-end/te:te-label
        /te:technology:
+---:(flexi-grid)
    +--rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path
        /te:path-in-segment/te:label-restrictions
        /te:label-restriction/te:label-step/te:technology:
+---:(flexi-grid)
    +--rw flexi-grid-channel-spacing?  identityref
    +--rw flexi-n-step?                uint8
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path
        /te:path-out-segment/te:label-restrictions
        /te:label-restriction/te:label-start/te:te-label
        /te:technology:
+---:(flexi-grid)
    +--rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path
        /te:path-out-segment/te:label-restrictions

```

```

        /te:label-restriction/te:label-end/te:te-label
        /te:technology:
+---:(flexi-grid)
    +--rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:primary-paths
        /te:primary-path/te:primary-reverse-path
        /te:path-out-segment/te:label-restrictions
        /te:label-restriction/te:label-step/te:technology:
+---:(flexi-grid)
    +--rw flexi-grid-channel-spacing?  identityref
    +--rw flexi-n-step?                uint8

```

```

augment /te:te/te:tunnels/te:tunnel/te:primary-paths
    /te:primary-path/te:primary-reverse-path
    /te:computed-paths-properties/te:computed-path-properties
    /te:path-properties/te:path-route-objects
    /te:path-route-object/te:type/te:label/te:label-hop
    /te:te-label/te:technology:
+---:(flexi-grid)
    +---ro (single-or-super-channel)?
        +---:(single)
            | +---ro flexi-n?          l0-types:flexi-n
            | +---ro flexi-m?          l0-types:flexi-m
        +---:(super)
            +---ro subcarrier-flexi-n* [flexi-n]
                +---ro flexi-n      l0-types:flexi-n
                +---ro flexi-m?     l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:optimizations/te:algorithm
    /te:metric/te:optimization-metric
    /te:explicit-route-exclude-objects
    /te:route-object-exclude-object/te:type/te:label
    /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
    +---rw (single-or-super-channel)?
        +---:(single)
            | +---rw flexi-n?          l0-types:flexi-n
            | +---rw flexi-m?          l0-types:flexi-m
        +---:(super)
            +---rw subcarrier-flexi-n* [flexi-n]
                +---rw flexi-n      l0-types:flexi-n
                +---rw flexi-m?     l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:optimizations/te:algorithm
    /te:metric/te:optimization-metric
    /te:explicit-route-include-objects
    /te:route-object-include-object/te:type/te:label
    /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)

```

```

+---rw (single-or-super-channel)?
    +---:(single)
        | +---rw flexi-n?          l0-types:flexi-n
        | +---rw flexi-m?          l0-types:flexi-m

```



```

    +---:(super)
        +---rw subcarrier-flexi-n* [flexi-n]
            +---rw flexi-n      l0-types:flexi-n
            +---rw flexi-m?    l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:explicit-route-objects-always
    /te:route-object-exclude-always/te:type/te:label
    /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
    +---rw (single-or-super-channel)?
        +---:(single)
            | +---rw flexi-n?          l0-types:flexi-n
            | +---rw flexi-m?          l0-types:flexi-m
        +---:(super)
            +---rw subcarrier-flexi-n* [flexi-n]
                +---rw flexi-n      l0-types:flexi-n
                +---rw flexi-m?    l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:explicit-route-objects-always
    /te:route-object-include-exclude/te:type/te:label
    /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
    +---rw (single-or-super-channel)?
        +---:(single)
            | +---rw flexi-n?          l0-types:flexi-n
            | +---rw flexi-m?          l0-types:flexi-m
        +---:(super)
            +---rw subcarrier-flexi-n* [flexi-n]
                +---rw flexi-n      l0-types:flexi-n
                +---rw flexi-m?    l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:path-in-segment
    /te:label-restrictions/te:label-restriction
    /te:label-start/te:te-label/te:technology:
+---:(flexi-grid)
    +---rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:path-in-segment
    /te:label-restrictions/te:label-restriction/te:label-end
    /te:te-label/te:technology:
+---:(flexi-grid)
    +---rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
    /te:secondary-path/te:path-in-segment

```

```

        /te:label-restrictions/te:label-restriction/te:label-step
        /te:technology:
+---:(flexi-grid)
    +---rw flexi-grid-channel-spacing?  identityref
    +---rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
        /te:secondary-path/te:path-out-segment
        /te:label-restrictions/te:label-restriction
        /te:label-start/te:te-label/te:technology:
+---:(flexi-grid)
    +---rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
        /te:secondary-path/te:path-out-segment
        /te:label-restrictions/te:label-restriction/te:label-end
        /te:te-label/te:technology:
+---:(flexi-grid)
    +---rw flexi-n?    l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
        /te:secondary-path/te:path-out-segment
        /te:label-restrictions/te:label-restriction/te:label-step
        /te:technology:
+---:(flexi-grid)
    +---rw flexi-grid-channel-spacing?  identityref
    +---rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
        /te:secondary-path/te:computed-paths-properties
        /te:computed-path-properties/te:path-properties
        /te:path-route-objects/te:path-route-object/te:type
        /te:label/te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
    +---ro (single-or-super-channel)?
        +---:(single)
            | +---ro flexi-n?           l0-types:flexi-n
            | +---ro flexi-m?           l0-types:flexi-m
        +---:(super)
            +---ro subcarrier-flexi-n* [flexi-n]
                +---ro flexi-n    l0-types:flexi-n
                +---ro flexi-m?   l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
        /te:secondary-reverse-path/te:optimizations/te:algorithm
        /te:metric/te:optimization-metric
        /te:explicit-route-exclude-objects
        /te:route-object-exclude-object/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
    +---rw (single-or-super-channel)?
        +---:(single)

```

| +--rw flexi-n? l0-types:flexi-n

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```

    | +--rw flexi-m?          l0-types:flexi-m
  +--:(super)
    +--rw subcarrier-flexi-n* [flexi-n]
      +--rw flexi-n          l0-types:flexi-n
      +--rw flexi-m?        l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path/te:optimizations/te:algorithm
  /te:metric/te:optimization-metric
  /te:explicit-route-include-objects
  /te:route-object-include-object/te:type/te:label
  /te:label-hop/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw (single-or-super-channel)?
    +--:(single)
      | +--rw flexi-n?          l0-types:flexi-n
      | +--rw flexi-m?          l0-types:flexi-m
    +--:(super)
      +--rw subcarrier-flexi-n* [flexi-n]
        +--rw flexi-n          l0-types:flexi-n
        +--rw flexi-m?        l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path
  /te:explicit-route-objects-always
  /te:route-object-exclude-always/te:type/te:label
  /te:label-hop/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw (single-or-super-channel)?
    +--:(single)
      | +--rw flexi-n?          l0-types:flexi-n
      | +--rw flexi-m?          l0-types:flexi-m
    +--:(super)
      +--rw subcarrier-flexi-n* [flexi-n]
        +--rw flexi-n          l0-types:flexi-n
        +--rw flexi-m?        l0-types:flexi-m
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path
  /te:explicit-route-objects-always
  /te:route-object-include-exclude/te:type/te:label
  /te:label-hop/te:te-label/te:technology:
+--:(flexi-grid)
```

```

+--rw (single-or-super-channel)?
  +--:(single)
  | +--rw flexi-n?          l0-types:flexi-n
  | +--rw flexi-m?          l0-types:flexi-m
  +--:(super)
    +--rw subcarrier-flexi-n* [flexi-n]
      +--rw flexi-n          l0-types:flexi-n
      +--rw flexi-m?         l0-types:flexi-m

```

```

augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path/te:path-in-segment
  /te:label-restrictions/te:label-restriction
  /te:label-start/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path/te:path-in-segment
  /te:label-restrictions/te:label-restriction/te:label-end
  /te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path/te:path-in-segment
  /te:label-restrictions/te:label-restriction/te:label-step
  /te:technology:
+--:(flexi-grid)
  +--rw flexi-grid-channel-spacing?  identityref
  +--rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path/te:path-out-segment
  /te:label-restrictions/te:label-restriction
  /te:label-start/te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path/te:path-out-segment
  /te:label-restrictions/te:label-restriction/te:label-end
  /te:te-label/te:technology:
+--:(flexi-grid)
  +--rw flexi-n?          l0-types:flexi-n
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
  /te:secondary-reverse-path/te:path-out-segment

```

```

        /te:label-restrictions/te:label-restriction/te:label-step
        /te:technology:
+---:(flexi-grid)
    +--rw flexi-grid-channel-spacing?  identityref
    +--rw flexi-n-step?                 uint8
augment /te:te/te:tunnels/te:tunnel/te:secondary-reverse-paths
        /te:secondary-reverse-path/te:computed-paths-properties
        /te:computed-path-properties/te:path-properties
        /te:path-route-objects/te:path-route-object/te:type
        /te:label/te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
    +--ro (single-or-super-channel)?
        +---:(single)
        | +--ro flexi-n?                l0-types:flexi-n
        | +--ro flexi-m?                l0-types:flexi-m

```

```

+---:(super)
    +--ro subcarrier-flexi-n* [flexi-n]
        +--ro flexi-n        l0-types:flexi-n
        +--ro flexi-m?      l0-types:flexi-m
augment /te:te/te:lsp/te:lsp/te:lsp-record-route-information
        /te:lsp-record-route-information/te:type/te:label
        /te:label-hop/te:te-label/te:technology:
+---:(flexi-grid)
    +--ro (single-or-super-channel)?
        +---:(single)
        | +--ro flexi-n?                l0-types:flexi-n
        | +--ro flexi-m?                l0-types:flexi-m
        +---:(super)
        +--ro subcarrier-flexi-n* [flexi-n]
            +--ro flexi-n        l0-types:flexi-n
            +--ro flexi-m?      l0-types:flexi-m

```

5.2. YANG Code

```

<CODE BEGINS> file "ietf-flexi-grid-tunnel@2022-07-11.yang"
module ietf-flexi-grid-tunnel {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-flexi-grid-tunnel";

```

```
prefix "flexg-tnl";

import ietf-te {
  prefix "te";
  revision-date "2022-07-11";
  reference
    "I-D.ietf-teas-yang-te-19: A YANG Data Model for Traffic
    Engineering Tunnels and Interfaces. ";
}

import ietf-layer0-types {
  prefix "l0-types";
}

import ietf-layer0-types-ext {
  prefix "l0-types-ext";
}

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

```
WG List:  <mailto:ccamp@ietf.org>
Editor:   Jorge E. Lopez de Vergara
          <jorge.lopez_vergara@uam.es>
Editor:   Daniel Perdices
          <daniel.perdices@naudit.es>
Editor:   Victor Lopez
          <victor.lopez@nokia.com>
Editor:   Young Lee
          <leeyoung@huawei.com>;
```

description

"This module defines a model for Flex-grid Tunnel Services.
The model fully conforms to the Network Management Datastore Architecture (NMDA).

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without modification, is permitted pursuant to, and subject to the license terms contained in, the Simplified 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 "2022-07-11" {
  description
    "Initial Revision";
  reference
    "RFC XXXX: YANG data model for Flexi-Grid tunnels";
  // RFC Ed.: replace XXXX with actual RFC number, update date
  // information and remove this note
}

/*
 * Data nodes
 */

augment "/te:te/te:tunnels/te:tunnel" {
  description
    "Augment with additional parameters required for flexi-grid
    tunnels.";
  uses l0-types-ext:l0-tunnel-attributes;
}

/*
```

```
 * Augment TE label range information
 */

augment "/te:te/te:globals/te:named-path-constraints/"
  + "te:named-path-constraint/te:path-in-segment/"
  + "te:label-restrictions/te:label-restriction" {
  description
    "Augment TE label range information for the ingress segment
    of the named path constraint.";
  uses l0-types:flexi-grid-label-range-info;
}
```

```

augment "/te:te/te:globals/te:named-path-constraints/"
  + "te:named-path-constraint/te:path-out-segment/"
  + "te:label-restrictions/"
  + "te:label-restriction" {
  description
    "Augment TE label range information for the egress segment
    of the named path constraint.";
  uses l0-types:flexi-grid-label-range-info;
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction" {
  description
    "Augment TE label range information for the ingress segment
    of the primay path.";
  uses l0-types:flexi-grid-label-range-info;
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction" {
  description
    "Augment TE label range information for the egress segment
    of the primay path.";
  uses l0-types:flexi-grid-label-range-info;
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction" {
  description

```

```

    "Augment TE label range information for the ingress segment
    of the primay reverse path.";
  uses l0-types:flexi-grid-label-range-info;
}

```



```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction" {
  description
    "Augment TE label range information for the egress segment
    of the primay reverse path.";
  uses l0-types:flexi-grid-label-range-info;
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-paths/te:secondary-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction" {
  description
    "Augment TE label range information for the ingress segment
    of the secondary path.";
  uses l0-types:flexi-grid-label-range-info;
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-paths/te:secondary-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction" {
  description
    "Augment TE label range information for the egress segment
    of the secondary path.";
  uses l0-types:flexi-grid-label-range-info;
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction" {
  description
    "Augment TE label range information for the ingress segment
    of the secondary reverse path.";
  uses l0-types:flexi-grid-label-range-info;
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"

```

```

    + "te:path-out-segment/te:label-restrictions/"
    + "te:label-restriction" {
description
    "Augment TE label range information for the egress segment
    of the secondary reverse path.";
uses l0-types:flexi-grid-label-range-info;
}

/*
 * Augment TE label.
 */

augment "/te:te/te:globals/te:named-path-constraints/"
    + "te:named-path-constraint/"
    + "te:explicit-route-objects-always/"
    + "te:route-object-exclude-always/te:type/te:label/"
    + "te:label-hop/te:te-label/te:technology" {
description
    "Augment TE label hop for the explicit route objects always
    excluded by the path computation with the named path
    constraint.";
case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:globals/te:named-path-constraints/"
    + "te:named-path-constraint/"
    + "te:explicit-route-objects-always/"
    + "te:route-object-include-exclude/te:type/te:label/"
    + "te:label-hop/te:te-label/te:technology" {
description
    "Augment TE label hop for the explicit route objects included
    or excluded by the path computation with the named path
    constraint.";
case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:globals/te:named-path-constraints/"
    + "te:named-path-constraint/te:path-in-segment/"
    + "te:label-restrictions/"
    + "te:label-restriction/te:label-start/"
    + "te:te-label/te:technology" {
description
    "Augment TE label range start for the ingress segment
    of the named path constraint.";
}

```

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```
    case flexi-grid {
      uses l0-types:flexi-grid-label-start-end;
    }
  }

augment "/te:te/te:globals/te:named-path-constraints/"
  + "te:named-path-constraint/te:path-in-segment/"
  + "te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
  description
    "Augment TE label range end for the ingress segment
    of the named path constraint.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
  }
}

augment "/te:te/te:globals/te:named-path-constraints/"
  + "te:named-path-constraint/te:path-in-segment/"
  + "te:label-restrictions/te:label-restriction/"
  + "te:label-step/te:technology" {
  description
    "Augment TE label range step for the ingress segment
    of the named path constraint.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-step;
  }
}

augment "/te:te/te:globals/te:named-path-constraints/"
  + "te:named-path-constraint/te:path-out-segment/"
  + "te:label-restrictions/"
  + "te:label-restriction/te:label-start/"
  + "te:te-label/te:technology" {
  description
    "Augment TE label range start for the egress segment
    of the named path constraint.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
  }
}
```

```
augment "/te:te/te:globals/te:named-path-constraints/"
  + "te:named-path-constraint/te:path-out-segment/"
  + "te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
```

```
  description
    "Augment TE label range end for the egress segment
    of the named path constraint.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
  }
}

augment "/te:te/te:globals/te:named-path-constraints/"
  + "te:named-path-constraint/te:path-out-segment/"
  + "te:label-restrictions/te:label-restriction/"
  + "te:label-step/te:technology" {
  description
    "Augment TE label range step for the egress segment
    of the named path constraint.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-step;
  }
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:optimizations/te:algorithm/te:metric/"
  + "te:optimization-metric/te:explicit-route-exclude-objects/"
  + "te:route-object-exclude-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
  description
    "Augment TE label hop for the optimization of the explicit
    route objects excluded by the path computation of the primary
    path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
  }
}
```

```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:optimizations/te:algorithm/te:metric/"
  + "te:optimization-metric/te:explicit-route-include-objects/"
  + "te:route-object-include-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the optimization of the explicit
  route objects included by the path computation of the primary
  path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

```

```

}

```

```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:explicit-route-objects-always/"
  + "te:route-object-exclude-always/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the explicit route objects always
  excluded by the path computation of the primary path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}
}

```

```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:explicit-route-objects-always/"
  + "te:route-object-include-exclude/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the explicit route objects included
  or excluded by the path computation of the primary path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}
}

```

```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-start/"
  + "te:te-label/te:technology" {
description
  "Augment TE label range start for the ingress segment
  of the primay path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

```

```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
description
  "Augment TE label range end for the ingress segment

```

```

  of the primay path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

```

```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-step/te:technology" {
description
  "Augment TE label range step for the ingress segment
  of the primay path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-step;
}
}

```

```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-out-segment/te:label-restrictions/"

```

```

    + "te:label-restriction/te:label-start/"
    + "te:te-label/te:technology" {
description
  "Augment TE label range start for the egress segment
  of the primay path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
description
  "Augment TE label range end for the egress segment
  of the primay path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-step/te:technology" {

```

```

description
  "Augment TE label range end for the egress segment
  of the primay path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-step;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:computed-paths-properties/"
  + "te:computed-path-properties/te:path-properties/"
  + "te:path-route-objects/te:path-route-object/"
  + "te:type/te:label/"

```

```

    + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the route object of the computed
  primary path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:optimizations/te:algorithm/te:metric/"
  + "te:optimization-metric/te:explicit-route-exclude-objects/"
  + "te:route-object-exclude-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the optimization of the explicit
  route objects excluded by the path computation of the primary
  reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:optimizations/te:algorithm/te:metric/"
  + "te:optimization-metric/te:explicit-route-include-objects/"
  + "te:route-object-include-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the optimization of the explicit

```

```

  route objects included by the path computation of the primary
  reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

```



```

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:explicit-route-objects-always/"
  + "te:route-object-exclude-always/"
  + "te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the explicit route objects always
  excluded by the path computation of the primary reverse
  path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:explicit-route-objects-always/"
  + "te:route-object-include-exclude/"
  + "te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the explicit route objects included
  or excluded by the path computation of the primary reverse
  path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-start/"
  + "te:te-label/te:technology" {
description
  "Augment TE label range start for the ingress segment
  of the primay reverse path.";
}

```

```

    case flexi-grid {
      uses l0-types:flexi-grid-label-start-end;
    }
  }

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
  description
    "Augment TE label range end for the ingress segment
    of the primay reverse path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
  }
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-step/te:technology" {
  description
    "Augment TE label range step for the ingress segment
    of the primay reverse path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-step;
  }
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-start/"
  + "te:te-label/te:technology" {
  description
    "Augment TE label range start for the egress segment
    of the primay reverse path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
  }
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"

```

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```
    + "te:primary-reverse-path/"
    + "te:path-out-segment/te:label-restrictions/"
    + "te:label-restriction/te:label-end/"
    + "te:te-label/te:technology" {
description
  "Augment TE label range end for the egress segment
  of the primay reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-step/te:technology" {
description
  "Augment TE label range step for the egress segment
  of the primay reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-step;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:primary-paths/te:primary-path/"
  + "te:primary-reverse-path/"
  + "te:computed-paths-properties/te:computed-path-properties/"
  + "te:path-properties/te:path-route-objects/"
  + "te:path-route-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the route object of the computed
  primary reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-paths/te:secondary-path/"
  + "te:optimizations/te:algorithm/te:metric/"
```

```
    + "te:optimization-metric/te:explicit-route-exclude-objects/"
    + "te:route-object-exclude-object/te:type/te:label/"
    + "te:label-hop/te:te-label/te:technology" {
description
    "Augment TE label hop for the optimization of the explicit
```

```
    route objects excluded by the path computation of the
    secondary path.";
case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
    + "te:secondary-paths/te:secondary-path/"
    + "te:optimizations/te:algorithm/te:metric/"
    + "te:optimization-metric/te:explicit-route-include-objects/"
    + "te:route-object-include-object/te:type/te:label/"
    + "te:label-hop/te:te-label/te:technology" {
description
    "Augment TE label hop for the optimization of the explicit
    route objects included by the path computation of the
    secondary path.";
case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
    + "te:secondary-paths/te:secondary-path/"
    + "te:explicit-route-objects-always/"
    + "te:route-object-exclude-always/te:type/te:label/"
    + "te:label-hop/te:te-label/te:technology" {
description
    "Augment TE label hop for the explicit route objects always
    excluded by the path computation of the secondary path.";
case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
```

```

    + "te:secondary-paths/te:secondary-path/"
    + "te:explicit-route-objects-always/"
    + "te:route-object-include-exclude/te:type/te:label/"
    + "te:label-hop/te:te-label/te:technology" {
description
    "Augment TE label hop for the explicit route objects included
    or excluded by the path computation of the secondary path.";
case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
}
}

```

```

augment "/te:te/te:tunnels/te:tunnel/"
    + "te:secondary-paths/te:secondary-path/"
    + "te:path-in-segment/te:label-restrictions/"
    + "te:label-restriction/te:label-start/"
    + "te:te-label/te:technology" {
description
    "Augment TE label range start for the ingress segment
    of the secondary path.";
case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
    + "te:secondary-paths/te:secondary-path/"
    + "te:path-in-segment/te:label-restrictions/"
    + "te:label-restriction/te:label-end/"
    + "te:te-label/te:technology" {
description
    "Augment TE label range end for the ingress segment
    of the secondary path.";
case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
    + "te:secondary-paths/te:secondary-path/"
    + "te:path-in-segment/te:label-restrictions/"
    + "te:label-restriction/te:label-step/te:technology" {

```

```

description
  "Augment TE label range step for the ingress segment
  of the secondary path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-step;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-paths/te:secondary-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-start/"
  + "te:te-label/te:technology" {
description
  "Augment TE label range start for the egress segment
  of the secondary path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

```

```

}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-paths/te:secondary-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
description
  "Augment TE label range end for the egress segment
  of the secondary path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-paths/te:secondary-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-step/te:technology" {
description
  "Augment TE label range step for the egress segment
  of the secondary path.";
}
}

```

```

    case flexi-grid {
      uses l0-types:flexi-grid-label-step;
    }
  }

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-paths/te:secondary-path/"
  + "te:computed-paths-properties/"
  + "te:computed-path-properties/"
  + "te:path-properties/te:path-route-objects/"
  + "te:path-route-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the route object of the computed
  secondary path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:optimizations/te:algorithm/te:metric/"
  + "te:optimization-metric/te:explicit-route-exclude-objects/"
  + "te:route-object-exclude-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {

```

```

description
  "Augment TE label hop for the optimization of the explicit
  route objects excluded by the path computation of the
  secondary reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:optimizations/te:algorithm/te:metric/"
  + "te:optimization-metric/te:explicit-route-include-objects/"
  + "te:route-object-include-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {

```

```

description
  "Augment TE label hop for the optimization of the explicit
  route objects included by the path computation of the
  secondary reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:explicit-route-objects-always/"
  + "te:route-object-exclude-always/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the explicit route objects always
  excluded by the path computation of the secondary reverse
  path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:explicit-route-objects-always/"
  + "te:route-object-include-exclude/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the explicit route objects included
  or excluded by the path computation of the secondary reverse
  path.";
case flexi-grid {

```

```

  uses l0-types:flexi-grid-label-hop;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-start/"

```



```

    + "te:te-label/te:technology" {
description
  "Augment TE label range start for the ingress segment
  of the secondary reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
description
  "Augment TE label range end for the ingress segment
  of the secondary reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-start-end;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:path-in-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-step/te:technology" {
description
  "Augment TE label range step for the ingress segment
  of the secondary reverse path.";
case flexi-grid {
  uses l0-types:flexi-grid-label-step;
}
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-start/"
  + "te:te-label/te:technology" {
description

```

"Augment TE label range start for the egress segment

```

    of the secondary reverse path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
  }
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-end/"
  + "te:te-label/te:technology" {
  description
    "Augment TE label range end for the egress segment
    of the secondary reverse path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-start-end;
  }
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:path-out-segment/te:label-restrictions/"
  + "te:label-restriction/te:label-step/te:technology" {
  description
    "Augment TE label range step for the egress segment
    of the secondary reverse path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-step;
  }
}

augment "/te:te/te:tunnels/te:tunnel/"
  + "te:secondary-reverse-paths/te:secondary-reverse-path/"
  + "te:computed-paths-properties/"
  + "te:computed-path-properties/"
  + "te:path-properties/te:path-route-objects/"
  + "te:path-route-object/te:type/te:label/"
  + "te:label-hop/te:te-label/te:technology" {
  description
    "Augment TE label hop for the route object of the computed
    secondary reverse path.";
  case flexi-grid {
    uses l0-types:flexi-grid-label-hop;
  }
}

augment "/te:te/te:lsps/"

```

```
    + "te:lsp/te:lsp-record-route-information/"
    + "te:lsp-record-route-information/te:type/te:label/"
    + "te:label-hop/te:te-label/te:technology" {
description
  "Augment TE label hop for the record route of the LSP.";
case flexi-grid {
  uses l0-types:flexi-grid-label-hop;
}
}
}
<CODE ENDS>
```

6. 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](#)] or RESTCONF [[RFC8040](#)]. The NETCONF access control model [[RFC8341](#)] provides the means to restrict access for particular NETCONF users to a preconfigured subset of all available NETCONF 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:

- * /te:te/te:tunnels/te:tunnel
- * /te:te/.../te:te-bandwidth/te:technology
- * /te:te/.../te:type/te:label/te:label-hop/te:te-label/te:technology
- * /te:te/.../te:label-restrictions/te:label-restriction/te:label-start/te:te-label/te:technology
- * /te:te/.../te:label-restrictions/te:label-restriction/te:label-end/te:te-label/te:technology
- * /te:te/.../te:label-restrictions/te:label-restriction/

Editors note: we are using simplified description by folding similar branches to avoid repetition.

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7. IANA Considerations

To be discussed.

8. Contributors

This work was developed by several additional people, who due to frontpage author restrictions, are listed below:

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10. References

10.1. Normative References

[I-D.ietf-ccamp-flexigrid-yang]

Mendez, J. E. L. D. V., Burrero, D. P., King, D., Lee, Y., and H. Zheng, "A YANG Data Model for Flexi-Grid Optical Networks", Work in Progress, Internet-Draft, [draft-ietf-ccamp-flexigrid-yang-13](https://www.ietf.org/archive/id/draft-ietf-ccamp-flexigrid-yang-13), 10 July 2022, <<https://www.ietf.org/archive/id/draft-ietf-ccamp-flexigrid-yang-13.txt>>.

[I-D.ietf-teas-yang-te]

Saad, T., Gandhi, R., Liu, X., Beeram, V. P., Bryskin, I., and O. G. D. Dios, "A YANG Data Model for Traffic Engineering Tunnels, Label Switched Paths and Interfaces", Work in Progress, Internet-Draft, [draft-ietf-teas-yang-te-29](https://www.ietf.org/archive/id/draft-ietf-teas-yang-te-29), 7 February 2022, <<https://www.ietf.org/archive/id/draft-ietf-teas-yang-te-29.txt>>.

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- [RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", [RFC 6241](https://www.rfc-editor.org/info/rfc6241), DOI 10.17487/RFC6241, June 2011, <<https://www.rfc-editor.org/info/rfc6241>>.
- [RFC7699] Farrel, A., King, D., Li, Y., and F. Zhang, "Generalized Labels for the Flexi-Grid in Lambda Switch Capable (LSC) Label Switching Routers", [RFC 7699](https://www.rfc-editor.org/info/rfc7699), DOI 10.17487/RFC7699, November 2015, <<https://www.rfc-editor.org/info/rfc7699>>.
- [RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", [RFC 7950](https://www.rfc-editor.org/info/rfc7950), DOI 10.17487/RFC7950, August 2016, <<https://www.rfc-editor.org/info/rfc7950>>.
- [RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", [RFC 8040](https://www.rfc-editor.org/info/rfc8040), DOI 10.17487/RFC8040, January 2017, <<https://www.rfc-editor.org/info/rfc8040>>.
- [RFC8341] Bierman, A. and M. Bjorklund, "Network Configuration Access Control Model", STD 91, [RFC 8341](https://www.rfc-editor.org/info/rfc8341), DOI 10.17487/RFC8341, March 2018, <<https://www.rfc-editor.org/info/rfc8341>>.

10.2. Informative References

- [RFC7446] Lee, Y., Ed., Bernstein, G., Ed., Li, D., and W. Imajuku, "Routing and Wavelength Assignment Information Model for Wavelength Switched Optical Networks", [RFC 7446](https://www.rfc-editor.org/info/rfc7446), DOI 10.17487/RFC7446, February 2015, <<https://www.rfc-editor.org/info/rfc7446>>.
- [RFC7698] Gonzalez de Dios, O., Ed., Casellas, R., Ed., Zhang, F.,

Fu, X., Ceccarelli, D., and I. Hussain, "Framework and Requirements for GMPLS-Based Control of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks", [RFC 7698](#), DOI 10.17487/RFC7698, November 2015, <<https://www.rfc-editor.org/info/rfc7698>>.

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