

TEAS Working Group
Internet Draft
Intended status: Standards Track

Xufeng Liu
Ericsson
Igor Bryskin
Huawei Technologies
Vishnu Pavan Beeram
Juniper Networks
Tarek Saad
Cisco Systems Inc
Himanshu Shah
Ciena
Oscar Gonzalez De Dios
Telefonica

Expires: September 20, 2016

March 20, 2016

YANG Data Model for TE Topologies
draft-ietf-teas-yang-te-topo-03

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF), its areas, and its working groups. Note that other groups may also distribute working documents as Internet-Drafts.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

The list of current Internet-Drafts can be accessed at <http://www.ietf.org/ietf/1id-abstracts.txt>

The list of Internet-Draft Shadow Directories can be accessed at <http://www.ietf.org/shadow.html>

This Internet-Draft will expire on September 20, 2016.

Copyright Notice

Copyright (c) 2016 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the [Trust Legal Provisions](#) and are provided without warranty as described in the Simplified BSD License.

Abstract

This document defines a YANG data model for representing, retrieving and manipulating TE Topologies. The model serves as a base model that other technology specific TE Topology models can augment.

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC-2119](#) [[RFC2119](#)].

Table of Contents

1.	Introduction.....	3
1.1.	Terminology.....	4
1.2.	Tree Structure - Legend.....	4
1.3.	Prefixes in Data Node Names.....	5
2.	Characterizing TE Topologies.....	5
3.	Modeling Abstractions and Transformations.....	7
3.1.	TE Topology.....	7
3.2.	TE Node.....	7
3.3.	TE Link.....	8
3.4.	TE Link Termination Point (LTP).....	8
3.5.	TE Tunnel Termination Point (TTP).....	8
3.6.	TE Node Connectivity Matrix.....	8
3.7.	TTP Local Link Connectivity List (LLCL).....	9
3.8.	TE Path.....	9
3.9.	Underlay TE topology.....	9
3.10.	Overlay TE topology.....	9
3.11.	Abstract TE topology.....	9
4.	Model Applicability.....	11
4.1.	Native TE Topologies.....	11
4.2.	Customized TE Topologies.....	13
5.	Modeling Considerations.....	15

5.1.	Generic network topology building blocks.....	15
5.2.	Technology agnostic TE Topology model.....	16
5.3.	Model Structure.....	16
5.4.	Topology Identifiers.....	18
5.5.	Generic TE Link Attributes.....	18
5.6.	Generic TE Node Attributes.....	19
5.7.	TED Information Sources.....	19
5.8.	Overlay/Underlay Relationship.....	20
5.9.	Scheduling Parameters.....	22
5.10.	Templates.....	22
5.11.	Notifications.....	23
5.12.	Open Items.....	23
6.	Tree Structure.....	23
6.1.	Base TE Topology Module.....	23
6.2.	Packet Switching TE Topology Module.....	49
7.	TE Topology Yang Modules.....	50
7.1.	Base TE Topology Module.....	50
7.2.	Packet Switching TE Topology Module.....	95
8.	Security Considerations.....	99
9.	IANA Considerations.....	99
10.	References.....	99
10.1.	Normative References.....	99
10.2.	Informative References.....	100
11.	Acknowledgments.....	100
	Contributors.....	100
	Authors' Addresses.....	100

[1.](#) Introduction

The Traffic Engineering Database (TED) is an essential component of Traffic Engineered (TE) systems that are based on MPLS-TE [[RFC2702](#)] and GMPLS [[RFC3945](#)]. The TED is a collection of all TE information about all TE nodes and TE links in the network. The TE Topology is a schematic arrangement of TE nodes and TE links present in a given TED. There could be one or more TE Topologies present in a given Traffic Engineered system. The TE Topology is the topology on which path computational algorithms are run to compute Traffic Engineered Paths (TE Paths).

This document defines a YANG [[RFC6020](#)] data model for representing and manipulating TE Topologies. This model contains technology agnostic TE Topology building blocks that can be augmented and used by other technology-specific TE Topology models.

1.1. Terminology

TED: The Traffic Engineering Database is a collection of all TE information about all TE nodes and TE links in a given network.

TE-Topology: The TE Topology is a schematic arrangement of TE nodes and TE links in a given TED. It forms the basis for a graph suitable for TE path computations.

Native TE Topology: Native TE Topology is a topology that is native to a given provider network. Native TE topology could be discovered via various routing protocols and/or subscribe/publish techniques. This is the topology on which path computational algorithms are run to compute TE Paths.

Customized TE Topology: Customized TE Topology is a custom topology that is produced by a provider for a given Client. This topology typically augments the Client's Native TE Topology. Path computational algorithms aren't typically run on the Customized TE Topology; they are run on the Client's augmented Native TE Topology.

1.2. Tree Structure - Legend

A simplified graphical representation of the data model is presented in [Section 6](#). of this document. The following notations are used for the YANG model data tree representation.

`<status> <flags> <name> <opts> <type>`

`<status>` is one of:

- + for current
- x for deprecated
- o for obsolete

`<flags>` is one of:

- rw for read-write configuration data
- ro for read-only non-configuration data
- x for execution rpcs
- n for notifications

`<name>` is the name of the node

If the node is augmented into the tree from another module, its name is printed as `<prefix>:<name>`

`<opts>` is one of:

? for an optional leaf or node
 ! for a presence container
 * for a leaf-list or list
 Brackets [<keys>] for a list's keys
 Curly braces {<condition>} for optional feature that make node conditional

Colon : for marking case nodes
 Ellipses ("...") subtree contents not shown

Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").

<type> is the name of the type for leafs and leaf-lists.

1.3. Prefixes in Data Node Names

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

Prefix	YANG module	Reference
yang	ietf-yang-types	[RFC6991]
inet	ietf-inet-types	[RFC6991]

Table 1: Prefixes and corresponding YANG modules

2. Characterizing TE Topologies

The data model proposed by this document takes the following characteristics of TE Topologies into account:

- TE Topology is an abstract control-plane representation of the data-plane topology. Hence attributes specific to the data-plane must make their way into the corresponding TE Topology modeling. The TE Topology comprises of dynamic auto-discovered data (data that may change frequently - example: unreserved bandwidth available on data-plane links) as well as fairly static data (data that rarely changes- examples: layer network identification, switching and adaptation capabilities and limitations, fate sharing, administrative colors) associated with data-plane nodes and links. It is possible for a single TE Topology to encompass TE information at multiple switching layers.

- TE Topologies are protocol independent. Information about topological elements may be learnt via link-state protocols, but the topology can exist without being dependent on any particular protocol.
- TE Topology may not be congruent to the routing topology (topology constructed based on routing adjacencies) in a given TE System. There isn't always a one-to-one association between a TE-link and a routing adjacency. For example, the presence of a TE link between a pair of nodes doesn't necessarily imply the existence of a routing-adjacency between these nodes.
- Each TE Topological element has an information source associated with it. In some scenarios, there could be more than one information source associated with each topological element.
- TE Topologies can be hierarchical. Each node and link of a given TE Topology can be associated with respective underlay topology. This means that each node and link of a given TE Topology can be associated with an independent stack of supporting TE Topologies.
- TE Topologies can be customized. TE topologies of a given network presented by the network provider to its client could be customized on per-client request basis. This customization could be performed by provider, by client or by provider/client negotiation. The relationship between a customized topology (as presented to the client) and provider's native topology (as known in its entirety to the provider itself) could be captured as hierarchical (overlay-underlay), but otherwise the two topologies are decoupled from each other.

In Figure 1, Node-1, Node-2, and Node-3 are TE nodes.

3.3. TE Link

TE link is an element of a TE topology (presented as an edge on TE graph, arrows indicate one or both directions of the TE link). TE link represents one or several (physical) links or a fraction of a link. TE link belongs to and is fully defined in exactly one TE topology. TE link is assigned with the TE topology scope unique ID. TE link attributes include parameters related to the data plane aspects of the associated link(s) (e.g. unreserved bandwidth, resource maps/pools, etc.), as well as the configuration data (such as remote node/link IDs, SRLGs, administrative colors, etc.). TE link is connected to TE node, terminating the TE link via exactly one TE link termination point (LTP).

In Figure 1, Link-12 and Link-23 are TE links.

3.4. TE Link Termination Point (LTP)

TE link termination point (LTP) is a conceptual point of connection of a TE node to one of the TE links, terminated by the TE node. Cardinality between an LTP and the associated TE link is 1:0..1.

In Figure 1, Node-2 has six LTPs: LTP-1 to LTP-6.

3.5. TE Tunnel Termination Point (TTP)

TE tunnel termination point (TTP) is an element of TE topology representing one or several of potential transport service termination points (i.e. service client adaptation points such as WDM/OCh transponder). TTP is associated with (hosted by) exactly one TE node. TTP is assigned with the TE node scope unique ID. Depending on the TE node's internal constraints, a given TTP hosted by the TE node could be accessed via one, several or all TE links terminated by the TE node.

In Figure 1, Node-1 has two TTPs: TTP-1 and TTP-2.

3.6. TE Node Connectivity Matrix

TE node connectivity matrix is a TE node's attribute describing the TE node's switching limitations in a form of valid switching combinations of the TE node's LTPs (see below). From the point of view of a potential TE path arriving at the TE node at a given inbound LTP, the node's connectivity matrix describes valid (permissible) outbound LTPs for the TE path to leave the TE node from.

In Figure 1, the connectivity matrix on Node-2 is:

```
{<LTP-6, LTP-1>, <LTP-5, LTP-2>, <LTP-5, LTP-4>, <LTP-4, LTP-1>,  
<LTP-3, LTP-2>}
```

3.7. TTP Local Link Connectivity List (LLCL)

TTP Local Link Connectivity List (LLCL) is a List of TE links terminated by the TTP hosting TE node (i.e. list of the TE link LTPs), which the TTP could be connected to. From the point of view of a potential TE path LLCL provides a list of valid TE links the TE path needs to start/stop on for the connection, taking the TE path, to be successfully terminated on the TTP in question.

In Figure 1, the LLCL on Node-1 is:

```
{<TTP-1, LTP-5>, <TTP-1, LTP-2>, <TTP-2, LTP-3>, <TTP-2, LTP4>}
```

3.8. TE Path

TE path is an ordered list of TE links and/or TE nodes on the TE topology graph, inter-connecting a pair of TTPs to be taken by a potential connection. TE paths, for example, could be a product of successful path computation performed for a given transport service.

In Figure 1, the TE Path for TE-Tunnel-1 is:

```
{Node-1:TTP-1, Link-12, Node-2, Link-23, Node-3:TTP1}
```

3.9. Underlay TE topology

Underlay TE topology is a TE topology that serves as a base for constructing of overlay TE topologies

3.10. Overlay TE topology

Overlay TE topology is a TE topology constructed based on one or more underlay TE topologies. Each TE node of the overlay TE topology represents an arbitrary segment of an underlay TE topology; each TE link of the overlay TE topology represents an arbitrary TE path in one of the underlay TE topologies. The overlay TE topology and the supporting underlay TE topologies may represent distinct layer networks (e.g. OTN/ODUK and WDM/OCh respectively) or the same layer network.

3.11. Abstract TE topology

Abstract TE topology is an overlay TE topology created by a topology provider and customized for a topology provider's client based on

one or more of the provider's native TE topologies (underlay TE topologies), the provider's policies and the client's preferences. For example, a first level topology provider (such as Domain Controller) can create an abstract TE topology for its client (e.g. Super Controller) based on the provider's one or more native TE topologies, local policies/profiles and the client's TE topology configuration requests

Figure 2 shows an example of abstract TE topology.

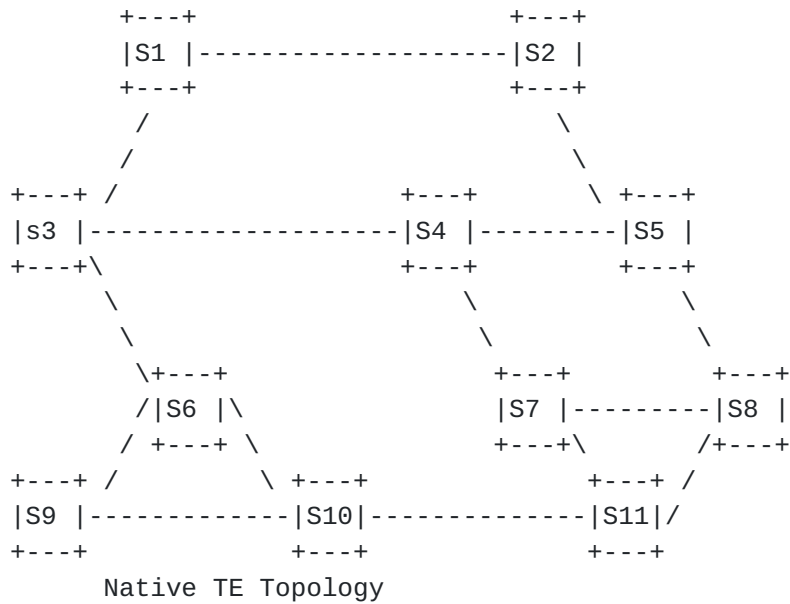
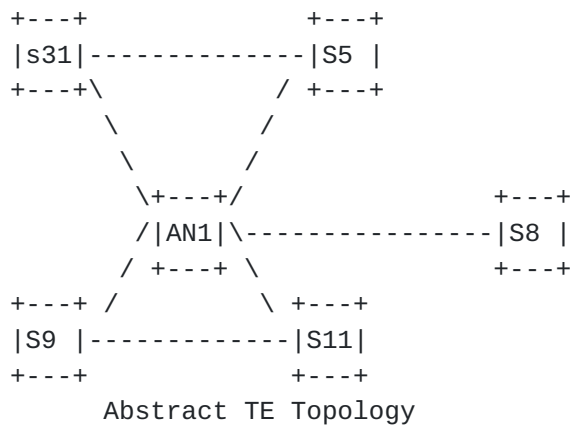


Figure 2: Abstract TE Topology

4. Model Applicability

4.1. Native TE Topologies

The model discussed in this draft can be used to represent and retrieve native TE topologies on a given TE system.

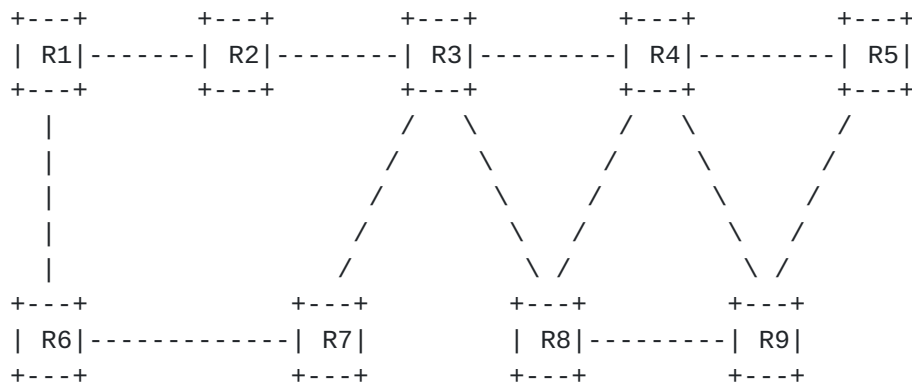


Figure 3a: Example Network Topology

Consider the network topology depicted in Figure 3a (R1 .. R9 are nodes representing routers). An implementation MAY choose to construct a native TE Topology using all nodes and links present in the given TED as depicted in Figure 3b. The data model proposed in this document can be used to retrieve/represent this TE topology.

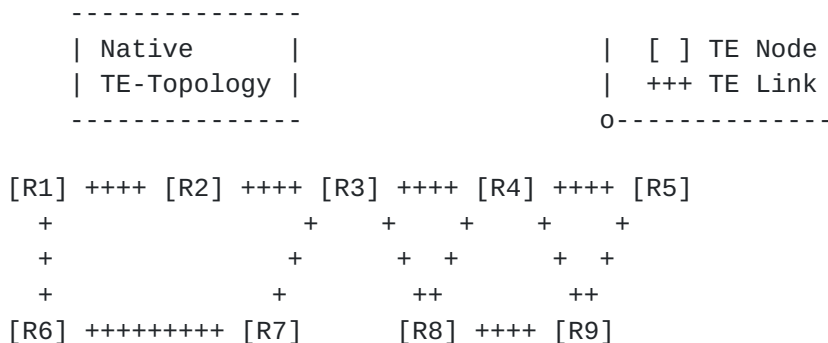


Figure 3b: Native TE Topology as seen on Node R3

Consider the case of the topology being split in a way that some nodes participate in OSPF-TE while others participate in ISIS-TE (Figure 4a). An implementation MAY choose to construct separate TE Topologies based on the information source. The native TE Topologies constructed using only nodes and links that were learnt via a specific information source are depicted in Figure 4b. The data model proposed in this document can be used to retrieve/represent these TE topologies.

Similarly, the data model can be used to represent/retrieve a TE Topology that is constructed using only nodes and links that belong to a particular technology layer. The data model is flexible enough to retrieve and represent many such native TE Topologies.

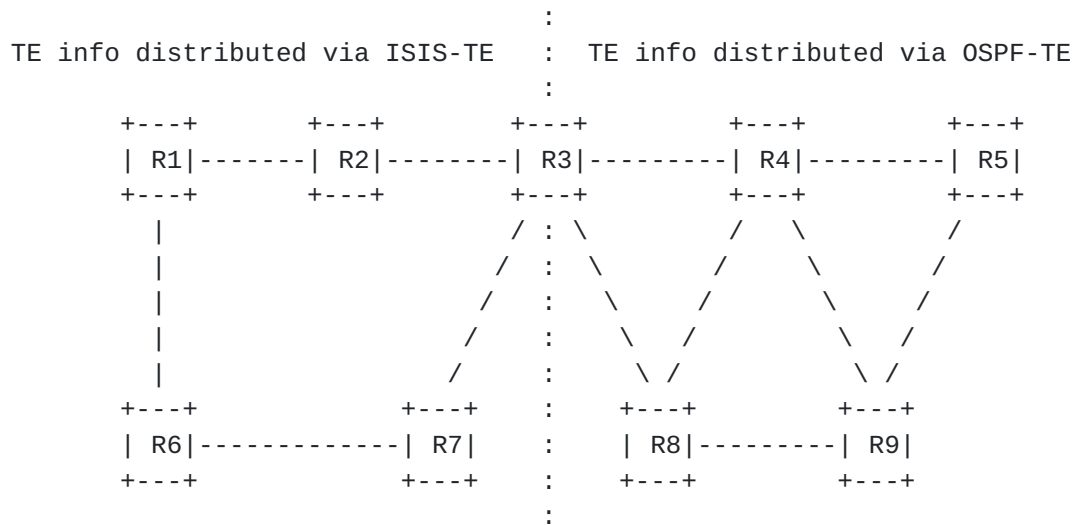


Figure 4a: Example Network Topology

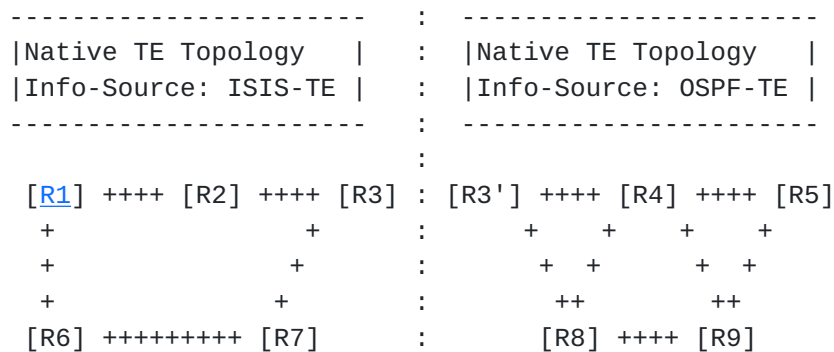


Figure 4b: Native TE Topologies as seen on Node R3

4.2. Customized TE Topologies

The model discussed in this draft can be used to represent, retrieve and manipulate customized TE Topologies. The model allows the provider to present the network in abstract TE Terms on a per client basis. These customized topologies contain sufficient information for the path computing client to select paths according to its policies.

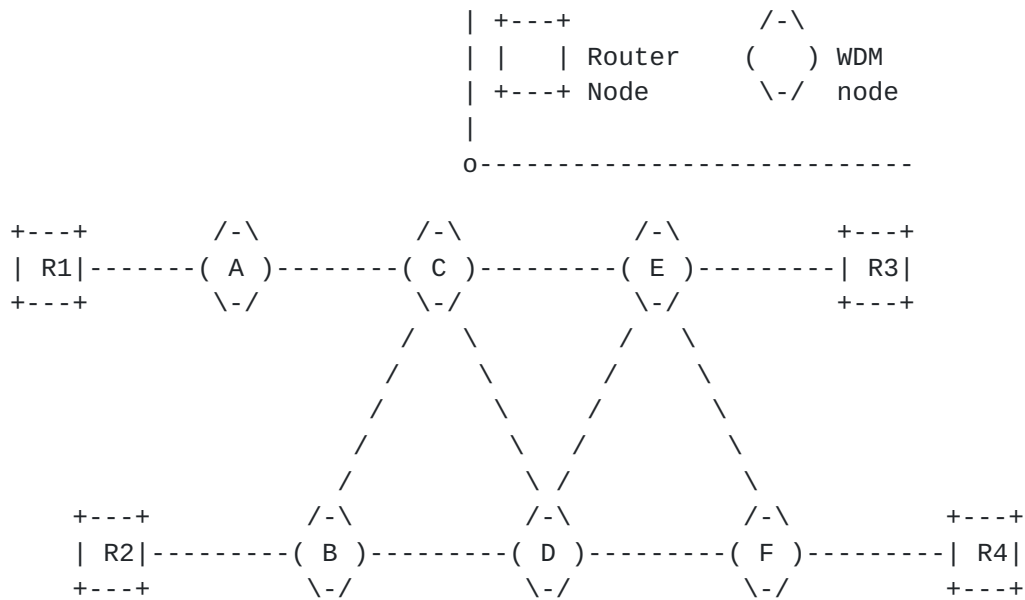


Figure 5: Example packet optical topology

Consider the network topology depicted in Figure 5. This is a typical packet optical transport deployment scenario where the WDM layer network domain serves as a Server Network Domain providing transport connectivity to the packet layer network Domain (Client Network Domain). Nodes R1, R2, R3 and R4 are IP routers that are connected to an Optical WDM transport network. A, B, C, D, E and F are WDM nodes that constitute the Server Network Domain.

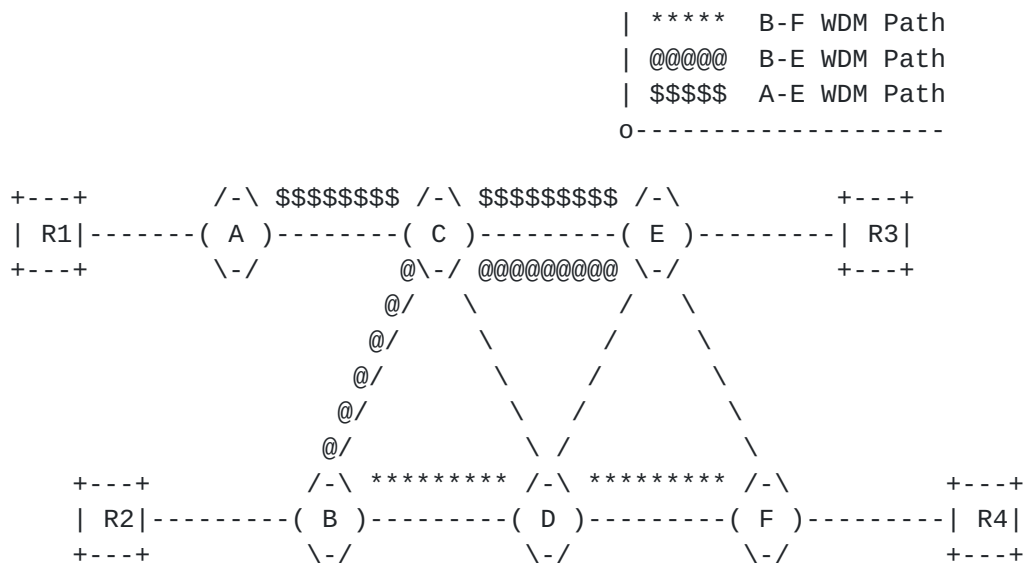


Figure 6a: Paths within the provider domain


```

+++++++ [A] ++++++ [E] ++++++
              +++++
              +++++
              +++++
              +++++
              +++++
+++++++ [B] ++++++ [F] ++++++

```

Figure 6b: Customized TE Topology provided to the Client

The goal here is to augment the Client TE Topology with a customized TE Topology provided by the WDM network. Given the availability of the paths A-E, B-F and B-E (Figure 6a), a customized TE Topology as depicted in Figure 6b is provided to the Client. This customized TE Topology is merged with the Client's Native TE Topology and the resulting topology is depicted in Figure 6c.

```

[R1] ++++++ [A] ++++++ [E] ++++++ [R3]
              +++++
              +++++
              +++++
              +++++
              +++++
[R2] ++++++ [B] ++++++ [F] ++++++ [R4]

```

Figure 6c: Customized TE Topology merged with the Client's Native TE Topology

The data model proposed in this document can be used to retrieve/represent/manipulate the customized TE Topology depicted in Figure 6b.

5. Modeling Considerations

5.1. Generic network topology building blocks

The generic network topology building blocks are discussed in [YANG-NET-TOPO]. The TE Topology model proposed in this document augments and uses the `ietf-network-topology` module defined in [YANG-NET-TOPO].

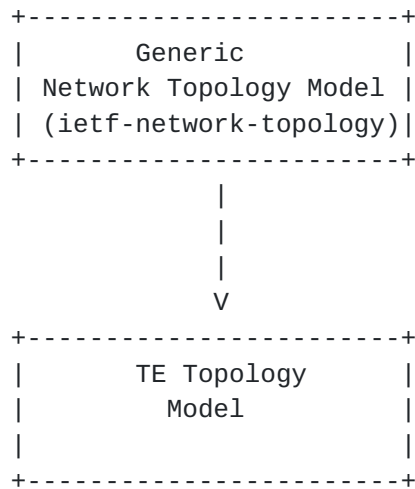


Figure 7: Augmenting the Generic Network Topology Model

5.2. Technology agnostic TE Topology model

The TE Topology model proposed in this document is meant to be technology agnostic. Other technology specific TE Topology models can augment and use the building blocks provided by the proposed model.

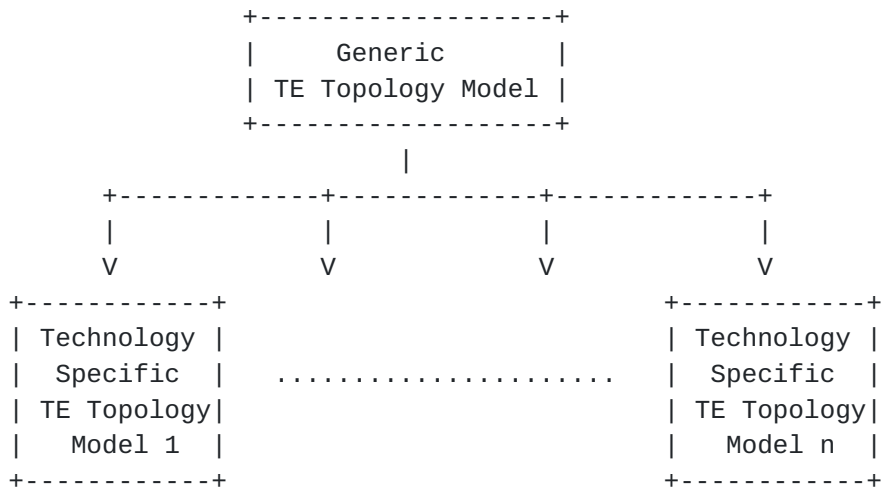


Figure 8: Augmenting the Technology agnostic TE Topology model

5.3. Model Structure

The high-level model structure proposed by this document is as shown below:


```

module: ietf-te-topology
augment /nw:networks/nw:network/nw:network-types:
  +--rw te-topology!

augment /nw:networks:
  +--rw te!
    +--rw templates
      +--rw node-template* [name] {template}?
      | .....
      +--rw link-template* [name] {template}?
      .....

augment /nw:networks/nw:network:
  +--rw te!
    +--rw provider-id      te-global-id
    +--rw client-id        te-global-id
    +--rw te-topology-id   te-topology-id
    +--rw config
    | .....
    +--ro state
    .....

augment /nw:networks/nw:network/nw:node:
  +--rw te!
    +--rw te-node-id      te-node-id
    +--rw config
    | .....
    +--ro state
    | .....
    +--rw tunnel-termination-point* [tunnel-tp-id]
      +--rw tunnel-tp-id   binary
      +--rw config
      | .....
      +--ro state

augment /nw:networks/nw:network/nt:link:
  +--rw te!
    +--rw config
    | .....
    +--ro state
    .....

augment /nw:networks/nw:network/nw:node/nt:termination-point:
  +--rw te!
    +--rw te-tp-id      te-tp-id
    +--rw config

```



```

    | .....
    +--ro state
    .....

notifications:
  +---n te-node-event
  | .....
  +---n te-link-event
  .....

```

5.4. Topology Identifiers

The TE-Topology is uniquely identified by a key that has 3 constituents - te-topology-id, provider-id and client-id. The combination of provider-id and te-topology-id uniquely identifies a native TE Topology on a given provider. The client-id is used only when Customized TE Topologies come into play; a value of "0" is used as the client-id for native TE Topologies.

```

augment /nw:networks/nw:network:
  +--rw te!
    +--rw provider-id      te-global-id
    +--rw client-id        te-global-id
    +--rw te-topology-id   te-topology-id

```

5.5. Generic TE Link Attributes

The model covers the definitions for generic TE Link attributes - bandwidth, admin groups, SRLGs, switching capabilities, TE metric extensions etc.

```

+--rw te-link-attributes
  .....
  +--rw admin-status?                te-admin-status
  +--rw performance-metric-throttle {te-performance-metric}?
  | .....
  +--rw link-index?                  uint64
  +--rw administrative-group?        te-types:admin-groups
  +--rw max-link-bandwidth?          decimal64
  +--rw max-resv-link-bandwidth?     decimal64
  +--rw unreserved-bandwidth* [priority]
  | .....
  +--rw te-default-metric?           uint32
  +--rw performance-metric {te-performance-metric}?
  | .....
  +--rw link-protection-type?        enumeration

```



```

+--rw interface-switching-capability* [switching-capability]
| .....
+--rw te-srlgs
| .....

```

5.6. Generic TE Node Attributes

The model covers the definitions for generic TE Node attributes.

The definition of a generic connectivity matrix is shown below:

```

+--rw te-node-attributes
| .....
+--rw connectivity-matrix* [id]
|   +--rw id                uint32
|   +--rw from
|   |   +--rw tp-ref?        leafref
|   +--rw to
|   |   +--rw tp-ref?        leafref
|   +--rw is-allowed?        boolean

```

The definition of a TTP Local Link Connectivity List is shown below:

```

+--rw tunnel-termination-point* [tunnel-tp-id]
+--rw tunnel-tp-id        binary
+--rw config
|   +--rw termination-capability* [link-tp]
|   +--rw link-tp        leafref
+--ro state
|   +--ro termination-capability* [link-tp]
|   +--ro link-tp        leafref
+--ro switching-capability        identityref
+--ro encoding                    identityref

```

5.7. TED Information Sources

The model allows each TE topological element to have multiple TE information sources (OSPF-TE, ISIS-TE, BGP-LS, User-Configured, System-Processed, Other). Each information source is associated with a credibility preference to indicate precedence. In scenarios where a customized TE Topology is merged into a Client's native TE Topology, the merged topological elements would point to the corresponding customized TE Topology as its information source.


```

augment /nw:networks/nw:network/nw:node:
  +--rw te!
    .....
    +--ro state
      .....
      +--ro information-source?          enumeration
      +--ro information-source-state
        +--ro credibility-preference?    uint16
        +--ro topology
          | +--ro provider-id-ref?        leafref
          | +--ro client-id-ref?          leafref
          | +--ro te-topology-id-ref?     leafref
          | +--ro network-id-ref?         leafref
          +--ro routing-instance?         string

augment /nw:networks/nw:network/nt:link:
  +--rw te!
    .....
    +--ro state
      .....
      +--ro information-source?          enumeration
      +--ro information-source-state
        | +--ro credibility-preference?    uint16
        | +--ro topology
          | | +--ro provider-id-ref?        leafref
          | | +--ro client-id-ref?          leafref
          | | +--ro te-topology-id-ref?     leafref
          | | +--ro network-id-ref?         leafref
          | +--ro routing-instance?         string
      +--ro alt-information-sources* [information-source]
        | .....

```

5.8. Overlay/Underlay Relationship

The model captures overlay and underlay relationship for TE nodes/links. For example - in networks where multiple TE Topologies are built hierarchically, this model allows the user to start from a specific topological element in the top most topology and traverse all the way down to the supporting topological elements in the bottom most topology.

This relationship is captured via the "underlay-topology" field for the node and via the "underlay" field for the link. The use of these fields is optional and this functionality is tagged as a "feature" ("te-topology-hierarchy").


```

augment /nw:networks/nw:network/nw:node:
  +--rw te!
    +--rw te-node-id      te-node-id
    +--rw config
      | +--rw te-node-template*      leafref {template}?
      | +--rw te-node-attributes
      | .....
      | +--rw underlay-topology {te-topology-hierarchy}?
      |   +--rw provider-id-ref?      leafref
      |   +--rw client-id-ref?        leafref
      |   +--rw te-topology-id-ref?   leafref
      |   +--rw network-id-ref?       leafref

```

```

augment /nw:networks/nw:network/nt:link:
  +--rw te!
    +--rw config
      | .....
      | +--rw te-link-attributes
      | .....
      | +--rw underlay! {te-topology-hierarchy}?
      |   | +--rw underlay-primary-path
      |   | | +--rw provider-id-ref?      leafref
      |   | | +--rw client-id-ref?        leafref
      |   | | +--rw te-topology-id-ref?   leafref
      |   | | +--rw network-id-ref?       leafref
      |   | | +--rw path-element* [path-element-id]
      |   | | .....
      |   | +--rw underlay-backup-path* [index]
      |   | | +--rw index                  uint32
      |   | | +--rw provider-id-ref?      leafref
      |   | | +--rw client-id-ref?        leafref
      |   | | +--rw te-topology-id-ref?   leafref
      |   | | +--rw network-id-ref?       leafref
      |   | | +--rw path-element* [path-element-id]
      |   | | .....
      |   | +--rw underlay-protection-type? uint16
      |   | +--rw underlay-trail-src
      |   | | .....
      |   | | +--rw network-ref?      leafref
      |   | +--rw underlay-trail-des
      |   | .....

```


5.9. Scheduling Parameters

The model allows time scheduling parameters to be specified for each topological element or for the topology as a whole. These parameters allow the provider to present different topological views to the client at different time slots. The use of "scheduling parameters" is optional and this functionality is tagged as a "feature" ("configuration-schedule"). The YANG data model for configuration scheduling is defined in [[YANG-SCHEDULE](#)] and imported by the TE Topology module.

5.10. Templates

The data model provides the users with the ability to define templates and apply them to link and node configurations. The use of "template" configuration is optional and this functionality is tagged as a "feature" ("template").

```

+--rw topology* [provider-id client-id te-topology-id]
| .....
| +--rw node* [te-node-id]
| | +--rw te-node-template?      leafref {template}?
| | .....
| +--rw link* [source-te-node-id source-te-link-id dest-te-node-
id dest-te-link-id]
|   +--rw te-link-template?      leafref {template}?
|   .....
+--rw node-template* [name] {template}?
| +--rw name                      te-template-name
| +--rw priority?                 uint16
| +--rw reference-change-policy?  enumeration
| +--rw te-node-attributes
| .....
+--rw link-template* [name] {template}?
  +--rw name                      te-template-name
  +--rw priority?                 uint16
  +--rw reference-change-policy?  enumeration
  +--rw te-link-attributes
  .....

```

Multiple templates can be specified to a configuration element. When two or more templates specify values for the same configuration field, the value from the template with the highest priority is used. The reference-change-policy specifies the action that needs to be taken when the template changes on a configuration element that

has a reference to this template. The choices of action include taking no action, rejecting the change to the template and applying the change to the corresponding configuration. [Editor's Note: The notion of "templates" has wider applicability. It is possible for this to be discussed in a separate document.]

5.11. Notifications

Notifications are a key component of any topology data model.

[YANG-PUSH] defines a subscription and push mechanism for YANG datastores. This mechanism currently allows the user to:

- Subscribe notifications on a per client basis
- Specify subtree filters or xpath filters so that only interested contents will be sent.
- Specify either periodic or on-demand notifications.

The authors would like to recommend the use of this mechanism for the TE-Topology notifications. They would also like to suggest the following extensions to [[YANG-PUSH](#)]

- Specify specific entities that will trigger the push notifications. These entities can be specified by xpath, like the way a filter is specified.
- Specify or limit the triggering event type, e.g. "add", "delete", "modify", or "all". The system sends the push notifications only when such events happen on the triggering entities.
- Have an option to request either "incremental" or "full" notifications for an entity. For "incremental", the notification will contain only the changed attributes.

5.12. Open Items

- Coordinating changes to [[YANG-PUSH](#)]: The changes to [[YANG-PUSH](#)] discussed in [Section 4.10](#) will need to be coordinated with the authors of that draft.

6. Tree Structure

6.1. Base TE Topology Module

module: ietf-te-topology


```

augment /nw:networks/nw:network/nw:network-types:
  +--rw te-topology!
augment /nw:networks:
  +--rw te!
    +--rw templates
      +--rw node-template* [name] {template}?
        | +--rw name                               te-template-name
        | +--rw priority?                          uint16
        | +--rw reference-change-policy?           enumeration
        | +--rw te-node-attributes
        |   +--rw schedules
        |     | +--rw schedule* [schedule-id]
        |     |   +--rw schedule-id                uint32
        |     |   +--rw start?                     yang:date-and-time
        |     |   +--rw schedule-duration?         string
        |     |   +--rw repeat-interval?           string
        |     +--rw admin-status?                  te-admin-status
        |     +--rw domain-id?                     uint32
        |     +--rw is-abstract?                   empty
        |     +--rw name?                          inet:domain-name
        |     +--rw signaling-address*             inet:ip-address
        |     +--rw underlay-topology {te-topology-hierarchy}?
        |       +--rw provider-id-ref?             leafref
        |       +--rw client-id-ref?               leafref
        |       +--rw te-topology-id-ref?          leafref
        |       +--rw network-id-ref?              leafref
      +--rw link-template* [name] {template}?
        +--rw name                               te-template-name
        +--rw priority?                          uint16
        +--rw reference-change-policy?           enumeration
        +--rw te-link-attributes
          +--rw schedules
            | +--rw schedule* [schedule-id]
            |   +--rw schedule-id                uint32
            |   +--rw start?                     yang:date-and-time
            |   +--rw schedule-duration?         string
            |   +--rw repeat-interval?           string
          +--rw access-type?                      te-link-
access-type
          +--rw is-abstract?                      empty
          +--rw name?                             string
          +--rw underlay! {te-topology-hierarchy}?
            | +--rw underlay-primary-path
            | | +--rw provider-id-ref?            leafref
            | | +--rw client-id-ref?              leafref
            | | +--rw te-topology-id-ref?         leafref

```



```

| | +--rw network-id-ref?      leafref
| | +--rw path-element* [path-element-id]
| |   +--rw path-element-id    uint32
| |   +--rw (type)?
| |     +--:(ipv4-address)
| |       | +--rw v4-address?    inet:ipv4-
address
| |       | +--rw v4-prefix-length? uint8
| |       | +--rw v4-loose?      boolean
| |       +--:(ipv6-address)
| |       | +--rw v6-address?    inet:ipv6-
address
| |       | +--rw v6-prefix-length? uint8
| |       | +--rw v6-loose?      boolean
| |       +--:(as-number)
| |       | +--rw as-number?     uint16
| |       +--:(unnumbered-link)
| |       | +--rw router-id?     inet:ip-
address
| |       | +--rw interface-id?  uint32
| |       +--:(label)
| |       +--rw value?           uint32
| +--rw underlay-backup-path* [index]
| |   +--rw index                uint32
| |   +--rw provider-id-ref?     leafref
| |   +--rw client-id-ref?       leafref
| |   +--rw te-topology-id-ref?  leafref
| |   +--rw network-id-ref?      leafref
| |   +--rw path-element* [path-element-id]
| |     +--rw path-element-id    uint32
| |     +--rw (type)?
| |       +--:(ipv4-address)
| |       | +--rw v4-address?    inet:ipv4-
address
| |       | +--rw v4-prefix-length? uint8
| |       | +--rw v4-loose?      boolean
| |       +--:(ipv6-address)
| |       | +--rw v6-address?    inet:ipv6-
address
| |       | +--rw v6-prefix-length? uint8
| |       | +--rw v6-loose?      boolean
| |       +--:(as-number)
| |       | +--rw as-number?     uint16
| |       +--:(unnumbered-link)
| |       | +--rw router-id?     inet:ip-
address

```



```

| | | +--rw interface-id?      uint32
| | | +--:(label)
| | | +--rw value?             uint32
| +--rw underlay-protection-type?  uint16
| +--rw underlay-trail-src
| | +--rw tp-ref?              leafref
| | +--rw node-ref?            leafref
| | +--rw network-ref?         leafref
| +--rw underlay-trail-des
| | +--rw tp-ref?              leafref
| | +--rw node-ref?            leafref
| | +--rw network-ref?         leafref
+--rw admin-status?              te-admin-
status
+--rw performance-metric-throttle {te-performance-
metric}?
| +--rw unidirectional-delay-offset?
uint32
| +--rw measure-interval?
uint32
| +--rw advertisement-interval?
uint32
| +--rw suppression-interval?
uint32
| +--rw threshold-out
| | +--rw unidirectional-delay?
uint32
| | +--rw unidirectional-min-delay?
uint32
| | +--rw unidirectional-max-delay?
uint32
| | +--rw unidirectional-delay-variation?
uint32
| | +--rw unidirectional-packet-loss?
decimal64
| | +--rw unidirectional-residual-bandwidth?
decimal64
| | +--rw unidirectional-available-bandwidth?
decimal64
| | +--rw unidirectional-utilized-bandwidth?
decimal64
| +--rw threshold-in
| | +--rw unidirectional-delay?
uint32
| | +--rw unidirectional-min-delay?
uint32

```



```

uint32      | | +--rw unidirectional-max-delay?
uint32      | | +--rw unidirectional-delay-variation?
decimal64   | | +--rw unidirectional-packet-loss?
decimal64   | | +--rw unidirectional-residual-bandwidth?
decimal64   | | +--rw unidirectional-available-bandwidth?
decimal64   | | +--rw unidirectional-utilized-bandwidth?
uint32      | +--rw threshold-accelerated-advertisement
              |   +--rw unidirectional-delay?
uint32      |   +--rw unidirectional-min-delay?
uint32      |   +--rw unidirectional-max-delay?
uint32      |   +--rw unidirectional-delay-variation?
decimal64   |   +--rw unidirectional-packet-loss?
decimal64   |   +--rw unidirectional-residual-bandwidth?
decimal64   |   +--rw unidirectional-available-bandwidth?
decimal64   |   +--rw unidirectional-utilized-bandwidth?
              +--rw link-index?                               uint64
              +--rw administrative-group?                     te-
types:admin-groups
              +--rw max-link-bandwidth?                       decimal64
              +--rw max-resv-link-bandwidth?                   decimal64
              +--rw unreserved-bandwidth* [priority]
              |   +--rw priority                               uint8
              |   +--rw bandwidth?                             decimal64
              +--rw te-default-metric?                         uint32
              +--rw performance-metric {te-performance-metric}?
              |   +--rw measurement
              | |   +--rw unidirectional-delay?
uint32      | |   +--rw unidirectional-min-delay?
uint32      | |   +--rw unidirectional-max-delay?
uint32

```



```

uint32          | | +--rw unidirectional-delay-variation?
decimal64       | | +--rw unidirectional-packet-loss?
decimal64       | | +--rw unidirectional-residual-bandwidth?
decimal64       | | +--rw unidirectional-available-bandwidth?
decimal64       | | +--rw unidirectional-utilized-bandwidth?
                | +--rw normality
                | +--rw unidirectional-delay?
performance-metric-normality
                | +--rw unidirectional-min-delay?
performance-metric-normality
                | +--rw unidirectional-max-delay?
performance-metric-normality
                | +--rw unidirectional-delay-variation?
performance-metric-normality
                | +--rw unidirectional-packet-loss?
performance-metric-normality
                | +--rw unidirectional-residual-bandwidth?
performance-metric-normality
                | +--rw unidirectional-available-bandwidth?
performance-metric-normality
                | +--rw unidirectional-utilized-bandwidth?
performance-metric-normality
                +--rw link-protection-type?          enumeration
                +--rw interface-switching-capability* [switching-
capability]
                | +--rw switching-capability
identityref
                | +--rw encoding?
identityref
                | +--rw max-lsp-bandwidth* [priority]
                | | +--rw priority      uint8
                | | +--rw bandwidth?   decimal64
                | +--rw time-division-multiplex-capable
                | | +--rw minimum-lsp-bandwidth? decimal64
                | | +--rw indication?   enumeration
                | +--rw interface-adjustment-capability* [upper-sc]
                | +--rw upper-sc        identityref
                | +--rw upper-encoding? identityref
                | +--rw max-lsp-bandwidth* [priority]
                | +--rw priority      uint8
                | +--rw bandwidth?   decimal64

```



```

        +--rw te-srlgs
            +--rw values*   te-types:srlg
augment /nw:networks/nw:network:
+--rw te!
  +--rw provider-id      te-global-id
  +--rw client-id        te-global-id
  +--rw te-topology-id   te-topology-id
  +--rw config
    | +--rw schedules
    | | +--rw schedule* [schedule-id]
    | |   +--rw schedule-id      uint32
    | |   +--rw start?           yang:date-and-time
    | |   +--rw schedule-duration? string
    | |   +--rw repeat-interval? string
    | +--rw preference?   uint8
+--ro state
  +--ro schedules
    | +--ro schedule* [schedule-id]
    |   +--ro schedule-id      uint32
    |   +--ro start?           yang:date-and-time
    |   +--ro schedule-duration? string
    |   +--ro repeat-interval? string
    +--ro preference?   uint8
augment /nw:networks/nw:network/nw:node:
+--rw te!
  +--rw te-node-id      te-node-id
  +--rw config
    | +--rw te-node-template*   leafref {template}?
    | +--rw te-node-attributes
    | | +--rw schedules
    | | | +--rw schedule* [schedule-id]
    | | |   +--rw schedule-id      uint32
    | | |   +--rw start?           yang:date-and-time
    | | |   +--rw schedule-duration? string
    | | |   +--rw repeat-interval? string
    | | +--rw admin-status?       te-admin-status
    | +--rw connectivity-matrix* [id]
    | | +--rw id                  uint32
    | | +--rw from
    | | | +--rw tp-ref?          leafref
    | | | +--rw to
    | | | | +--rw tp-ref?        leafref
    | | | +--rw is-allowed?      boolean
    | +--rw domain-id?           uint32
    | +--rw is-abstract?         empty
    | +--rw name?                inet:domain-name

```



```

|     +--rw signaling-address*      inet:ip-address
|     +--rw underlay-topology {te-topology-hierarchy}?
|         +--rw provider-id-ref?    leafref
|         +--rw client-id-ref?      leafref
|         +--rw te-topology-id-ref? leafref
|         +--rw network-id-ref?     leafref
+--ro state
| +--ro te-node-template*          leafref {template}?
| +--ro te-node-attributes
| | +--ro schedules
| | | +--ro schedule* [schedule-id]
| | |     +--ro schedule-id        uint32
| | |     +--ro start?             yang:date-and-time
| | |     +--ro schedule-duration? string
| | |     +--ro repeat-interval?   string
| | +--ro admin-status?           te-admin-status
| | +--ro connectivity-matrix* [id]
| | | +--ro id                    uint32
| | | +--ro from
| | | | +--ro tp-ref?            leafref
| | | | +--ro to
| | | | | +--ro tp-ref?         leafref
| | | | +--ro is-allowed?       boolean
| | +--ro domain-id?             uint32
| | +--ro is-abstract?           empty
| | +--ro name?                  inet:domain-name
| | +--ro signaling-address*     inet:ip-address
| | +--ro underlay-topology {te-topology-hierarchy}?
| |     +--ro provider-id-ref?    leafref
| |     +--ro client-id-ref?      leafref
| |     +--ro te-topology-id-ref? leafref
| |     +--ro network-id-ref?     leafref
| +--ro oper-status?             te-oper-status
| +--ro is-multi-access-dr?      empty
| +--ro information-source?       enumeration
| +--ro information-source-state
| | +--ro credibility-preference? uint16
| | +--ro topology
| | | +--ro provider-id-ref?      leafref
| | | +--ro client-id-ref?        leafref
| | | +--ro te-topology-id-ref?   leafref
| | | +--ro network-id-ref?       leafref
| | +--ro routing-instance?      string
| +--ro alt-information-sources* [information-source]
|     +--ro information-source     enumeration
|     +--ro information-source-state

```



```

|   | +--ro credibility-preference?  uint16
|   | +--ro topology
|   | | +--ro provider-id-ref?      leafref
|   | | +--ro client-id-ref?       leafref
|   | | +--ro te-topology-id-ref?  leafref
|   | | +--ro network-id-ref?     leafref
|   | +--ro routing-instance?      string
|   +--ro connectivity-matrix* [id]
|   | +--ro id                    uint32
|   | +--ro from
|   | | +--ro tp-ref?             leafref
|   | +--ro to
|   | | +--ro tp-ref?             leafref
|   | +--ro is-allowed?           boolean
|   +--ro domain-id?              uint32
|   +--ro is-abstract?             empty
|   +--ro name?                    inet:domain-name
|   +--ro signaling-address*       inet:ip-address
|   +--ro underlay-topology {te-topology-hierarchy}?
|       +--ro provider-id-ref?     leafref
|       +--ro client-id-ref?       leafref
|       +--ro te-topology-id-ref?  leafref
|       +--ro network-id-ref?     leafref
+--rw tunnel-termination-point* [tunnel-tp-id]
    +--rw tunnel-tp-id    binary
    +--rw config
    | +--rw termination-capability* [link-tp]
    | +--rw link-tp      leafref
    +--ro state
    | +--ro termination-capability* [link-tp]
    | +--ro link-tp      leafref
    +--ro switching-capability    identityref
    +--ro encoding                identityref
augment /nw:networks/nw:network/nt:link:
    +--rw te!
    +--rw config
    | +--rw (bundle-stack-level)?
    | | +--:(bundle)
    | | | +--rw bundled-links
    | | | | +--rw bundled-link* [sequence]
    | | | | +--rw sequence      uint32
    | | | | +--rw src-tp-ref?   leafref
    | | | | +--rw des-tp-ref?   leafref
    | | +--:(component)
    | | +--rw component-links
    | | +--rw component-link* [sequence]

```



```

| | +--rw sequence                uint32
| | +--rw src-interface-ref?      string
| | +--rw des-interface-ref?      string
| +--rw te-link-template*         leafref {template}?
| +--rw te-link-attributes
| | +--rw schedules
| | | +--rw schedule* [schedule-id]
| | | | +--rw schedule-id          uint32
| | | | +--rw start?               yang:date-and-time
| | | | +--rw schedule-duration?   string
| | | | +--rw repeat-interval?     string
| | +--rw access-type?            te-link-access-
type
| | +--rw is-abstract?            empty
| | +--rw name?                   string
| | +--rw underlay! {te-topology-hierarchy}?
| | | +--rw underlay-primary-path
| | | | +--rw provider-id-ref?     leafref
| | | | +--rw client-id-ref?       leafref
| | | | +--rw te-topology-id-ref?  leafref
| | | | +--rw network-id-ref?      leafref
| | | | +--rw path-element* [path-element-id]
| | | | | +--rw path-element-id    uint32
| | | | | +--rw (type)?
| | | | | +--:(ipv4-address)
| | | | | | +--rw v4-address?       inet:ipv4-
address
| | | | | | +--rw v4-prefix-length? uint8
| | | | | | +--rw v4-loose?         boolean
| | | | | +--:(ipv6-address)
| | | | | | +--rw v6-address?       inet:ipv6-
address
| | | | | | +--rw v6-prefix-length? uint8
| | | | | | +--rw v6-loose?         boolean
| | | | | +--:(as-number)
| | | | | | +--rw as-number?        uint16
| | | | | +--:(unnumbered-link)
| | | | | | +--rw router-id?        inet:ip-address
| | | | | | +--rw interface-id?     uint32
| | | | | +--:(label)
| | | | | | +--rw value?            uint32
| | | +--rw underlay-backup-path* [index]
| | | | +--rw index                uint32
| | | | +--rw provider-id-ref?     leafref
| | | | +--rw client-id-ref?       leafref
| | | | +--rw te-topology-id-ref?  leafref

```



```

| | | +--rw network-id-ref?      leafref
| | | +--rw path-element* [path-element-id]
| | |   +--rw path-element-id      uint32
| | |   +--rw (type)?
| | |     +--:(ipv4-address)
| | |       | +--rw v4-address?      inet:ipv4-
address
| | |       | +--rw v4-prefix-length?  uint8
| | |       | +--rw v4-loose?         boolean
| | |     +--:(ipv6-address)
| | |       | +--rw v6-address?      inet:ipv6-
address
| | |       | +--rw v6-prefix-length?  uint8
| | |       | +--rw v6-loose?         boolean
| | |     +--:(as-number)
| | |       | +--rw as-number?        uint16
| | |     +--:(unnumbered-link)
| | |       | +--rw router-id?        inet:ip-address
| | |       | +--rw interface-id?    uint32
| | |     +--:(label)
| | |       | +--rw value?           uint32
| | | +--rw underlay-protection-type?  uint16
| | | +--rw underlay-trail-src
| | |   +--rw tp-ref?      leafref
| | |   +--rw node-ref?   leafref
| | |   +--rw network-ref? leafref
| | | +--rw underlay-trail-des
| | |   +--rw tp-ref?      leafref
| | |   +--rw node-ref?   leafref
| | |   +--rw network-ref? leafref
| | +--rw admin-status?      te-admin-status
| +--rw performance-metric-throttle {te-performance-
metric}?
| | +--rw unidirectional-delay-offset?      uint32
| | +--rw measure-interval?                 uint32
| | +--rw advertisement-interval?           uint32
| | +--rw suppression-interval?             uint32
| | +--rw threshold-out
| | | +--rw unidirectional-delay?           uint32
| | | +--rw unidirectional-min-delay?       uint32
| | | +--rw unidirectional-max-delay?       uint32
| | | +--rw unidirectional-delay-variation? uint32
| | +--rw unidirectional-packet-loss?
decimal64
| | +--rw unidirectional-residual-bandwidth?
decimal64

```



```

    | | | +--rw unidirectional-available-bandwidth?
decimal64
    | | | +--rw unidirectional-utilized-bandwidth?
decimal64
    | | +--rw threshold-in
    | | | +--rw unidirectional-delay? uint32
    | | | +--rw unidirectional-min-delay? uint32
    | | | +--rw unidirectional-max-delay? uint32
    | | | +--rw unidirectional-delay-variation? uint32
    | | | +--rw unidirectional-packet-loss?
decimal64
    | | | +--rw unidirectional-residual-bandwidth?
decimal64
    | | | +--rw unidirectional-available-bandwidth?
decimal64
    | | | +--rw unidirectional-utilized-bandwidth?
decimal64
    | | +--rw threshold-accelerated-advertisement
    | | | +--rw unidirectional-delay? uint32
    | | | +--rw unidirectional-min-delay? uint32
    | | | +--rw unidirectional-max-delay? uint32
    | | | +--rw unidirectional-delay-variation? uint32
    | | | +--rw unidirectional-packet-loss?
decimal64
    | | +--rw unidirectional-residual-bandwidth?
decimal64
    | | +--rw unidirectional-available-bandwidth?
decimal64
    | | +--rw unidirectional-utilized-bandwidth?
decimal64
    | +--rw link-index? uint64
    | +--rw administrative-group? te-types:admin-
groups
    | +--rw max-link-bandwidth? decimal64
    | +--rw max-resv-link-bandwidth? decimal64
    | +--rw unreserved-bandwidth* [priority]
    | | +--rw priority uint8
    | | +--rw bandwidth? decimal64
    | +--rw te-default-metric? uint32
    | +--rw performance-metric {te-performance-metric}?
    | | +--rw measurement
    | | | +--rw unidirectional-delay? uint32
    | | | +--rw unidirectional-min-delay? uint32
    | | | +--rw unidirectional-max-delay? uint32
    | | | +--rw unidirectional-delay-variation? uint32

```



```

    |      | | +--rw unidirectional-packet-loss?
decimal64
    |      | | +--rw unidirectional-residual-bandwidth?
decimal64
    |      | | +--rw unidirectional-available-bandwidth?
decimal64
    |      | | +--rw unidirectional-utilized-bandwidth?
decimal64
    |      | +--rw normality
    |      | +--rw unidirectional-delay?
performance-metric-normality
    |      | +--rw unidirectional-min-delay?
performance-metric-normality
    |      | +--rw unidirectional-max-delay?
performance-metric-normality
    |      | +--rw unidirectional-delay-variation?
performance-metric-normality
    |      | +--rw unidirectional-packet-loss?
performance-metric-normality
    |      | +--rw unidirectional-residual-bandwidth?
performance-metric-normality
    |      | +--rw unidirectional-available-bandwidth?
performance-metric-normality
    |      | +--rw unidirectional-utilized-bandwidth?
performance-metric-normality
    |      +--rw link-protection-type? enumeration
    |      +--rw interface-switching-capability* [switching-
capability]
    |      | +--rw switching-capability identityref
    |      | +--rw encoding? identityref
    |      | +--rw max-lsp-bandwidth* [priority]
    |      | | +--rw priority uint8
    |      | | +--rw bandwidth? decimal64
    |      | +--rw time-division-multiplex-capable
    |      | | +--rw minimum-lsp-bandwidth? decimal64
    |      | | +--rw indication? enumeration
    |      | +--rw interface-adjustment-capability* [upper-sc]
    |      | +--rw upper-sc identityref
    |      | +--rw upper-encoding? identityref
    |      | +--rw max-lsp-bandwidth* [priority]
    |      | +--rw priority uint8
    |      | +--rw bandwidth? decimal64
    |      +--rw te-srlgs
    |      +--rw values* te-types:srlg
+--ro state
    +--ro (bundle-stack-level)?

```



```

|   +--:(bundle)
|   |   +--ro bundled-links
|   |       +--ro bundled-link* [sequence]
|   |           +--ro sequence          uint32
|   |           +--ro src-tp-ref?       leafref
|   |           +--ro des-tp-ref?       leafref
|   +--:(component)
|       +--ro component-links
|           +--ro component-link* [sequence]
|               +--ro sequence          uint32
|               +--ro src-interface-ref? string
|               +--ro des-interface-ref? string
+--ro te-link-template*          leafref {template}?
+--ro te-link-attributes
|   +--ro schedules
|   |   +--ro schedule* [schedule-id]
|   |       +--ro schedule-id          uint32
|   |       +--ro start?                yang:date-and-time
|   |       +--ro schedule-duration?    string
|   |       +--ro repeat-interval?      string
|   +--ro access-type?              te-link-access-
type
|   +--ro is-abstract?              empty
|   +--ro name?                     string
|   +--ro underlay! {te-topology-hierarchy}?
|   |   +--ro underlay-primary-path
|   |   |   +--ro provider-id-ref?      leafref
|   |   |   +--ro client-id-ref?        leafref
|   |   |   +--ro te-topology-id-ref?    leafref
|   |   |   +--ro network-id-ref?        leafref
|   |   |   +--ro path-element* [path-element-id]
|   |   |       +--ro path-element-id    uint32
|   |   |       +--ro (type)?
|   |   |           +--:(ipv4-address)
|   |   |           |   +--ro v4-address?      inet:ipv4-
address
|   |   |           |   +--ro v4-prefix-length? uint8
|   |   |           |   +--ro v4-loose?        boolean
|   |   |           +--:(ipv6-address)
|   |   |           |   +--ro v6-address?      inet:ipv6-
address
|   |   |           |   +--ro v6-prefix-length? uint8
|   |   |           |   +--ro v6-loose?        boolean
|   |   |           +--:(as-number)
|   |   |           |   +--ro as-number?      uint16
|   |   |           +--:(unnumbered-link)

```



```

| | | | +--ro router-id?          inet:ip-address
| | | | +--ro interface-id?       uint32
| | | | +--:(label)
| | | | +--ro value?              uint32
| | +--ro underlay-backup-path* [index]
| | | +--ro index                  uint32
| | | +--ro provider-id-ref?      leafref
| | | +--ro client-id-ref?       leafref
| | | +--ro te-topology-id-ref?  leafref
| | | +--ro network-id-ref?     leafref
| | | +--ro path-element* [path-element-id]
| | | | +--ro path-element-id    uint32
| | | | +--ro (type)?
| | | | +--:(ipv4-address)
| | | | | +--ro v4-address?      inet:ipv4-
address
| | | | | +--ro v4-prefix-length? uint8
| | | | | +--ro v4-loose?        boolean
| | | | +--:(ipv6-address)
| | | | | +--ro v6-address?      inet:ipv6-
address
| | | | | +--ro v6-prefix-length? uint8
| | | | | +--ro v6-loose?        boolean
| | | | +--:(as-number)
| | | | | +--ro as-number?       uint16
| | | | +--:(unnumbered-link)
| | | | | +--ro router-id?      inet:ip-address
| | | | | +--ro interface-id?   uint32
| | | | | +--:(label)
| | | | | +--ro value?          uint32
| | +--ro underlay-protection-type? uint16
| | +--ro underlay-trail-src
| | | +--ro tp-ref?             leafref
| | | +--ro node-ref?          leafref
| | | +--ro network-ref?       leafref
| | +--ro underlay-trail-des
| | | +--ro tp-ref?             leafref
| | | +--ro node-ref?          leafref
| | | +--ro network-ref?       leafref
| +--ro admin-status?           te-admin-status
| +--ro performance-metric-throttle {te-performance-
metric}?
| | +--ro unidirectional-delay-offset? uint32
| | +--ro measure-interval?          uint32
| | +--ro advertisement-interval?    uint32
| | +--ro suppression-interval?      uint32

```



```

    | | +--ro threshold-out
    | | | +--ro unidirectional-delay?          uint32
    | | | +--ro unidirectional-min-delay?      uint32
    | | | +--ro unidirectional-max-delay?      uint32
    | | | +--ro unidirectional-delay-variation? uint32
    | | | +--ro unidirectional-packet-loss?
decimal64
    | | | +--ro unidirectional-residual-bandwidth?
decimal64
    | | | +--ro unidirectional-available-bandwidth?
decimal64
    | | | +--ro unidirectional-utilized-bandwidth?
decimal64
    | | +--ro threshold-in
    | | | +--ro unidirectional-delay?          uint32
    | | | +--ro unidirectional-min-delay?      uint32
    | | | +--ro unidirectional-max-delay?      uint32
    | | | +--ro unidirectional-delay-variation? uint32
    | | | +--ro unidirectional-packet-loss?
decimal64
    | | | +--ro unidirectional-residual-bandwidth?
decimal64
    | | | +--ro unidirectional-available-bandwidth?
decimal64
    | | | +--ro unidirectional-utilized-bandwidth?
decimal64
    | | +--ro threshold-accelerated-advertisement
    | | | +--ro unidirectional-delay?          uint32
    | | | +--ro unidirectional-min-delay?      uint32
    | | | +--ro unidirectional-max-delay?      uint32
    | | | +--ro unidirectional-delay-variation? uint32
    | | | +--ro unidirectional-packet-loss?
decimal64
    | | +--ro unidirectional-residual-bandwidth?
decimal64
    | | +--ro unidirectional-available-bandwidth?
decimal64
    | | +--ro unidirectional-utilized-bandwidth?
decimal64
    | +--ro link-index?          uint64
    | +--ro administrative-group? te-types:admin-
groups
    | +--ro max-link-bandwidth?    decimal64
    | +--ro max-resv-link-bandwidth? decimal64
    | +--ro unreserved-bandwidth* [priority]
    | | +--ro priority            uint8

```



```

    | | +--ro bandwidth?    decimal64
    | +--ro te-default-metric?          uint32
    | +--ro performance-metric {te-performance-metric}?
    | | +--ro measurement
    | | | +--ro unidirectional-delay?          uint32
    | | | +--ro unidirectional-min-delay?      uint32
    | | | +--ro unidirectional-max-delay?      uint32
    | | | +--ro unidirectional-delay-variation? uint32
    | | | +--ro unidirectional-packet-loss?
decimal64
    | | | +--ro unidirectional-residual-bandwidth?
decimal64
    | | | +--ro unidirectional-available-bandwidth?
decimal64
    | | | +--ro unidirectional-utilized-bandwidth?
decimal64
    | | +--ro normality
    | | +--ro unidirectional-delay?
performance-metric-normality
    | | +--ro unidirectional-min-delay?
performance-metric-normality
    | | +--ro unidirectional-max-delay?
performance-metric-normality
    | | +--ro unidirectional-delay-variation?
performance-metric-normality
    | | +--ro unidirectional-packet-loss?
performance-metric-normality
    | | +--ro unidirectional-residual-bandwidth?
performance-metric-normality
    | | +--ro unidirectional-available-bandwidth?
performance-metric-normality
    | | +--ro unidirectional-utilized-bandwidth?
performance-metric-normality
    | +--ro link-protection-type?          enumeration
    | +--ro interface-switching-capability* [switching-
capability]
    | | +--ro switching-capability          identityref
    | | +--ro encoding?                     identityref
    | | +--ro max-lsp-bandwidth* [priority]
    | | | +--ro priority    uint8
    | | | +--ro bandwidth?  decimal64
    | | +--ro time-division-multiplex-capable
    | | | +--ro minimum-lsp-bandwidth?    decimal64
    | | | +--ro indication?              enumeration
    | | +--ro interface-adjustment-capability* [upper-sc]
    | | +--ro upper-sc                  identityref

```



```

    | |      +--ro upper-encoding?      identityref
    | |      +--ro max-lsp-bandwidth* [priority]
    | |      +--ro priority      uint8
    | |      +--ro bandwidth?      decimal64
    | +--ro te-srlgs
    |   +--ro values*      te-types:srlg
+--ro oper-status?      te-oper-status
+--ro information-source?      enumeration
+--ro information-source-state
| +--ro credibility-preference?      uint16
| +--ro topology
| | +--ro provider-id-ref?      leafref
| | +--ro client-id-ref?      leafref
| | +--ro te-topology-id-ref?      leafref
| | +--ro network-id-ref?      leafref
| +--ro routing-instance?      string
+--ro alt-information-sources* [information-source]
| +--ro information-source      enumeration
| +--ro information-source-state
| | +--ro credibility-preference?      uint16
| | +--ro topology
| | | +--ro provider-id-ref?      leafref
| | | +--ro client-id-ref?      leafref
| | | +--ro te-topology-id-ref?      leafref
| | | +--ro network-id-ref?      leafref
| | +--ro routing-instance?      string
| +--ro link-index?      uint64
| +--ro administrative-group?      te-types:admin-
groups
| +--ro max-link-bandwidth?      decimal64
| +--ro max-resv-link-bandwidth?      decimal64
| +--ro unreserved-bandwidth* [priority]
| | +--ro priority      uint8
| | +--ro bandwidth?      decimal64
| +--ro te-default-metric?      uint32
| +--ro performance-metric {te-performance-metric}?
| | +--ro measurement
| | | +--ro unidirectional-delay?      uint32
| | | +--ro unidirectional-min-delay?      uint32
| | | +--ro unidirectional-max-delay?      uint32
| | | +--ro unidirectional-delay-variation?      uint32
| | | +--ro unidirectional-packet-loss?
decimal64
| | | +--ro unidirectional-residual-bandwidth?
decimal64

```



```

    | | | +--ro unidirectional-available-bandwidth?
decimal64
    | | | +--ro unidirectional-utilized-bandwidth?
decimal64
    | | +--ro normality
    | | +--ro unidirectional-delay?
performance-metric-normality
    | | +--ro unidirectional-min-delay?
performance-metric-normality
    | | +--ro unidirectional-max-delay?
performance-metric-normality
    | | +--ro unidirectional-delay-variation?
performance-metric-normality
    | | +--ro unidirectional-packet-loss?
performance-metric-normality
    | | +--ro unidirectional-residual-bandwidth?
performance-metric-normality
    | | +--ro unidirectional-available-bandwidth?
performance-metric-normality
    | | +--ro unidirectional-utilized-bandwidth?
performance-metric-normality
    | +--ro link-protection-type? enumeration
    | +--ro interface-switching-capability* [switching-
capability]
    | | +--ro switching-capability identityref
    | | +--ro encoding? identityref
    | | +--ro max-lsp-bandwidth* [priority]
    | | | +--ro priority uint8
    | | | +--ro bandwidth? decimal64
    | | +--ro time-division-multiplex-capable
    | | | +--ro minimum-lsp-bandwidth? decimal64
    | | | +--ro indication? enumeration
    | | +--ro interface-adjustment-capability* [upper-sc]
    | | +--ro upper-sc identityref
    | | +--ro upper-encoding? identityref
    | | +--ro max-lsp-bandwidth* [priority]
    | | +--ro priority uint8
    | | +--ro bandwidth? decimal64
    | +--ro te-srlgs
    | +--ro values* te-types:srlg
+--ro recovery
    | +--ro restoration-status? te-recovery-status
    | +--ro protection-status? te-recovery-status
+--ro underlay {te-topology-hierarchy}?
    +--ro dynamic? boolean
    +--ro committed? boolean

```



```

augment /nw:networks/nw:network/nw:node/nt:termination-point:
  +--rw te!
    +--rw te-tp-id      te-tp-id
    +--rw config
      | +--rw schedules
      |   +--rw schedule* [schedule-id]
      |     +--rw schedule-id      uint32
      |     +--rw start?           yang:date-and-time
      |     +--rw schedule-duration? string
      |     +--rw repeat-interval? string
    +--ro state
      +--ro schedules
        +--ro schedule* [schedule-id]
          +--ro schedule-id      uint32
          +--ro start?           yang:date-and-time
          +--ro schedule-duration? string
          +--ro repeat-interval? string

notifications:
  +---n te-node-event
    | +--ro event-type?           te-topology-event-type
    | +--ro node-ref?             leafref
    | +--ro network-ref?         leafref
    | +--ro te-topology!
    | +--ro te-node-attributes
    | | +--ro schedules
    | | | +--ro schedule* [schedule-id]
    | | |   +--ro schedule-id      uint32
    | | |   +--ro start?           yang:date-and-time
    | | |   +--ro schedule-duration? string
    | | |   +--ro repeat-interval? string
    | | +--ro admin-status?       te-admin-status
    | | +--ro connectivity-matrix* [id]
    | | | +--ro id                uint32
    | | | +--ro from
    | | | | +--ro tp-ref?         leafref
    | | | | +--ro node-ref?       leafref
    | | | | +--ro network-ref?    leafref
    | | | +--ro to
    | | | | +--ro tp-ref?         leafref
    | | | | +--ro node-ref?       leafref
    | | | | +--ro network-ref?    leafref
    | | | +--ro is-allowed?       boolean
    | | +--ro domain-id?          uint32
    | | +--ro is-abstract?         empty
    | | +--ro name?               inet:domain-name
    | | +--ro signaling-address*   inet:ip-address

```



```

| | +--ro underlay-topology {te-topology-hierarchy}?
| |   +--ro provider-id-ref?      leafref
| |   +--ro client-id-ref?       leafref
| |   +--ro te-topology-id-ref?  leafref
| |   +--ro network-id-ref?     leafref
| +--ro oper-status?            te-oper-status
| +--ro is-multi-access-dr?     empty
| +--ro information-source?     enumeration
| +--ro information-source-state
| | +--ro credibility-preference? uint16
| | +--ro topology
| | | +--ro provider-id-ref?      leafref
| | | +--ro client-id-ref?       leafref
| | | +--ro te-topology-id-ref?  leafref
| | | +--ro network-id-ref?     leafref
| | +--ro routing-instance?      string
| +--ro alt-information-sources* [information-source]
|   +--ro information-source      enumeration
|   +--ro information-source-state
|   | +--ro credibility-preference? uint16
|   | +--ro topology
|   | | +--ro provider-id-ref?      leafref
|   | | +--ro client-id-ref?       leafref
|   | | +--ro te-topology-id-ref?  leafref
|   | | +--ro network-id-ref?     leafref
|   | +--ro routing-instance?      string
| +--ro connectivity-matrix* [id]
|   +--ro id                      uint32
|   +--ro from
|   | +--ro tp-ref?              leafref
|   | +--ro node-ref?           leafref
|   | +--ro network-ref?        leafref
|   +--ro to
|   | +--ro tp-ref?              leafref
|   | +--ro node-ref?           leafref
|   | +--ro network-ref?        leafref
|   +--ro is-allowed?            boolean
| +--ro domain-id?                uint32
| +--ro is-abstract?              empty
| +--ro name?                     inet:domain-name
| +--ro signaling-address*        inet:ip-address
| +--ro underlay-topology {te-topology-hierarchy}?
|   +--ro provider-id-ref?      leafref
|   +--ro client-id-ref?       leafref
|   +--ro te-topology-id-ref?  leafref
|   +--ro network-id-ref?     leafref

```



```

+---n te-link-event
  +--ro event-type?          te-topology-event-type
  +--ro link-ref?            leafref
  +--ro network-ref?         leafref
  +--ro te-topology!
  +--ro te-link-attributes
  | +--ro schedules
  | | +--ro schedule* [schedule-id]
  | |   +--ro schedule-id      uint32
  | |   +--ro start?           yang:date-and-time
  | |   +--ro schedule-duration? string
  | |   +--ro repeat-interval? string
  | +--ro access-type?        te-link-access-type
  | +--ro is-abstract?        empty
  | +--ro name?               string
  | +--ro underlay! {te-topology-hierarchy}?
  | | +--ro underlay-primary-path
  | | | +--ro provider-id-ref?  leafref
  | | | +--ro client-id-ref?    leafref
  | | | +--ro te-topology-id-ref? leafref
  | | | +--ro network-id-ref?   leafref
  | | | +--ro path-element* [path-element-id]
  | | |   +--ro path-element-id  uint32
  | | |   +--ro (type)?
  | | |     +--:(ipv4-address)
  | | |       | +--ro v4-address?  inet:ipv4-address
  | | |       | +--ro v4-prefix-length? uint8
  | | |       | +--ro v4-loose?    boolean
  | | |       +--:(ipv6-address)
  | | |       | +--ro v6-address?  inet:ipv6-address
  | | |       | +--ro v6-prefix-length? uint8
  | | |       | +--ro v6-loose?    boolean
  | | |       +--:(as-number)
  | | |       | +--ro as-number?    uint16
  | | |       +--:(unnumbered-link)
  | | |       | +--ro router-id?    inet:ip-address
  | | |       | +--ro interface-id? uint32
  | | |       +--:(label)
  | | |       +--ro value?          uint32
  | | +--ro underlay-backup-path* [index]
  | | | +--ro index                uint32
  | | | +--ro provider-id-ref?      leafref
  | | | +--ro client-id-ref?        leafref
  | | | +--ro te-topology-id-ref?    leafref
  | | | +--ro network-id-ref?        leafref
  | | | +--ro path-element* [path-element-id]

```



```

| | | +--ro path-element-id      uint32
| | | +--ro (type)?
| | |   +--:(ipv4-address)
| | |     | +--ro v4-address?      inet:ipv4-address
| | |     | +--ro v4-prefix-length? uint8
| | |     | +--ro v4-loose?        boolean
| | |   +--:(ipv6-address)
| | |     | +--ro v6-address?      inet:ipv6-address
| | |     | +--ro v6-prefix-length? uint8
| | |     | +--ro v6-loose?        boolean
| | |   +--:(as-number)
| | |     | +--ro as-number?        uint16
| | |   +--:(unnumbered-link)
| | |     | +--ro router-id?        inet:ip-address
| | |     | +--ro interface-id?     uint32
| | |   +--:(label)
| | |     +--ro value?              uint32
| | +--ro underlay-protection-type? uint16
| | +--ro underlay-trail-src
| | | +--ro tp-ref?      leafref
| | | +--ro node-ref?    leafref
| | | +--ro network-ref? leafref
| | +--ro underlay-trail-des
| | | +--ro tp-ref?      leafref
| | | +--ro node-ref?    leafref
| | | +--ro network-ref? leafref
| | +--ro dynamic?      boolean
| | +--ro committed?    boolean
| +--ro admin-status?    te-admin-status
| +--ro performance-metric-throttle {te-performance-metric}?
| | +--ro unidirectional-delay-offset?      uint32
| | +--ro measure-interval?                  uint32
| | +--ro advertisement-interval?            uint32
| | +--ro suppression-interval?              uint32
| | +--ro threshold-out
| | | +--ro unidirectional-delay?            uint32
| | | +--ro unidirectional-min-delay?        uint32
| | | +--ro unidirectional-max-delay?        uint32
| | | +--ro unidirectional-delay-variation?  uint32
| | | +--ro unidirectional-packet-loss?      decimal64
| | | +--ro unidirectional-residual-bandwidth? decimal64
| | | +--ro unidirectional-available-bandwidth? decimal64
| | | +--ro unidirectional-utilized-bandwidth? decimal64
| | +--ro threshold-in
| | | +--ro unidirectional-delay?            uint32
| | | +--ro unidirectional-min-delay?        uint32

```



```

    | | | +--ro unidirectional-max-delay?          uint32
    | | | +--ro unidirectional-delay-variation?     uint32
    | | | +--ro unidirectional-packet-loss?         decimal64
    | | | +--ro unidirectional-residual-bandwidth?  decimal64
    | | | +--ro unidirectional-available-bandwidth? decimal64
    | | | +--ro unidirectional-utilized-bandwidth?  decimal64
    | | +--ro threshold-accelerated-advertisement
    | |   +--ro unidirectional-delay?               uint32
    | |   +--ro unidirectional-min-delay?           uint32
    | |   +--ro unidirectional-max-delay?           uint32
    | |   +--ro unidirectional-delay-variation?     uint32
    | |   +--ro unidirectional-packet-loss?         decimal64
    | |   +--ro unidirectional-residual-bandwidth?  decimal64
    | |   +--ro unidirectional-available-bandwidth? decimal64
    | |   +--ro unidirectional-utilized-bandwidth?  decimal64
    | +--ro link-index?                             uint64
    | +--ro administrative-group?                   te-types:admin-
groups
    | +--ro max-link-bandwidth?                     decimal64
    | +--ro max-resv-link-bandwidth?                 decimal64
    | +--ro unreserved-bandwidth* [priority]
    | | +--ro priority      uint8
    | | +--ro bandwidth?   decimal64
    | +--ro te-default-metric?                      uint32
    | +--ro performance-metric {te-performance-metric}?
    | | +--ro measurement
    | | | +--ro unidirectional-delay?               uint32
    | | | +--ro unidirectional-min-delay?           uint32
    | | | +--ro unidirectional-max-delay?           uint32
    | | | +--ro unidirectional-delay-variation?     uint32
    | | | +--ro unidirectional-packet-loss?         decimal64
    | | | +--ro unidirectional-residual-bandwidth?  decimal64
    | | | +--ro unidirectional-available-bandwidth? decimal64
    | | | +--ro unidirectional-utilized-bandwidth?  decimal64
    | | +--ro normality
    | |   +--ro unidirectional-delay?
performance-metric-normality
    | |   +--ro unidirectional-min-delay?
performance-metric-normality
    | |   +--ro unidirectional-max-delay?
performance-metric-normality
    | |   +--ro unidirectional-delay-variation?
performance-metric-normality
    | |   +--ro unidirectional-packet-loss?
performance-metric-normality

```



```

    | |      +--ro unidirectional-residual-bandwidth?
performance-metric-normality
    | |      +--ro unidirectional-available-bandwidth?
performance-metric-normality
    | |      +--ro unidirectional-utilized-bandwidth?
performance-metric-normality
    | +--ro link-protection-type?          enumeration
    | +--ro interface-switching-capability* [switching-
capability]
    | | +--ro switching-capability          identityref
    | | +--ro encoding?                    identityref
    | | +--ro max-lsp-bandwidth* [priority]
    | | | +--ro priority      uint8
    | | | +--ro bandwidth?   decimal64
    | | +--ro time-division-multiplex-capable
    | | | +--ro minimum-lsp-bandwidth?   decimal64
    | | | +--ro indication?      enumeration
    | | +--ro interface-adjustment-capability* [upper-sc]
    | |   +--ro upper-sc          identityref
    | |   +--ro upper-encoding?   identityref
    | |   +--ro max-lsp-bandwidth* [priority]
    | |     +--ro priority      uint8
    | |     +--ro bandwidth?   decimal64
    | +--ro te-srlgs
    |   +--ro values*   te-types:srlg
+--ro oper-status?      te-oper-status
+--ro information-source? enumeration
+--ro information-source-state
| +--ro credibility-preference?  uint16
| +--ro topology
| | +--ro provider-id-ref?      leafref
| | +--ro client-id-ref?       leafref
| | +--ro te-topology-id-ref?   leafref
| | +--ro network-id-ref?      leafref
| +--ro routing-instance?      string
+--ro alt-information-sources* [information-source]
| +--ro information-source      enumeration
| +--ro information-source-state
| | +--ro credibility-preference?  uint16
| | +--ro topology
| | | +--ro provider-id-ref?      leafref
| | | +--ro client-id-ref?       leafref
| | | +--ro te-topology-id-ref?   leafref
| | | +--ro network-id-ref?      leafref
| | +--ro routing-instance?      string
| +--ro link-index?            uint64

```



```

    | +--ro administrative-group?          te-types:admin-
groups
    | +--ro max-link-bandwidth?            decimal64
    | +--ro max-resv-link-bandwidth?       decimal64
    | +--ro unreserved-bandwidth* [priority]
    | | +--ro priority      uint8
    | | +--ro bandwidth?   decimal64
    | +--ro te-default-metric?              uint32
    | +--ro performance-metric {te-performance-metric}?
    | | +--ro measurement
    | | | +--ro unidirectional-delay?      uint32
    | | | +--ro unidirectional-min-delay?  uint32
    | | | +--ro unidirectional-max-delay?  uint32
    | | | +--ro unidirectional-delay-variation?  uint32
    | | | +--ro unidirectional-packet-loss? decimal64
    | | | +--ro unidirectional-residual-bandwidth? decimal64
    | | | +--ro unidirectional-available-bandwidth? decimal64
    | | | +--ro unidirectional-utilized-bandwidth? decimal64
    | | +--ro normality
    | | +--ro unidirectional-delay?
performance-metric-normality
    | | +--ro unidirectional-min-delay?
performance-metric-normality
    | | +--ro unidirectional-max-delay?
performance-metric-normality
    | | +--ro unidirectional-delay-variation?
performance-metric-normality
    | | +--ro unidirectional-packet-loss?
performance-metric-normality
    | | +--ro unidirectional-residual-bandwidth?
performance-metric-normality
    | | +--ro unidirectional-available-bandwidth?
performance-metric-normality
    | | +--ro unidirectional-utilized-bandwidth?
performance-metric-normality
    | +--ro link-protection-type?          enumeration
    | +--ro interface-switching-capability* [switching-
capability]
    | | +--ro switching-capability          identityref
    | | +--ro encoding?                    identityref
    | | +--ro max-lsp-bandwidth* [priority]
    | | | +--ro priority      uint8
    | | | +--ro bandwidth?   decimal64
    | | +--ro time-division-multiplex-capable
    | | | +--ro minimum-lsp-bandwidth?    decimal64
    | | | +--ro indication?              enumeration

```



```

| | +--ro interface-adjustment-capability* [upper-sc]
| |   +--ro upper-sc          identityref
| |   +--ro upper-encoding?   identityref
| |   +--ro max-lsp-bandwidth* [priority]
| |       +--ro priority      uint8
| |       +--ro bandwidth?    decimal64
| +--ro te-srlgs
|   +--ro values*    te-types:srlg
+--ro recovery
| +--ro restoration-status?    te-recovery-status
| +--ro protection-status?     te-recovery-status
+--ro underlay {te-topology-hierarchy}?
    +--ro dynamic?             boolean
    +--ro committed?           Boolean

```

6.2. Packet Switching TE Topology Module

```

module: ietf-te-topology-psc
augment /nw:networks/tet:te/tet:templates/tet:link-template/tet:te-
link-attributes/tet:interface-switching-capability:
  +--rw packet-switch-capable
  +--rw minimum-lsp-bandwidth?    decimal64
  +--rw interface-mtu?            uint16
augment /nw:networks/nw:network/nt:link/tet:te/tet:config/tet:te-
link-attributes/tet:interface-switching-capability:
  +--rw packet-switch-capable
  +--rw minimum-lsp-bandwidth?    decimal64
  +--rw interface-mtu?            uint16
augment /nw:networks/nw:network/nt:link/tet:te/tet:state/tet:te-
link-attributes/tet:interface-switching-capability:
  +--ro packet-switch-capable
  +--ro minimum-lsp-bandwidth?    decimal64
  +--ro interface-mtu?            uint16
augment /nw:networks/nw:network/nt:link/tet:te/tet:state/tet:alt-
information-sources/tet:interface-switching-capability:
  +--ro packet-switch-capable
  +--ro minimum-lsp-bandwidth?    decimal64
  +--ro interface-mtu?            uint16
augment /tet:te-link-event/tet:te-link-attributes/tet:interface-
switching-capability:
  +---- packet-switch-capable
  +---- minimum-lsp-bandwidth?    decimal64
  +---- interface-mtu?            uint16
augment /tet:te-link-event/tet:alt-information-
sources/tet:interface-switching-capability:
  +---- packet-switch-capable

```



```
+---- minimum-lsp-bandwidth?    decimal64
+---- interface-mtu?            uint16
```

7. TE Topology Yang Modules

7.1. Base TE Topology Module

```
<CODE BEGINS> file "ietf-te-topology@2016-03-17.yang"
module iETF-te-topology {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-te-topology";
  // replace with IANA namespace when assigned

  prefix "tet";

  import iETF-inet-types {
    prefix "inet";
  }

  import iETF-schedule {
    prefix "sch";
  }

  import iETF-te-types {
    prefix "te-types";
  }

  import iETF-network {
    prefix "nw";
  }

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

  organization
    "Traffic Engineering Architecture and Signaling (TEAS)
    Working Group";

  contact
    "WG Web:    <http://tools.ietf.org/wg/teas/>
```

WG List: <mailto:teas@ietf.org>

WG Chair: Lou Berger
<mailto:lberger@labn.net>

WG Chair: Vishnu Pavan Beeram
<mailto:vbeeram@juniper.net>

Editor: Xufeng Liu
<mailto:xliu@kuatrotech.com>

Editor: Igor Bryskin
<mailto:Igor.Bryskin@huawei.com>

Editor: Vishnu Pavan Beeram
<mailto:vbeeram@juniper.net>

Editor: Tarek Saad
<mailto:tsaad@cisco.com>

Editor: Himanshu Shah
<mailto:hshah@ciena.com>

Editor: Oscar Gonzalez De Dios
<mailto:oscar.gonzalezdedios@telefonica.com>;

description "TE topology model";

```
revision "2016-03-17" {  
  description "Initial revision";  
  reference "TBD";  
}
```

```
/*  
 * Features  
 */
```

```
feature configuration-schedule {  
  description  
    "This feature indicates that the system supports
```

```
        configuration scheduling.";
    }

    feature te-topology-hierarchy {
        description
            "This feature indicates that the system allows underlay
            and/or overlay TE topology hierarchy.";
    }

    feature te-performance-metric {
        description
            "This feature indicates that the system supports
            TE performance metric defined in
            RFC7471: OSPF Traffic Engineering (TE) Metric Extensions.";
    }

    feature template {
        description
            "This feature indicates that the system supports
            template configuration.";
    }

    /*
     * Typedefs
     */
    typedef performance-metric-normality {
        type enumeration {
            enum "unknown" {
                value 0;
                description
                    "Unknown.";
            }
            enum "normal" {
                value 1;
                description
                    "Normal.";
            }
            enum "abnormal" {
                value 2;
                description
```

```
        "Abnormal. The anomalous bit is set.";
    }
}
description
    "Indicates whether a performance metric is normal, abnormal,
or
    unknown.";
reference
    "RFC7471: OSPF Traffic Engineering (TE) Metric Extensions.";
}

typedef te-admin-status {
    type enumeration {
        enum up {
            description
                "Enabled.";
        }
        enum down {
            description
                "Disabled.";
        }
        enum testing {
            description
                "In some test mode.";
        }
        enum preparing-maintenance {
            description
                "Resource is disabled in the control plane to prepare for
                graceful shutdown for maintenance purposes.";
            reference
                "RFC5817: Graceful Shutdown in MPLS and Generalized MPLS
                Traffic Engineering Networks";
        }
        enum maintenance {
            description
                "Resource is disabled in the data plane for maintenance
                purposes.";
        }
    }
}
description
```

```
"Defines a type representing the administrative status of
  a TE resource.";
}

typedef te-global-id {
  type uint32;
  description
    "An identifier to uniquely identify an operator, which can be
     either a provider or a client.
     The definition of this type is taken from RFC6370 and
RFC5003.
     This attribute type is used solely to provide a globally
     unique context for TE topologies.";
}

typedef te-link-access-type {
  type enumeration {
    enum point-to-point {
      description
        "The link is point-to-point.";
    }
    enum multi-access {
      description
        "The link is multi-access, including broadcast and NBMA.";
    }
  }
  description
    "Defines a type representing the access type of a TE link.";
  reference
    "RFC3630: Traffic Engineering (TE) Extensions to OSPF
    Version 2.";
}

typedef te-node-id {
  type inet:ip-address;
  description
    "An identifier for a node in a topology.
     The identifier is represented as an IPv4 or IPv6 address.
     This attribute is mapped to Router ID in
     RFC3630, RFC5329, RFC5305, and RFC 6119.";
}
```

```
}

typedef te-oper-status {
  type enumeration {
    enum up {
      description
        "Operational up.";
    }
    enum down {
      description
        "Operational down.";
    }
    enum testing {
      description
        "In some test mode.";
    }
    enum unknown {
      description
        "Status cannot be determined for some reason.";
    }
    enum preparing-maintenance {
      description
        "Resource is disabled in the control plane to prepare for
        graceful shutdown for maintenance purposes.";
      reference
        "RFC5817: Graceful Shutdown in MPLS and Generalized MPLS
        Traffic Engineering Networks";
    }
    enum maintenance {
      description
        "Resource is disabled in the data plane for maintenance
        purposes.";
    }
  }
  description
    "Defines a type representing the operational status of
    a TE resource.";
}

typedef te-recovery-status {
```

```
type enumeration {
  enum normal {
    description
      "Both the recovery and working spans are fully
      allocated and active, data traffic is being
      transported over (or selected from) the working
      span, and no trigger events are reported.";
  }
  enum recovery-started {
    description
      "The recovery action has been started, but not
      completed.";
  }
  enum recovery-succeeded {
    description
      "The recovery action has succeeded. The working span has
      reported a failure/degrade condition and the user traffic
      is being transported (or selected) on the recovery
      span.";
  }
  enum recovery-failed {
    description
      "The recovery action has failed.";
  }
  enum reversion-started {
    description
      "The reversion has started.";
  }
  enum reversion-failed {
    description
      "The reversion has failed.";
  }
  enum recovery-unavailable {
    description
      "The recovery is unavailable -- either as a result of an
      operator Lockout command or a failure condition detected
      on the recovery span.";
  }
  enum recovery-admin {
    description
```

```
        "The operator has issued a command switching the user
        traffic to the recovery span.";
    }
    enum wait-to-restore {
        description
            "The recovery domain is recovering from a failuer/degrade
            condition on the working span that is being controlled by
            the Wait-to-Restore (WTR) timer.";
    }
}
description
    "Defines the status of a recovery action.";
reference
    "RFC4427: Recovery (Protection and Restoration) Terminology
    for Generalized Multi-Protocol Label Switching (GMPLS).
    RFC6378: MPLS Transport Profile (MPLS-TP) Linear Protection";
}

typedef te-template-name {
    type string {
        pattern '/?([a-zA-Z0-9\-\_\.]+)(/[a-zA-Z0-9\-\_\.]+)*';
    }
    description
        "A type for the name of a TE node template or TE link
        template.";
}

typedef te-topology-event-type {
    type enumeration {
        enum "add" {
            value 0;
            description
                "A TE node or te-link has been added.";
        }
        enum "remove" {
            value 1;
            description
                "A TE node or te-link has been removed.";
        }
        enum "update" {
```

```
        value 2;
        description
            "A TE node or te-link has been updated.";
    }
}
description "TE Event type for notifications";
} // te-topology-event-type

typedef te-topology-id {
    type string {
        pattern '/?([a-zA-Z0-9\-\_\.]+)(/[a-zA-Z0-9\-\_\.]+)*';
    }
    description
        "An identifier for a topology.";
}

typedef te-tp-id {
    type union {
        type uint32;           // Unnumbered
        type inet:ip-address; // IPv4 or IPv6 address
    }
    description
        "An identifier for a TE link endpoint on a node.
        This attribute is mapped to local or remote link identifier
in
    RFC3630 and RFC5305.";
}

/*
 * Identities
 */

/*
 * Groupings
 */
grouping information-source-attributes {
    description
        "The attributes identifying source that has provided the
        related information, and the source credibility.";
    leaf information-source {
```

```
type enumeration {
  enum "unknown" {
    description "The source is unknown.";
  }
  enum "locally-configured" {
    description "Configured entity.";
  }
  enum "ospfv2" {
    description "OSPFv2.";
  }
  enum "ospfv3" {
    description "OSPFv3.";
  }
  enum "isis" {
    description "ISIS.";
  }
  enum "system-processed" {
    description "System processed entity.";
  }
  enum "other" {
    description "Other source.";
  }
}
description
  "Indicates the source of the information.";
}
container information-source-state {
  description
    "The container contains state attributes related to
    the information source.";
  leaf credibility-preference {
    type uint16;
    description
      "The preference value to calculate the traffic
      engineering database credibility value used for
      tie-break selection between different
      information-source values.
      Higher value is more preferable.";
  }
}
container topology {
```

```
        description
            "When the information is processed by the system,
            the attributes in this container indicate which topology
            is used to process to generate the result information.";
        uses te-topology-ref;
    } // topology
    leaf routing-instance {
        type string;
        description
            "When applicable, this is the name of a routing instance
            from which the information is learned.";
    } // routing-information
}
} // information-source-attributes

grouping performance-metric-attributes {
    description
        "Link performance information in real time.";
    reference
        "RFC7471: OSPF Traffic Engineering (TE) Metric Extensions.";
    leaf unidirectional-delay {
        type uint32 {
            range 0..16777215;
        }
        description "Delay or latency in micro seconds.";
    }
    leaf unidirectional-min-delay {
        type uint32 {
            range 0..16777215;
        }
        description "Minimum delay or latency in micro seconds.";
    }
    leaf unidirectional-max-delay {
        type uint32 {
            range 0..16777215;
        }
        description "Maximum delay or latency in micro seconds.";
    }
    leaf unidirectional-delay-variation {
        type uint32 {
```

```
        range 0..16777215;
    }
    description "Delay variation in micro seconds.";
}
leaf unidirectional-packet-loss {
    type decimal64 {
        fraction-digits 6;
        range "0 .. 50.331642";
    }
    description
        "Packet loss as a percentage of the total traffic sent
        over a configurable interval. The finest precision is
        0.000003%.";
}
leaf unidirectional-residual-bandwidth {
    type decimal64 {
        fraction-digits 2;
    }
    description
        "Residual bandwidth that subtracts tunnel
        reservations from Maximum Bandwidth (or link capacity)
        [RFC3630] and provides an aggregated remainder across QoS
        classes.";
}
leaf unidirectional-available-bandwidth {
    type decimal64 {
        fraction-digits 2;
    }
    description
        "Available bandwidth that is defined to be residual
        bandwidth minus the measured bandwidth used for the
        actual forwarding of non-RSVP-TE LSP packets. For a
        bundled link, available bandwidth is defined to be the
        sum of the component link available bandwidths.";
}
leaf unidirectional-utilized-bandwidth {
    type decimal64 {
        fraction-digits 2;
    }
    description
```

```
        "Bandwidth utilization that represents the actual
        utilization of the link (i.e. as measured in the router).
        For a bundled link, bandwidth utilization is defined to
        be the sum of the component link bandwidth
        utilizations.";
    }
} // performance-metric-attributes

grouping performance-metric-normality-attributes {
    description
        "Link performance metric normality attributes.";
    reference
        "RFC7471: OSPF Traffic Engineering (TE) Metric Extensions.";
    leaf unidirectional-delay {
        type performance-metric-normality;
        description "Delay normality.";
    }
    leaf unidirectional-min-delay {
        type performance-metric-normality;
        description "Minimum delay or latency normality.";
    }
    leaf unidirectional-max-delay {
        type performance-metric-normality;
        description "Maximum delay or latency normality.";
    }
    leaf unidirectional-delay-variation {
        type performance-metric-normality;
        description "Delay variation normality.";
    }
    leaf unidirectional-packet-loss {
        type performance-metric-normality;
        description "Packet loss normality.";
    }
    leaf unidirectional-residual-bandwidth {
        type performance-metric-normality;
        description "Residual bandwidth normality.";
    }
    leaf unidirectional-available-bandwidth {
        type performance-metric-normality;
        description "Available bandwidth normality.";
    }
}
```

```
    }
    leaf unidirectional-utilized-bandwidth {
      type performance-metric-normality;
      description "Bandwidth utilization normality.";
    }
  } // performance-metric-normality-attributes

grouping performance-metric-throttle-container {
  description
    "A container controlling performance metric throttle.";
  container performance-metric-throttle {
    if-feature te-performance-metric;
    must "suppression-interval >= measure-interval" {
      error-message
        "suppression-interval cannot be less than
        measure-interval.";
      description
        "Constraint on suppression-interval and
        measure-interval.";
    }
  }
  description
    "Link performance information in real time.";
  reference
    "RFC7471: OSPF Traffic Engineering (TE) Metric Extensions.";
  leaf unidirectional-delay-offset {
    type uint32 {
      range 0..16777215;
    }
    description
      "Offset value to be added to the measured delay value.";
  }
  leaf measure-interval {
    type uint32;
    default 30;
    description
      "Interval in seconds to measure the extended metric
      values.";
  }
  leaf advertisement-interval {
    type uint32;
```

```
        description
          "Interval in seconds to advertise the extended metric
            values.";
      }
      leaf suppression-interval {
        type uint32 {
          range "1 .. max";
        }
        default 120;
        description
          "Interval in seconds to suppress advertising the extended
            metric values.";
      }
      container threshold-out {
        uses performance-metric-attributes;
        description
          "If the measured parameter falls outside an upper bound
            for all but the min delay metric (or lower bound for
            min-delay metric only) and the advertised value is not
            already outside that bound, anomalous announcement will
be
          triggered.";
      }
      container threshold-in {
        uses performance-metric-attributes;
        description
          "If the measured parameter falls inside an upper bound
            for all but the min delay metric (or lower bound for
            min-delay metric only) and the advertised value is not
            already inside that bound, normal (anomalous-flag
cleared)
          announcement will be triggered.";
      }
      container threshold-accelerated-advertisement {
        description
          "When the difference between the last advertised value and
            current measured value exceed this threshold, anomalous
            announcement will be triggered.";
        uses performance-metric-attributes;
      }
    }
```

```
    }
  } // performance-metric-throttle-container

  grouping te-link-augment {
    description
      "Augmentation for TE link.";

    container te {
      presence "TE support.";
      description
        "Indicates TE support.";

      container config {
        description
          "Configuration data.";
        uses te-link-config;
      } // config
      container state {
        config false;
        description
          "Operational state data.";
        uses te-link-config;
        uses te-link-state-derived;
      } // state
    } // te
  } // te-link-augment

  grouping te-link-config {
    description
      "TE link configuration grouping.";
    choice bundle-stack-level {
      description
        "The TE link can be partitioned into bundled
        links, or component links.";
      case bundle {
        container bundled-links {
          description
            "A set of bundled links.";
          reference
            "RFC4201: Link Bundling in MPLS Traffic Engineering";
        }
      }
    }
  }
}
```

```

    (TE).";
  list bundled-link {
    key "sequence";
    description
      "Specify a bundled interface that is
       further partitioned.";
    leaf sequence {
      type uint32;
      description
        "Identify the sequence in the bundle.";
    }
    leaf src-tp-ref {
      type leafref {
        path "../.../.../.../nw:node[nw:node-id = "
          + "current()/.../.../.../nt:source/"
          + "nt:source-node]/"
          + "nt:termination-point/nt:tp-id";
        require-instance true;
      }
      description
        "Reference to another TE termination point on the
         same source node.";
    }
    leaf des-tp-ref {
      type leafref {
        path "../.../.../.../nw:node[nw:node-id = "
          + "current()/.../.../.../nt:destination/"
          + "nt:dest-node]/"
          + "nt:termination-point/nt:tp-id";
        require-instance true;
      }
      description
        "Reference to another TE termination point on the
         same destination node.";
    }
  } // list bundled-link
}
case component {
  container component-links {

```

```
    description
      "A set of component links";
  list component-link {
    key "sequence";
    description
      "Specify a component interface that is
       sufficient to unambiguously identify the
       appropriate resources";

    leaf sequence {
      type uint32;
      description
        "Identify the sequence in the bundle.";
    }
    leaf src-interface-ref {
      type string;
      description
        "Reference to component link interface on the
         source node.";
    }
    leaf des-interface-ref {
      type string;
      description
        "Reference to component link interface on the
         destination node.";
    }
  }
}
} // bundle-stack-level

leaf-list te-link-template {
  if-feature template;
  type leafref {
    path "../../../../../te/templates/link-template/name";
  }
  description
    "The reference to a TE link template.";
}
uses te-link-config-attributes;
```

```
} // te-link-config

grouping te-link-config-attributes {
  description
    "Link configuration attributes in a TE topology.";
  container te-link-attributes {
    description "Link attributes in a TE topology.";
    uses sch:schedules;
    leaf access-type {
      type te-link-access-type;
      description
        "Link access type, which can be point-to-point or
        multi-access.";
    }
    leaf is-abstract {
      type empty;
      description "Present if the link is abstract.";
    }
    leaf name {
      type string;
      description "Link Name.";
    }
    container underlay {
      if-feature te-topology-hierarchy;
      presence
        "Indicates the underlay exists for this link.";
      description "Attributes of the te-link underlay.";
      reference
        "RFC4206: Label Switched Paths (LSP) Hierarchy with
        Generalized Multi-Protocol Label Switching (GMPLS)
        Traffic Engineering (TE)";

      uses te-link-underlay-attributes;
    } // underlay
    leaf admin-status {
      type te-admin-status;
      description
        "The administrative state of the link.";
    }
  }
}
```

```
    uses performance-metric-throttle-container;
    uses te-link-info-attributes;
  } // te-link-attributes
} // te-link-config-attributes

grouping te-link-info-attributes {
  description
    "Advertised TE information attributes.";
  leaf link-index {
    type uint64;
    description
      "The link identifier.  If OSPF is used, this represents an
      ospfLsdbID.  If IS-IS is used, this represents an
      isisLSPID.
      If a locally configured link is used, this object
      represents
      a unique value, which is locally defined in a router.";
  }
  leaf administrative-group {
    type te-types:admin-groups;
    description
      "Administrative group or color of the link.
      This attribute covers both administrative group (defined in
      RFC3630, RFC5329, and RFC5305), and extended administrative
      group (defined in RFC7308).";
  }
  leaf max-link-bandwidth {
    type decimal64 {
      fraction-digits 2;
    }
    description
      "Maximum bandwidth that can be seen on this link in this
      direction. Units in bytes per second.";
    reference
      "RFC3630: Traffic Engineering (TE) Extensions to OSPF
      Version 2.
      RFC5305: IS-IS Extensions for Traffic Engineering.";
  }
  leaf max-resv-link-bandwidth {
    type decimal64 {
```

```
        fraction-digits 2;
    }
    description
        "Maximum amount of bandwidth that can be reserved in this
        direction in this link. Units in bytes per second.";
    reference
        "RFC3630: Traffic Engineering (TE) Extensions to OSPF
        Version 2.
        RFC5305: IS-IS Extensions for Traffic Engineering.";
}
list unreserved-bandwidth {
    key "priority";
    max-elements "8";
    description
        "Unreserved bandwidth for 0-7 priority levels. Units in
        bytes per second.";
    reference
        "RFC3630: Traffic Engineering (TE) Extensions to OSPF
        Version 2.
        RFC5305: IS-IS Extensions for Traffic Engineering.";
    leaf priority {
        type uint8 {
            range "0..7";
        }
        description "Priority.";
    }
    leaf bandwidth {
        type decimal64 {
            fraction-digits 2;
        }
        description
            "Unreserved bandwidth for this level.";
    }
}
leaf te-default-metric {
    type uint32;
    description
        "Traffic Engineering Metric.";
}
container performance-metric {
```

```
if-feature te-performance-metric;
description
  "Link performance information in real time.";
reference
  "RFC7471: OSPF Traffic Engineering (TE) Metric Extensions.";
container measurement {
  description
    "Measured performance metric values. Static configuration
    and manual overrides of these measurements are also
    allowed.";
  uses performance-metric-attributes;
}
container normality
{
  description
    "Performance metric normality values.";
  uses performance-metric-normality-attributes;
}
}
leaf link-protection-type {
  type enumeration {
    enum "unprotected" {
      description "Unprotected.";
    }
    enum "extra-traffic" {
      description "Extra traffic.";
    }
    enum "shared" {
      description "Shared.";
    }
    enum "1-for-1" {
      description "One for one protection.";
    }
    enum "1-plus-1" {
      description "One plus one protection.";
    }
    enum "enhanced" {
      description "Enhanced protection.";
    }
  }
}
```

```
    description
      "Link Protection Type desired for this link.";
    reference
      "RFC4202: Routing Extensions in Support of
        Generalized Multi-Protocol Label Switching (GMPLS).";
  }
  list interface-switching-capability {
    key "switching-capability";
    description
      "List of Interface Switching Capabilities Descriptors (ISCD)
        for this link.";
    reference
      "RFC3471: Generalized Multi-Protocol Label Switching (GMPLS)
        Signaling Functional Description.
        RFC4203: OSPF Extensions in Support of Generalized
        Multi-Protocol Label Switching (GMPLS).";
    leaf switching-capability {
      type identityref {
        base te-types:switching-capabilities;
      }
      description
        "Switching Capability for this interface.";
    }
    leaf encoding {
      type identityref {
        base te-types:lsp-encoding-types;
      }
      description
        "Encoding supported by this interface.";
    }
  }
  list max-lsp-bandwidth {
    key "priority";
    max-elements "8";
    description
      "Maximum LSP Bandwidth at priorities 0-7.";
    leaf priority {
      type uint8 {
        range "0..7";
      }
      description "Priority.";
    }
  }
```

```
    }
    leaf bandwidth {
      type decimal64 {
        fraction-digits 2;
      }
      description
        "Max LSP Bandwidth for this level";
    }
  }
  container time-division-multiplex-capable {
    when "../switching-capability = 'TDM'" {
      description "Valid only for TDM";
    }
    description
      "Interface has time-division multiplex capabilities.";

    leaf minimum-lsp-bandwidth {
      type decimal64 {
        fraction-digits 2;
      }
      description
        "Minimum LSP Bandwidth. Units in bytes per second.";
    }
    leaf indication {
      type enumeration {
        enum "standard" {
          description
            "Indicates support of standard SONET/SDH.";
        }
        enum "arbitrary" {
          description
            "Indicates support of arbitrary SONET/SDH.";
        }
      }
      description
        "Indication whether the interface supports Standard or
        Arbitrary SONET/SDH";
    }
  }
}
list interface-adjustment-capability {
```

```
    key "upper-sc";
    description
      "List of Interface Adjustment Capability Descriptors
(IACD)
      for this link.";
    reference
      "RFC6001: Generalized MPLS (GMPLS) Protocol Extensions
      for Multi-Layer and Multi-Region Networks (MLN/MRN).";
    leaf upper-sc {
      type identityref {
        base te-types:switching-capabilities;
      }
      description
        "Switching Capability for this interface.";
    }
    leaf upper-encoding {
      type identityref {
        base te-types:lsp-encoding-types;
      }
      description
        "Encoding supported by this interface.";
    }
    list max-lsp-bandwidth {
      key "priority";
      max-elements "8";
      description
        "Maximum LSP Bandwidth at priorities 0-7.";
      leaf priority {
        type uint8 {
          range "0..7";
        }
        description "Priority.";
      }
      leaf bandwidth {
        type decimal64 {
          fraction-digits 2;
        }
        description
          "Max LSP Bandwidth for this level.";
      }
    }
```

```
    }
  } // interface-adjustment-capability
} // interface-switching-capability
container te-srlgs {
  description
    "A list of SRLGs.";
  leaf-list values {
    type te-types:srlg;
    description "SRLG value.";
    reference
      "RFC4202: Routing Extensions in Support of
        Generalized Multi-Protocol Label Switching (GMPLS).";
  }
}
} // te-link-info-attributes

grouping te-link-state-derived {
  description
    "Link state attributes in a TE topology.";
  leaf oper-status {
    type te-oper-status;
    description
      "The current operational state of the link.";
  }
  uses information-source-attributes;
  list alt-information-sources {
    key "information-source";
    description
      "A list of information sources learned but not used.";
    uses information-source-attributes;
    uses te-link-info-attributes;
  }
  container recovery {
    description
      "Status of the recovery process.";
    leaf restoration-status {
      type te-recovery-status;
      description
        "Restoration status.";
    }
  }
}
```

```
    leaf protection-status {
      type te-recovery-status;
      description
        "Protection status.";
    }
  }
  container underlay {
    if-feature te-topology-hierarchy;
    description "State attributes for te-link underlay.";
    uses te-link-state-underlay-attributes;
  }
} // te-link-state-derived

grouping te-link-state-underlay-attributes {
  description "State attributes for te-link underlay.";
  leaf dynamic {
    type boolean;
    description
      "true if the underlay is dynamically created.";
  }
  leaf committed {
    type boolean;
    description
      "true if the underlay is committed.";
  }
} // te-link-state-underlay-attributes

grouping te-link-underlay-attributes {
  description "Attributes for te-link underlay.";
  reference
    "RFC4206: Label Switched Paths (LSP) Hierarchy with
    Generalized Multi-Protocol Label Switching (GMPLS)
    Traffic Engineering (TE)";
  container underlay-primary-path {
    description
      "The service path on the underlay topology that
      supports this link.";
    uses te-topology-ref;
    list path-element {
      key "path-element-id";
    }
  }
}
```

```
        description
            "A list of path elements describing the service path.";
        leaf path-element-id {
            type uint32;
            description "To identify the element in a path.";
        }
        uses te-path-element;
    }
} // underlay-primary-path
list underlay-backup-path {
    key "index";
    description
        "A list of backup service paths on the underlay topology
that
    protect the underlay primary path. If the primary path is
    not protected, the list contains zero elements. If the
    primary path is protected, the list contains one or more
    elements.";
    leaf index {
        type uint32;
        description
            "A sequence number to identify a backup path.";
    }
    uses te-topology-ref;
    list path-element {
        key "path-element-id";
        description
            "A list of path elements describing the backup service
            path";
        leaf path-element-id {
            type uint32;
            description "To identify the element in a path.";
        }
        uses te-path-element;
    }
} // underlay-backup-path
leaf underlay-protection-type {
    type uint16;
    description
        "Underlay protection type desired for this link";
```

```
    }
    container underlay-trail-src {
      uses nt:tp-ref;
      description
        "Source TE link of the underlay trail.";
    }
    container underlay-trail-des {
      uses nt:tp-ref;
      description
        "Destination TE link of the underlay trail.";
    }
  } // te-link-underlay-attributes

  grouping te-node-augment {
    description
      "Augmentation for TE node.";

    container te {
      presence "TE support.";
      description
        "Indicates TE support.";

      leaf te-node-id {
        type te-node-id;
        mandatory true;
        description
          "The identifier of a node in the TE topology.
           A node is specific to a topology to which it belongs.";
      }

      container config {
        description
          "Configuration data.";
        uses te-node-config;
      } // config
      container state {
        config false;
        description
          "Operational state data.";
```

```
    uses te-node-config;
    uses te-node-state-derived;
} // state

list tunnel-termination-point {
    key "tunnel-tp-id";
    description
        "A termination point can terminate a tunnel.";
    leaf tunnel-tp-id {
        type binary;
        description
            "Tunnel termination point identifier.";
    }

    container config {
        description
            "Configuration data.";
        uses te-node-tunnel-termination-capability;
    }

    container state {
        config false;
        description
            "Operational state data.";

        uses te-node-tunnel-termination-capability;
        leaf switching-capability {
            type identityref {
                base te-types:switching-capabilities;
            }
            mandatory true;
            description
                "Switching Capability.";
        }
        leaf encoding {
            type identityref {
                base te-types:lsp-encoding-types;
            }
            mandatory true;
            description
```

```
        "Encoding type.";
    }
} // state

} // tunnel-termination-point
} // te
} // te-node-augment

grouping te-node-config {
    description "TE node configuration grouping.";

    leaf-list te-node-template {
        if-feature template;
        type leafref {
            path "../../../../../te/templates/node-template/name";
        }
        description
            "The reference to a TE node template.";
    }
    uses te-node-config-attributes;
} // te-node-config

grouping te-node-config-attributes {
    description "Configuration node attributes in a TE topology.";
    container te-node-attributes {
        description "Containing node attributes in a TE topology.";
        uses sch:schedules;
        leaf admin-status {
            type te-admin-status;
            description
                "The administrative state of the link.";
        }
        uses te-node-connectivity-matrix;
        uses te-node-info-attributes;
    } // te-node-attributes
} // te-node-config-attributes

grouping te-node-config-attributes-notification {
    description
```

```
    "Configuration node attributes for template in a TE
topology.";
    container te-node-attributes {
        description "Containing node attributes in a TE topology.";
        uses sch:schedules;
        leaf admin-status {
            type te-admin-status;
            description
                "The administrative state of the link.";
        }
        uses te-node-connectivity-matrix-abs;
        uses te-node-info-attributes;
    } // te-node-attributes
} // te-node-config-attributes-notification

grouping te-node-config-attributes-template {
    description
        "Configuration node attributes for template in a TE
topology.";
    container te-node-attributes {
        description "Containing node attributes in a TE topology.";
        uses sch:schedules;
        leaf admin-status {
            type te-admin-status;
            description
                "The administrative state of the link.";
        }
        uses te-node-info-attributes;
    } // te-node-attributes
} // te-node-config-attributes-template

grouping te-node-connectivity-matrix {
    description "Connectivity matrix on a TE node.";
    list connectivity-matrix {
        key "id";
        description
            "Represents node's switching limitations, i.e. limitations
            in interconnecting network TE links across the node.";
        reference
            "RFC7579: General Network Element Constraint Encoding
```

```
    for GMPLS-Controlled Networks.";
  leaf id {
    type uint32;
    description "Identifies the connectivity-matrix entry.";
  }
  container from {
    leaf tp-ref {
      type leafref {
        path "../.../.../.../nt:termination-point/nt:tp-id";
      }
      description
        "Relative reference to source termination point.";
    }
    description
      "Reference to source NTP.";
  }
  container to {
    leaf tp-ref {
      type leafref {
        path "../.../.../.../nt:termination-point/nt:tp-id";
      }
      description
        "Relative reference to destination termination point.";
    }
    description
      "Reference to destination NTP.";
  }
  leaf is-allowed {
    type boolean;
    description
      "true - switching is allowed,
       false - switching is disallowed.";
  }
}
} // te-node-connectivity-matrix

grouping te-node-connectivity-matrix-abs {
  description
    "Connectivity matrix on a TE node, using absolute
     paths to reference termination points.";
```

```
list connectivity-matrix {
  key "id";
  description
    "Represents node's switching limitations, i.e. limitations
     in interconnecting network TE links across the node.";
  reference
    "RFC7579: General Network Element Constraint Encoding
     for GMPLS-Controlled Networks.";
  leaf id {
    type uint32;
    description "Identifies the connectivity-matrix entry.";
  }
  container from {
    uses nt:tp-ref;
    description
      "Reference to source NTP.";
  }
  container to {
    uses nt:tp-ref;
    description
      "Reference to destination NTP.";
  }
  leaf is-allowed {
    type boolean;
    description
      "true - switching is allowed,
       false - switching is disallowed.";
  }
}
} // te-node-connectivity-matrix-abs

grouping te-node-info-attributes {
  description
    "Advertised TE information attributes.";
  leaf domain-id {
    type uint32;
    description
      "Identifies the domain that this node belongs.
       This attribute is used to support inter-domain links.";
    reference
```

```
    "RFC5152: A Per-Domain Path Computation Method for
    Establishing Inter-Domain Traffic Engineering (TE)
    Label Switched Paths (LSPs).
    RFC5392: OSPF Extensions in Support of Inter-Autonomous
    System (AS) MPLS and GMPLS Traffic Engineering.
    RFC5316: ISIS Extensions in Support of Inter-Autonomous
    System (AS) MPLS and GMPLS Traffic Engineering.";
  }
  leaf is-abstract {
    type empty;
    description
      "Present if the node is abstract, not present if the node
      is actual.";
  }
  leaf name {
    type inet:domain-name;
    description "Node name.";
  }
  leaf-list signaling-address {
    type inet:ip-address;
    description "Node signaling address.";
  }
  container underlay-topology {
    if-feature te-topology-hierarchy;
    description
      "When an abstract node encapsulates a topology,
      the attributes in this container point to said topology.";
    uses te-topology-ref;
  }
} // te-node-info-attributes

grouping te-node-state-derived {
  description "Node state attributes in a TE topology.";
  leaf oper-status {
    type te-oper-status;
    description
      "The current operational state of the node.";
  }
  leaf is-multi-access-dr {
    type empty;
```

```
    description
      "The presence of this attribute indicates that this TE node
       is a pseudonode elected as a designated router.";
    reference
      "RFC3630: Traffic Engineering (TE) Extensions to OSPF
       Version 2.
       RFC1195: Use of OSI IS-IS for Routing in TCP/IP and Dual
       Environments.";
  }
  uses information-source-attributes;
  list alt-information-sources {
    key "information-source";
    description
      "A list of information sources learned but not used.";
    uses information-source-attributes;
    uses te-node-connectivity-matrix;
    uses te-node-info-attributes;
  }
} // te-node-state-derived

grouping te-node-state-derived-notification {
  description "Node state attributes in a TE topology.";
  leaf oper-status {
    type te-oper-status;
    description
      "The current operational state of the node.";
  }
  leaf is-multi-access-dr {
    type empty;
    description
      "The presence of this attribute indicates that this TE node
       is a pseudonode elected as a designated router.";
    reference
      "RFC3630: Traffic Engineering (TE) Extensions to OSPF
       Version 2.
       RFC1195: Use of OSI IS-IS for Routing in TCP/IP and Dual
       Environments.";
  }
  uses information-source-attributes;
  list alt-information-sources {
```

```
    key "information-source";
    description
      "A list of information sources learned but not used.";
    uses information-source-attributes;
    uses te-node-connectivity-matrix-abs;
    uses te-node-info-attributes;
  }
} // te-node-state-derived-notification

grouping te-node-tunnel-termination-capability {
  description
    "Termination capability of a tunnel termination point on a
    TE node.";

  list termination-capability {
    key "link-tp";
    description
      "The termination capabilities between
      tunnel-termination-point and link termination-point.
      The capability information can be used to compute
      the tunnel path.";
    leaf link-tp {
      type leafref {
        path "../../../../../nt:termination-point/nt:tp-id";
      }
      description
        "Link termination point.";
    }
  } // termination-capability
} // te-node-tunnel-termination-capability

grouping te-path-element {
  description
    "A group of attributes defining an element in a TE path
    such as TE node, TE link, TE atomic resource or label.";
  uses te-types:explicit-route-subobject;
} // te-path-element

grouping te-termination-point-augment {
  description
```

```
"Augmentation for TE termination point.";

container te {
  presence "TE support.";
  description
    "Indicates TE support.";

  leaf te-tp-id {
    type te-tp-id;
    mandatory true;
    description
      "An identifier to uniquely identify a TE termination
       point.";
  }

  container config {
    description
      "Configuration data.";
    uses te-termination-point-config;
  } // config
  container state {
    config false;
    description
      "Operational state data.";
    uses te-termination-point-config;
  } // state
} // te

} // te-termination-point-augment

grouping te-termination-point-config {
  description
    "TE termination point configuration grouping.";
  uses sch:schedules;
} // te-termination-point-config

grouping te-topologies-augment {
  description
    "Augmentation for TE topologies.";

  container te {
```

```
presence "TE support.";
description
  "Indicates TE support.";

container templates {
  description
    "Configuration parameters for templates used for TE
    topology.";

  list node-template {
    if-feature template;
    key "name";
    leaf name {
      type te-template-name;
      description
        "The name to identify a TE node template.";
    }
    description
      "The list of TE node templates used to define sharable
      and reusable TE node attributes.";
    uses template-attributes;
    uses te-node-config-attributes-template;
  } // node-template

  list link-template {
    if-feature template;
    key "name";
    leaf name {
      type te-template-name;
      description
        "The name to identify a TE link template.";
    }
    description
      "The list of TE link templates used to define sharable
      and reusable TE link attributes.";
    uses template-attributes;
    uses te-link-config-attributes;
  } // link-template
} // templates
} // te
```

```
} // te-topologies-augment

grouping te-topology-augment {
  description
    "Augmentation for TE topology.";

  container te {
    presence "TE support.";
    description
      "Indicates TE support.";

    leaf provider-id {
      type te-global-id;
      mandatory true;
      description
        "An identifier to uniquely identify a provider.";
    }
    leaf client-id {
      type te-global-id;
      mandatory true;
      description
        "An identifier to uniquely identify a client.";
    }
    leaf te-topology-id {
      type te-topology-id;
      mandatory true;
      description
        "It is presumed that a datastore will contain many
        topologies. To distinguish between topologies it is
        vital to have UNIQUE topology identifiers.";
    }
  }

  container config {
    description
      "Configuration data.";
    uses te-topology-config;
  } // config
  container state {
    config false;
    description
```

```
        "Operational state data.";
        uses te-topology-config;
    } // state
} // te
} // te-topology-augment

grouping te-topology-config {
    description
        "TE topology configuration grouping.";
    uses sch:schedules;
    leaf preference {
        type uint8 {
            range "1..255";
        }
        description
            "Specifies a preference for this topology. A lower number
            indicates a higher preference.";
    }
} // te-topology-config

grouping te-topology-ref {
    description
        "References a TE topology.";
    leaf provider-id-ref {
        type leafref {
            path "/nw:networks/nw:network[nw:network-id = "
                + "current()/../network-id-ref]/tet:te/tet:provider-id";
            require-instance false;
        }
        description
            "A reference to a provider-id.";
    }
    leaf client-id-ref {
        type leafref {
            path "/nw:networks/nw:network[nw:network-id = "
                + "current()/../network-id-ref]/tet:te/tet:client-id";
            require-instance false;
        }
        description
            "A reference to a client-id.";
    }
}
```

```
    }
    leaf te-topology-id-ref {
      type leafref {
        path "/nw:networks/nw:network[nw:network-id = "
          + "current()/../network-id-ref]/tet:te/tet:te-topology-
id";
        require-instance false;
      }
      description
        "A reference to a te-topology-id.";
    }
    leaf network-id-ref {
      type leafref {
        path "/nw:networks/nw:network/nw:network-id";
        require-instance false;
      }
      description
        "A reference to a network-id in base ietf-network module.";
    }
  } // te-topology-ref

  grouping te-topology-type {
    description
      "Identifies the TE topology type.";
    container te-topology {
      presence "Indicates TE topology.";
      description
        "Its presence identifies the TE topology type.";
    }
  } // te-topology-type

  grouping template-attributes {
    description
      "Common attributes for all templates.";

    leaf priority {
      type uint16;
      description
        "The preference value to resolve conflicts between different
        templates. When two or more templates specify values for
```

```
        one configuration attribute, the value from the template
        with the highest priority is used.";
    }
    leaf reference-change-policy {
        type enumeration {
            enum no-action {
                description
                    "When an attribute changes in this template, the
                    configuration node referring to this template does
                    not take any action.";
            }
            enum not-allowed {
                description
                    "When any configuration object has a reference to this
                    template, changing this template is not allowed.";
            }
            enum cascade {
                description
                    "When an attribute changes in this template, the
                    configuration object referring to this template applies
                    the new attribute value to the corresponding
                    configuration.";
            }
        }
        description
            "This attribute specifies the action taken to a
configuration
            node that has a reference to this template.";
    }
} // template-attributes

/*
 * Configuration data nodes
 */
augment "/nw:networks/nw:network/nw:network-types" {
    description
        "Introduce new network type for TE topology.";
    uses te-topology-type;
}
```

```
augment "/nw:networks" {
  description
    "Augmentation parameters for TE topologies.";
  uses te-topologies-augment;
}

augment "/nw:networks/nw:network" {
  when "nw:network-types/te-topology" {
    description
      "Augmentation parameters apply only for networks with
      TE topology type.";
  }
  description
    "Configuration parameters for TE topology.";
  uses te-topology-augment;
}

augment "/nw:networks/nw:network/nw:node" {
  when "../nw:network-types/te-topology" {
    description
      "Augmentation parameters apply only for networks with
      TE topology type.";
  }
  description
    "Configuration parameters for TE at node level.";
  uses te-node-augment;
}

augment "/nw:networks/nw:network/nt:link" {
  when "../nw:network-types/te-topology" {
    description
      "Augmentation parameters apply only for networks with
      TE topology type.";
  }
  description
    "Configuration parameters for TE at link level";
  uses te-link-augment;
}

augment "/nw:networks/nw:network/nw:node/"
```

```
    + "nt:termination-point" {
when "../nw:network-types/te-topology" {
  description
    "Augmentation parameters apply only for networks with
    TE topology type.";
}
description
  "Configuration parameters for TE at termination point level";
uses te-termination-point-augment;
}

/*
 * Operational state data nodes
 */

/*
 * Notifications
 */

notification te-node-event {
  description "Notification event for TE node.";
  leaf event-type {
    type te-topology-event-type;
    description "Event type.";
  }
  uses nw:node-ref;
  uses te-topology-type;
  uses tet:te-node-config-attributes-notification;
  uses tet:te-node-state-derived-notification;
}

notification te-link-event {
  description "Notification event for TE link.";
  leaf event-type {
    type te-topology-event-type;
    description "Event type";
  }
  uses nt:link-ref;
  uses te-topology-type;
  uses tet:te-link-config-attributes;
```

```
    uses tet:te-link-state-derived;
  }

  augment "/te-link-event/te-link-attributes/underlay" {
    description "Add state attributes to te-link underlay.";
    uses te-link-state-underlay-attributes;
  }
}
<CODE ENDS>
```

7.2. Packet Switching TE Topology Module

```
<CODE BEGINS> file "ietf-te-topology-psc@2016-03-17.yang"
module ietf-te-topology-psc {
  yang-version 1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-te-topology-psc";
  // replace with IANA namespace when assigned

  prefix "tet-psc";

  import ietf-network {
    prefix "nw";
  }

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

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

  organization
    "Traffic Engineering Architecture and Signaling (TEAS)
    Working Group";

  contact
    "WG Web:  <http://tools.ietf.org/wg/teas/>
    WG List:  <mailto:teas@ietf.org>

    WG Chair: Lou Berger
```

<mailto:lberger@labn.net>

WG Chair: Vishnu Pavan Beeram
<mailto:vbeeram@juniper.net>

Editors: Xufeng Liu
<mailto:xliu@kuatrotech.com>

Igor Bryskin
<mailto:Igor.Bryskin@huawei.com>

Vishnu Pavan Beeram
<mailto:vbeeram@juniper.net>

Tarek Saad
<mailto:tsaad@cisco.com>

Himanshu Shah
<mailto:hshah@ciena.com>

Oscar Gonzalez De Dios
<mailto:oscar.gonzalezdedios@telefonica.com>;

```
description "TE topology model";

revision "2016-03-17" {
  description "Initial revision";
  reference "TBD";
}

/*
 * Groupings
 */
grouping packet-switch-capable-container {
  description
    "The container of packet switch capable attributes.";
  container packet-switch-capable {
    description
      "Interface has packet-switching capabilities.";
    leaf minimum-lsp-bandwidth {
```

```
        type decimal64 {
            fraction-digits 2;
        }
        description
            "Minimum LSP Bandwidth. Units in bytes per second";
    }
    leaf interface-mtu {
        type uint16;
        description
            "Interface MTU.";
    }
}

/*
 * Configuration data nodes
 */
augment "/nw:networks/tet:te/tet:templates/"
    + "tet:link-template/tet:te-link-attributes/"
    + "tet:interface-switching-capability" {
    when "switching-capability = 'switching-psc1' " {
        description "Valid only for PSC";
    }
    description
        "Parameters for PSC TE topology.";
    uses packet-switch-capable-container;
}

augment "/nw:networks/nw:network/nt:link/tet:te/tet:config/"
    + "tet:te-link-attributes/"
    + "tet:interface-switching-capability" {
    when "switching-capability = 'switching-psc1' " {
        description "Valid only for PSC";
    }
    description
        "Parameters for PSC TE topology.";
    uses packet-switch-capable-container;
}

/*
```

```

    * Operational state data nodes
    */
augment "/nw:networks/nw:network/nt:link/tet:te/tet:state/"
    + "tet:te-link-attributes/"
    + "tet:interface-switching-capability" {
    when "switching-capability = 'switching-psc1' " {
        description "Valid only for PSC";
    }
    description
        "Parameters for PSC TE topology.";
    uses packet-switch-capable-container;
}

augment "/nw:networks/nw:network/nt:link/tet:te/tet:state/"
    + "tet:alt-information-sources/"
    + "tet:interface-switching-capability" {
    when "switching-capability = 'switching-psc1' " {
        description "Valid only for PSC";
    }
    description
        "Parameters for PSC TE topology.";
    uses packet-switch-capable-container;
}

/*
    * Notifications
    */
augment "/tet:te-link-event/tet:te-link-attributes/"
    + "tet:interface-switching-capability" {
    when "switching-capability = 'switching-psc1' " {
        description "Valid only for PSC";
    }
    description
        "Parameters for PSC TE topology.";
    uses packet-switch-capable-container;
}

augment "/tet:te-link-event/tet:alt-information-sources/"
    + "tet:interface-switching-capability" {
    when "switching-capability = 'switching-psc1' " {

```

```
        description "Valid only for PSC";
    }
    description
        "Parameters for PSC TE topology.";
    uses packet-switch-capable-container;
}
}
<CODE ENDS>
```

8. Security Considerations

The transport protocol used for retrieving/manipulating the TE topology data MUST support authentication and SHOULD support encryption. The data-model by itself does not create any security implications.

9. IANA Considerations

This document registers the following URIs in the IETF XML registry [[RFC3688](#)]. Following the format in [[RFC3688](#)], the following registration is requested to be made.

URI: urn:ietf:params:xml:ns:yang:ietf-te-topology
XML: N/A, the requested URI is an XML namespace.

This document registers a YANG module in the YANG Module Names registry [[RFC6020](#)].

name: ietf-te-topology
namespace: urn:ietf:params:xml:ns:yang:ietf-te-topology
prefix: tet

10. References

10.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC3688] Mealling, M., "The IETF XML Registry", [BCP 81](#), [RFC 3688](#), January 2004.
- [RFC6020] Bjorklund, M., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", [RFC 6020](#),

October 2010.

- [RFC6991] Schoenwaelder, J., "Common YANG Data Types", [RFC 6991](#), July 2013.
- [RFC3945] Mannie, E., "Generalized Multi-Protocol Label Switching (GMPLS) Architecture", October 2004.
- [YANG-NET-TOPO] Clemm, A., "A Data Model for Network Topologies", [draft-ietf-i2rs-yang-network-topo](#) (Work in Progress).
- [YANG-PUSH] Clemm, A., "Subscribing to YANG datastore push updates", [draft-clemm-netconf-yang-push](#) (Work in Progress).
- [YANG-SCHEDULE] Liu, X., "A YANG Data Model for Configuration Scheduling", [draft-liu-netmod-yang-schedule-00](#) (Work in Progress).

10.2. Informative References

- [RFC2702] Awduche, D., "Requirements for Traffic Engineering Over MPLS", [RFC 2702](#), September 1999.

11. Acknowledgments

The authors would like to thank Lou Berger, Sue Hares, Mazen Khaddam, Cyril Margaria and Zafar Ali for participating in design discussions and providing valuable insights.

Contributors

Sergio Belotti
Alcatel Lucent
Email: sergio.belotti@alcatel-lucent.com

Dieter Beller
Alcatel Lucent
Email: dieter.beller@alcatel-lucent.com

Authors' Addresses

Xufeng Liu
Ericsson

Email: xliu@kuatrotech.com

Igor Bryskin
Huawei Technologies
Email: Igor.Bryskin@huawei.com

Vishnu Pavan Beeram
Juniper Networks
Email: vbeeram@juniper.net

Tarek Saad
Cisco Systems Inc
Email: tsaad@cisco.com

Himanshu Shah
Ciena
Email: hshah@ciena.com

Oscar Gonzalez De Dios
Telefonica
Email: oscar.gonzalezdedios@telefonica.com