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A YANG Data Model for MPLS Traffic Engineering Tunnels

Abstract

This document defines a YANG data model for the configuration and management of Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) tunnels, Label Switched Paths (LSPs) and interfaces. The model augments the TE generic YANG model for MPLS packet dataplane technology.

This model covers data for configuration, operational state, remote procedural calls, and event notifications.

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1. Introduction

YANG [RFC6020] and [RFC7950] is a data modeling language used to define the contents of a conceptual data store that allows networked devices to be managed using NETCONF [RFC6241]. YANG has proved relevant beyond its initial confines, as bindings to other interfaces (e.g. RESTCONF [RFC8040]) and encoding other than XML (e.g. JSON) are being defined. Furthermore, YANG data models can be used as the basis of implementation for other interfaces, such as CLI and programmatic APIs.

This document describes the YANG data model for configuration and management of MPLS TE tunnels, LSPs, and interfaces. Other YANG module(s) that model the establishment of MPLS LSP(s) via signaling protocols such as RSVP-TE ([RFC3209], [RFC3473]) are described in separate document(s).

1.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

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

1.2. 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]
rt-types	ietf-routing-types	[RFC8294]
te	ietf-te	[I-D.ietf-teas-yang-te]
te-mpls	ietf-te-mpls	This document
te-types	ietf-te-types	[RFC8776]

Table 1: Prefixes and corresponding YANG modules

1.3. Acronyms and Abbreviations

MPLS: Multiprotocol Label Switching LSP: Label Switched Path LSR: Label Switching Router LER: Label Edge Router TE: Traffic Engineering

2. MPLS TE YANG Model

The MPLS TE YANG model covers the configuration, state, RPC and notifications data pertaining to MPLS TE interfaces, tunnels and LSPs parameters. The data specific to the signaling protocol used to establish MPLS LSP(s) is outside the scope of this document and is covered in other documents.

2.1. Module(s) Relationship

The MPLS TE YANG module "ietf-te-mpls" imports the following modules:

*ietf-te defined in [I-D.ietf-teas-yang-te]

*ietf-te-types and ietf-te-packet-types defined in [RFC8776]

*ietf-routing-types defined in [RFC8294]

*ietf-mpls-static defined in [I-D.ietf-mpls-static-yang]

This module references the following documents: [RFC8233], [RFC4710], [RFC8570], and [RFC4124].

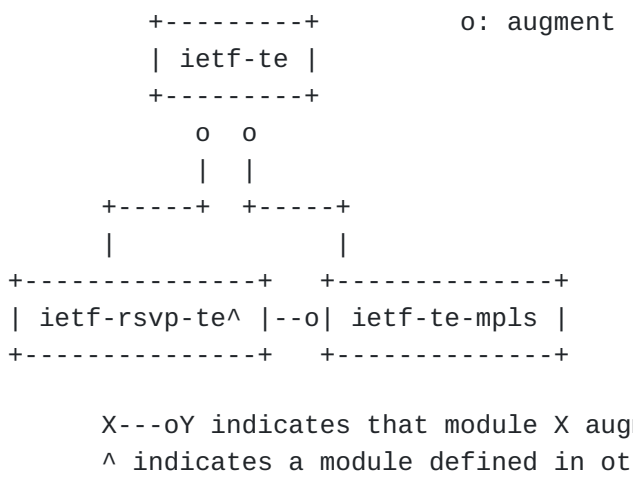

Figure 1: Relationship of MPLS TE module with TE generic and RSVP-TE YANG modules

The MPLS TE YANG module "ietf-te-mpls" augments the "ietf-te" TE generic YANG module as shown in Figure 1.

2.2. Model Tree Diagram

Figure 2 shows the tree diagram of the MPLS TE YANG model that is defined in ietf-te-mpls.yang.

```
module: ietf-te-mpls
  augment /te:te/te-dev:performance-thresholds:
    +--rw throttle
       +--rw one-way-delay-offset?                  uint32
       +--rw measure-interval?                      uint32
       +--rw advertisement-interval?                uint32
       +--rw suppression-interval?                  uint32
       +--rw threshold-out
       |  +--rw one-way-delay?                 uint32
       |  +--rw one-way-residual-bandwidth?
       |  |       rt-types:bandwidth-ieee-float32
       |  +--rw one-way-available-bandwidth?
       |  |       rt-types:bandwidth-ieee-float32
       |  +--rw one-way-utilized-bandwidth?
       |  |       rt-types:bandwidth-ieee-float32
       |  +--rw two-way-delay?                 uint32
       |  +--rw one-way-min-delay?             uint32
       |  +--rw one-way-max-delay?             uint32
       |  +--rw one-way-delay-variation?       uint32
       |  +--rw one-way-packet-loss?           decimal64
       |  +--rw two-way-min-delay?             uint32
       |  +--rw two-way-max-delay?             uint32
       |  +--rw two-way-delay-variation?       uint32
       |  +--rw two-way-packet-loss?           decimal64
       +--rw threshold-in
       |  +--rw one-way-delay?                 uint32
       |  +--rw one-way-residual-bandwidth?
       |  |       rt-types:bandwidth-ieee-float32
       |  +--rw one-way-available-bandwidth?
       |  |       rt-types:bandwidth-ieee-float32
       |  +--rw one-way-utilized-bandwidth?
       |  |       rt-types:bandwidth-ieee-float32
       |  +--rw two-way-delay?                 uint32
       |  +--rw one-way-min-delay?             uint32
       |  +--rw one-way-max-delay?             uint32
       |  +--rw one-way-delay-variation?       uint32
       |  +--rw one-way-packet-loss?           decimal64
       |  +--rw two-way-min-delay?             uint32
       |  +--rw two-way-max-delay?             uint32
       |  +--rw two-way-delay-variation?       uint32
       |  +--rw two-way-packet-loss?           decimal64
       +--rw threshold-accelerated-advertisement
          +--rw one-way-delay?                 uint32
          +--rw one-way-residual-bandwidth?
          |       rt-types:bandwidth-ieee-float32
          +--rw one-way-available-bandwidth?
          |       rt-types:bandwidth-ieee-float32
          +--rw one-way-utilized-bandwidth?
          |       rt-types:bandwidth-ieee-float32
```

```
        +--rw two-way-delay?                uint32
        +--rw one-way-min-delay?            uint32
        +--rw one-way-max-delay?            uint32
        +--rw one-way-delay-variation?      uint32
        +--rw one-way-packet-loss?          decimal64
        +--rw two-way-min-delay?            uint32
        +--rw two-way-max-delay?            uint32
        +--rw two-way-delay-variation?      uint32
        +--rw two-way-packet-loss?          decimal64
augment /te:te/te:tunnels/te:tunnel:
  +--rw tunnel-igp-shortcut
  |  +--rw shortcut-eligible?   boolean
  |  +--rw metric-type?         identityref
  |  +--rw metric?              int32
  |  +--rw routing-afs*         inet:ip-version
  +--rw forwarding
  |  +--rw binding-label?   rt-types:mpls-label
  |  +--rw load-share?      uint32
  |  +--rw policy-class?    uint8
  +--rw bandwidth-mpls
     +--rw specification-type?
     |       te-packet-types:te-bandwidth-requested-type
     +--rw set-bandwidth?        te-packet-types:bandwidth-kbps
     +--rw class-type?           te-types:te-ds-class
     +--ro state
     |  +--ro signaled-bandwidth?   te-packet-types:bandwidth-kbps
     +--rw auto-bandwidth
        +--rw enabled?            boolean
        +--rw min-bw?             te-packet-types:bandwidth-kbps
        +--rw max-bw?             te-packet-types:bandwidth-kbps
        +--rw adjust-interval?    uint32
        +--rw adjust-threshold?   rt-types:percentage
        +--rw overflow
        |  +--rw enabled?               boolean
        |  +--rw overflow-threshold?    rt-types:percentage
        |  +--rw trigger-event-count?   uint16
        +--rw underflow
           +--rw enabled?               boolean
           +--rw underflow-threshold?   rt-types:percentage
           +--rw trigger-event-count?   uint16
augment /te:te/te:tunnels/te:tunnel/te:primary-paths/te:primary-path:
  +--rw static-lsp-name?   mpls-static:static-lsp-ref
augment /te:te/te:tunnels/te:tunnel/te:secondary-paths
          /te:secondary-path:
  +--rw static-lsp-name?   mpls-static:static-lsp-ref
augment /te:te/te:globals/te:named-path-constraints
          /te:named-path-constraint:
  +--rw bandwidth
     +--rw specification-type?
```

```
     |       te-packet-types:te-bandwidth-requested-type
     +--rw set-bandwidth?        te-packet-types:bandwidth-kbps
     +--rw class-type?           te-types:te-ds-class
     +--ro state
        +--ro signaled-bandwidth?   te-packet-types:bandwidth-kbps
augment /te:te/te:tunnels/te:tunnel/te:primary-paths/te:primary-path
          /te:lsps/te:lsp:
  +--ro performance-metrics-one-way
  |  +--ro one-way-delay?                          uint32
  |  +--ro one-way-delay-normality?
  |  |       te-types:performance-metrics-normality
  |  +--ro one-way-residual-bandwidth?
  |  |       rt-types:bandwidth-ieee-float32
  |  +--ro one-way-residual-bandwidth-normality?
  |  |       te-types:performance-metrics-normality
  |  +--ro one-way-available-bandwidth?
  |  |       rt-types:bandwidth-ieee-float32
  |  +--ro one-way-available-bandwidth-normality?
  |  |       te-types:performance-metrics-normality
  |  +--ro one-way-utilized-bandwidth?
  |  |       rt-types:bandwidth-ieee-float32
  |  +--ro one-way-utilized-bandwidth-normality?
  |  |       te-types:performance-metrics-normality
  |  +--ro one-way-min-delay?                      uint32
  |  +--ro one-way-min-delay-normality?
  |  |       te-types:performance-metrics-normality
  |  +--ro one-way-max-delay?                      uint32
  |  +--ro one-way-max-delay-normality?
  |  |       te-types:performance-metrics-normality
  |  +--ro one-way-delay-variation?                uint32
  |  +--ro one-way-delay-variation-normality?
  |  |       te-types:performance-metrics-normality
  |  +--ro one-way-packet-loss?                    decimal64
  |  +--ro one-way-packet-loss-normality?
  |          te-types:performance-metrics-normality
  +--ro performance-metrics-two-way
     +--ro two-way-delay?                     uint32
     +--ro two-way-delay-normality?
     |       te-types:performance-metrics-normality
     +--ro two-way-min-delay?                 uint32
     +--ro two-way-min-delay-normality?
     |       te-types:performance-metrics-normality
     +--ro two-way-max-delay?                 uint32
     +--ro two-way-max-delay-normality?
     |       te-types:performance-metrics-normality
     +--ro two-way-delay-variation?           uint32
     +--ro two-way-delay-variation-normality?
     |       te-types:performance-metrics-normality
     +--ro two-way-packet-loss?               decimal64
```

```
+--ro two-way-packet-loss-normality?
        te-types:performance-metrics-normality
```

Figure 2: MPLS TE model configuration and state tree

2.3. MPLS TE YANG Module

```
<CODE BEGINS> file "ietf-te-mpls@2023-05-25.yang"

module ietf-te-mpls {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-te-mpls";

  /* Replace with IANA when assigned */
  prefix "te-mpls";

  /* Import TE base model */
  import ietf-te {
    prefix te;
    reference "draft-ietf-teas-yang-te: A YANG Data Model for Traffic
               Engineering Tunnels and Interfaces";
  }

  /* Import TE MPLS types */
  import ietf-te-packet-types {
    prefix "te-packet-types";
    reference "RFC8776: A YANG Data Model for
               Common Traffic Engineering Types";
  }

  /* Import TE generic types */
  import ietf-te-types {
    prefix te-types;
    reference "RFC8776: A YANG Data Model for
               Common Traffic Engineering Types";
  }

  /* Import routing types */
  import ietf-routing-types {
    prefix rt-types;
    reference "RFC8294: Common YANG Data Types for the Routing Area";
  }

  import ietf-mpls-static {
    prefix mpls-static;
    reference "draft-ietf-mpls-static-yang: A YANG Data Model
               for MPLS Static LSPs";
  }

  import ietf-inet-types {
    prefix inet;
    reference "RFC6991: Common YANG Data Types";
  }

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

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

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   Editor:   Xufeng Liu
             <mailto: xufeng.liu.ietf@gmail.com>

   Editor:   Igor Bryskin
             <mailto:i_bryskin@yahoo.com>";

description
  "YANG data module for MPLS TE configurations,
   state, RPC and notifications. The model fully conforms to
   the Network Management Datastore Architecture (NMDA).

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   (https://trustee.ietf.org/license-info).
   This version of this YANG module is part of RFC XXXX; see
   the RFC itself for full legal notices.";

// RFC Ed.: replace XXXX with actual RFC number and remove this
// note.

// RFC Ed.: update the date below with the date of RFC publication
// and remove this note.

revision "2023-05-25" {
  description "Latest update to MPLS TE YANG module.";
  reference
    "RFCXXXX: A YANG Data Model for MPLS-TE Tunnels and LSP(s)";
}

/* MPLS TE Identities */
```

```
identity tunnel-action-resetup {
  base te-types:tunnel-action-type;
  description "Resetup tunnel action type";
}

identity path-metric-loss {
  base te-types:path-metric-type;
  description
    "The path loss metric type (as a packet percentage) that
     encodes a function of the unidirectional loss metrics of all
     links traversed by a P2P path. The basic unit is 0.000003%,
     where (2^24 - 2) or 50.331642% is the highest packet-loss
     percentage that can be expressed.";
  reference "RFC8233, RFC4710, and RFC8570";
}

/* MPLS TE tunnel properties*/
grouping tunnel-igp-shortcut-config {
  description "TE tunnel IGP shortcut configs";
  leaf shortcut-eligible {
    type boolean;
    default "true";
    description
      "Whether this LSP is considered to be eligible for us as a
      shortcut in the IGP. In the case that this leaf is set to
      true, the IGP SPF calculation uses the metric specified to
      determine whether traffic should be carried over this LSP";
  }
  leaf metric-type {
    type identityref {
      base te-types:lsp-metric-type;
    }
    default te-types:lsp-metric-inherited;
    description
      "The type of metric specification that should be used to set
      the LSP(s) metric";
  }
  leaf metric {
    type int32;
    description
      "The value of the metric that should be specified. The value
      supplied in this leaf is used in conjunction with the metric
      type to determine the value of the metric used by the system.
      Where the metric-type is set to lsp-metric-absolute - the
      value of this leaf is used directly; where it is set to
      lsp-metric-relative, the relevant (positive or negative)
      offset is used to formulate the metric; where metric-type
      is lsp-metric-inherited, the value of this leaf is not
      utilized";
```

```
  }
  leaf-list routing-afs {
    type inet:ip-version;
    description
      "Address families";
  }
}

grouping tunnel-igp-shortcuts {
  description
    "TE tunnel IGP shortcut grouping";
  container tunnel-igp-shortcut {
    description
      "Tunnel IGP shortcut properties";
    uses tunnel-igp-shortcut-config;
  }
}

grouping tunnel-forwarding-adjacency-configs {
  description "Tunnel forwarding adjacency grouping";
  leaf binding-label {
    type rt-types:mpls-label;
    description "MPLS tunnel binding label";
  }
  leaf load-share {
    type uint32 {
      range "1..4294967295";
    }
    description "ECMP tunnel forwarding
      load-share factor.";
  }
  leaf policy-class {
    type uint8 {
      range "1..7";
    }
    description
      "The class associated with this tunnel";
  }
}

grouping tunnel-forwarding-adjacency {
  description "Properties for using tunnel in forwarding.";
  container forwarding {
    description
      "Tunnel forwarding properties container";
    uses tunnel-forwarding-adjacency-configs;
  }
}
```

```
/*** End of MPLS TE tunnel configuration/state */
grouping te-lsp-auto-bandwidth-config {
  description
    "Configuration parameters related to autobandwidth";

  leaf enabled {
    type boolean;
    default false;
    description
      "Enables MPLS auto-bandwidth on the
       LSP";
  }

  leaf min-bw {
    type te-packet-types:bandwidth-kbps;
    description
      "set the minimum bandwidth in Kbps for an
       auto-bandwidth LSP";
  }

  leaf max-bw {
    type te-packet-types:bandwidth-kbps;
    description
      "set the maximum bandwidth in Kbps for an
       auto-bandwidth LSP";
  }

  leaf adjust-interval {
    type uint32;
    description
      "time in seconds between adjustments to
       LSP bandwidth";
  }

  leaf adjust-threshold {
    type rt-types:percentage;
    description
      "percentage difference between the LSP's
       specified bandwidth and its current bandwidth
       allocation -- if the difference is greater than the
       specified percentage, auto-bandwidth adjustment is
       triggered";
  }
}

grouping te-lsp-overflow-config {
  description
   "configuration for MPLS LSP bandwidth
    overflow adjustment";
```

```
  leaf enabled {
    type boolean;
    default false;
    description
     "Enables MPLS LSP bandwidth overflow
      adjustment on the LSP";
  }

  leaf overflow-threshold {
    type rt-types:percentage;
    description
     "bandwidth percentage change to trigger
      an overflow event";

  }

  leaf trigger-event-count {
    type uint16;
    description
     "number of consecutive overflow sample
      events needed to trigger an overflow adjustment";
  }
}

grouping te-lsp-underflow-config {
  description
    "configuration for MPLS LSP bandwidth
    underflow adjustment";

  leaf enabled {
    type boolean;
    default false;
    description
     "enables bandwidth underflow
      adjustment on the LSP";
  }

  leaf underflow-threshold {
    type rt-types:percentage;
    description
     "bandwidth percentage change to trigger
      and underflow event";
  }

  leaf trigger-event-count {
    type uint16;
    description
     "number of consecutive underflow sample
      events needed to trigger an underflow adjustment";
```

```
  }
}
grouping te-tunnel-bandwidth-config {
  description
    "Configuration parameters related to bandwidth for a tunnel";

  leaf specification-type {
    type te-packet-types:te-bandwidth-requested-type;
    default specified;
    description
      "The method used for setting the bandwidth, either explicitly
       specified or configured";
  }

  leaf set-bandwidth {
    when "../specification-type = 'specified'" {
     description
       "The bandwidth value when bandwidth is explicitly
        specified";
    }
    type te-packet-types:bandwidth-kbps;
    description
     "set bandwidth explicitly, e.g., using
      offline calculation";
  }
  leaf class-type {
    type te-types:te-ds-class;
    description
      "The Class-Type of traffic transported by the LSP.";
    reference "RFC4124: section-4.3.1";
  }
}

grouping te-tunnel-bandwidth-state {
  description
    "Operational state parameters relating to bandwidth for
     a tunnel";

  leaf signaled-bandwidth {
    type te-packet-types:bandwidth-kbps;
    description
      "The currently signaled bandwidth of the LSP. In the case
       where the bandwidth is specified explicitly, then this will
       match the value of the set-bandwidth leaf; in cases where
       the bandwidth is dynamically computed by the system, the
       current value of the bandwidth should be reflected.";
  }
}
```

```
grouping tunnel-bandwidth_top {
  description
    "Top level grouping for specifying bandwidth for a tunnel";

  container bandwidth-mpls {
    description
      "Bandwidth configuration for TE LSPs";

    uses te-tunnel-bandwidth-config;

    container state {
      config false;
      description
        "State parameters related to bandwidth
        configuration of TE tunnels";
      uses te-tunnel-bandwidth-state;
    }

    container auto-bandwidth {
      when "../specification-type = 'auto'" {
        description
          "Include this container for auto bandwidth
          specific configuration";
      }
      description
        "Parameters related to auto-bandwidth";

      uses te-lsp-auto-bandwidth-config;

      container overflow {
        description
          "configuration of MPLS overflow bandwidth
          adjustment for the LSP";

        uses te-lsp-overflow-config;
      }

      container underflow {
        description
          "configuration of MPLS underflow bandwidth
          adjustment for the LSP";

        uses te-lsp-underflow-config;
      }
    }
  }
}

grouping te-path-bandwidth_top {
  description
```

```
    "Top level grouping for specifying bandwidth for a TE path";

  container bandwidth {
    description
      "Bandwidth configuration for TE LSPs";

    uses te-tunnel-bandwidth-config;
    container state {
      config false;
      description
        "State parameters related to bandwidth
        configuration of TE tunnels";
      uses te-tunnel-bandwidth-state;
    }
  }
}



/**
 * MPLS TE augmentations
 */
augment "/te:te" {
  container performance-thresholds {
    uses "te-packet-types:" +
      "performance-metrics-throttle-container-packet";
      description
        "Performance parameters configurable thresholds";
  }
  description
    "Performance parameters configurable thresholds";
}

/* MPLS TE interface augmentations */


/* MPLS TE tunnel augmentations */
augment "/te:te/te:tunnels/te:tunnel" {
  description "MPLS TE tunnel config augmentations";
  uses tunnel-igp-shortcuts;
  uses tunnel-forwarding-adjacency;
  uses tunnel-bandwidth_top;
}

/* MPLS TE LSPs augmentations */
augment "/te:te/te:tunnels/te:tunnel/" +
        "te:primary-paths/te:primary-path" {
  when "/te:te/te:tunnels/te:tunnel" +
    "/te:primary-paths/te:primary-path" +
    "/te:signaling-type = 'te-types:path-setup-static'" {
```

```
      description
      "When the path is statically provisioned";
    }
    description "MPLS TE LSP augmentation";
    leaf static-lsp-name {
      type mpls-static:static-lsp-ref;
      description "Static LSP name";
    }
  }

  augment "/te:te/te:tunnels/te:tunnel/" +
          "te:secondary-paths/te:secondary-path" {
    when "/te:te/te:tunnels/te:tunnel" +
      "/te:secondary-paths/te:secondary-path/" +
      "te:signaling-type = 'te-types:path-setup-static'" {
      description
      "When the path is statically provisioned";
    }
    description "MPLS TE LSP augmentation";
    leaf static-lsp-name {
      type mpls-static:static-lsp-ref;
      description "Static LSP name";
    }
  }

  augment "/te:te/te:globals/te:named-path-constraints/" +
          "te:named-path-constraint" {
    description "foo";
    uses te-path-bandwidth_top;
  }

  augment "/te:te/te:tunnels/te:tunnel/te:primary-paths" +
          "/te:primary-path/te:lsps/te:lsp" {
    description
      "MPLS TE generic data augmentation pertaining to specific TE
       LSP";
    uses te-packet-types:performance-metrics-attributes-packet;
  }
}

<CODE ENDS>
```

Figure 3: TE generic YANG module

3. 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-mpls
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-mpls
namespace: urn:ietf:params:xml:ns:yang:ietf-te-mpls
prefix: ietf-te-mpls
reference: RFC3209

4. Security Considerations

The YANG module defined in this memo is designed to be accessed via the NETCONF protocol [RFC6241]. The lowest NETCONF layer is the secure transport layer and the mandatory-to-implement secure transport is SSH [RFC6242]. The NETCONF access control model [RFC8341] provides means to restrict access for particular NETCONF users to a pre-configured subset of all available NETCONF protocol operations and content.

A number of data nodes defined in this YANG module are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., <edit-config>) to these data nodes without proper protection can have a negative effect on MPLS network operations. Following are the subtrees and data nodes and their sensitivity/vulnerability:

"/te/tunnels": The augmentation to this list specifies configuration to TE tunnels on a device. Unauthorized access to this list could cause the device to ignore packets it should receive and process.

"/te/globals": The augmentation to this target specifies configuration applicable to the to all or one TE device. Unauthorized access to this list could cause the device to ignore packets it should receive and process.

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