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RFC 8776
Common YANG Data Types for Traffic Engineering

Abstract

This document defines a collection of common data types and groupings in YANG data modeling language. These derived common types and groupings are intended to be imported by modules that model Traffic Engineering (TE) configuration and state capabilities.

Status of This Memo

This is an Internet Standards Track document.

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Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc8776.

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1. Introduction

YANG [RFC6020] [RFC7950] is a data modeling language used to model configuration data, state data, Remote Procedure Calls, and notifications for network management protocols such as the Network Configuration Protocol (NETCONF) [RFC6241]. The YANG language supports a small set of built-in data types and provides mechanisms to derive other types from the built-in types.

This document introduces a collection of common data types derived from the built-in YANG data types. The derived types and groupings are designed to be the common types applicable for modeling Traffic Engineering (TE) features in model(s) defined outside of this document.

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-types	ietf-te-types	This document
te-packet-types	ietf-te-packet-types	This document

Table 1: Prefixes and Corresponding YANG Modules

2. Acronyms and Abbreviations

GMPLS: Generalized Multiprotocol Label Switching

LSP: Label Switched Path

LSR: Label Switching Router

LER: Label Edge Router

MPLS: Multiprotocol Label Switching

RSVP: Resource Reservation Protocol

TE: Traffic Engineering

DS-TE: Differentiated Services Traffic Engineering

SRLG: Shared Risk Link Group

NBMA: Non-Broadcast Multi-Access

APS: Automatic Protection Switching

SD: Signal Degrade

SF: Signal Fail

WTR: Wait-to-Restore

PM: Performance Metrics

3. Overview

This document defines two YANG modules for common TE types: "ietf-te-types" for TE generic types and "ietf-te-packet-types" for packet-specific types. Other technology-specific TE types are outside the scope of this document.

3.1. TE Types Module Contents

The "ietf-te-types" module (Section 4) contains common TE types that are independent and agnostic of any specific technology or control-plane instance.

The "ietf-te-types" module contains the following YANG reusable types and groupings:

te-bandwidth:
: A YANG grouping that defines the generic TE bandwidth. The modeling structure allows augmentation for each technology. For unspecified technologies, the string-encoded "te-bandwidth" type is used.

te-label:
: A YANG grouping that defines the generic TE label. The modeling structure allows augmentation for each technology. For unspecified technologies, "rt-types:generalized-label" is used.

performance-metrics-attributes:
: A YANG grouping that defines one-way and two-way measured Performance Metrics (PM) and indications of anomalies on link(s) or the path as defined in [RFC7471], [RFC8570], and [RFC7823].

performance-metrics-throttle-container:
: A YANG grouping that defines configurable thresholds for advertisement suppression and measurement intervals.

te-ds-class:
: A type representing the Differentiated Services (DS) Class-Type of traffic as defined in [RFC4124].

te-label-direction:
: An enumerated type for specifying the forward or reverse direction of a label.

te-hop-type:
: An enumerated type for specifying that a hop is loose or strict.

te-global-id:
: A type representing the identifier that uniquely identifies 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.

te-node-id:
: A type representing the identifier for a node in a TE topology. The identifier is represented as 4 octets in dotted-quad notation. This attribute **MAY** be mapped to the Router Address TLV described in Section 2.4.1 of [RFC3630], the TE Router ID described in Section 3 of [RFC6827], the Traffic Engineering Router ID TLV described in Section 4.3 of [RFC5305], or the TE Router ID TLV described in Section 3.2.1 of [RFC6119]. The reachability of such a TE node **MAY** be achieved by a mechanism such as that described in Section 6.2 of [RFC6827].

te-topology-id:
: A type representing the identifier for a topology. It is optional to have one or more prefixes at the beginning, separated by colons. The prefixes can be "network-types" as defined in the "ietf-network" module in [RFC8345], to help the user better understand the topology before further inquiry is made.

te-tp-id:
: A type representing the identifier of a TE interface Link Termination Point (LTP) on a specific TE node where the TE link connects. This attribute is mapped to a local or remote link identifier [RFC3630] [RFC5305].

te-path-disjointness:
: A type representing the different resource disjointness options for a TE tunnel path as defined in [RFC4872].

admin-groups:
: A union type for a TE link's classic or extended administrative groups as defined in [RFC3630], [RFC5305], and [RFC7308].

srlg:
: A type representing the Shared Risk Link Group (SRLG) as defined in [RFC4203] and [RFC5307].

te-metric:
: A type representing the TE metric as defined in [RFC3785].

te-recovery-status:
: An enumerated type for the different statuses of a recovery action as defined in [RFC4427] and [RFC6378].

path-attribute-flags:
: A base YANG identity for supported LSP path flags as defined in [RFC3209], [RFC4090], [RFC4736], [RFC5712], [RFC4920], [RFC5420], [RFC7570], [RFC4875], [RFC5151], [RFC5150], [RFC6001], [RFC6790], [RFC7260], [RFC8001], [RFC8149], and [RFC8169].

link-protection-type:
: A base YANG identity for supported link protection types as defined in [RFC4872] and [RFC4427].

restoration-scheme-type:
: A base YANG identity for supported LSP restoration schemes as defined in [RFC4872].

protection-external-commands:
: A base YANG identity for supported protection-related external commands used for troubleshooting purposes, as defined in [RFC4427].

association-type:
: A base YANG identity for supported LSP association types as defined in [RFC6780], [RFC4872], and [RFC4873].

objective-function-type:
: A base YANG identity for supported path computation objective functions as defined in [RFC5541].

te-tunnel-type:
: A base YANG identity for supported TE tunnel types as defined in [RFC3209] and [RFC4875].

lsp-encoding-types:
: A base YANG identity for supported LSP encoding types as defined in [RFC3471].

lsp-protection-type:
: A base YANG identity for supported LSP protection types as defined in [RFC4872] and [RFC4873].

switching-capabilities:
: A base YANG identity for supported interface switching capabilities as defined in [RFC3471].

resource-affinities-type:
: A base YANG identity for supported attribute filters associated with a tunnel that must be satisfied for a link to be acceptable as defined in [RFC2702] and [RFC3209].

path-metric-type:
: A base YANG identity for supported path metric types as defined in [RFC3785] and [RFC7471].

explicit-route-hop:
: A YANG grouping that defines supported explicit routes as defined in [RFC3209] and [RFC3477].

te-link-access-type:
: An enumerated type for the different TE link access types as defined in [RFC3630].

3.2. Packet TE Types Module Contents

The "ietf-te-packet-types" module (Section 5) covers the common types and groupings that are specific to packet technology.

The "ietf-te-packet-types" module contains the following YANG reusable types and groupings:

backup-protection-type:
: A base YANG identity for supported protection types that a backup or bypass tunnel can provide as defined in [RFC4090].

te-class-type:
: A type that represents the Diffserv-TE Class-Type as defined in [RFC4124].

bc-type:
: A type that represents Diffserv-TE Bandwidth Constraints (BCs) as defined in [RFC4124].

bc-model-type:
: A base YANG identity for supported Diffserv-TE Bandwidth Constraints Models as defined in [RFC4125], [RFC4126], and [RFC4127].

te-bandwidth-requested-type:
: An enumerated type for the different options to request bandwidth for a specific tunnel.

performance-metrics-attributes-packet:
: A YANG grouping that contains the generic performance metrics and additional packet-specific metrics.

4. TE Types YANG Module

The "ietf-te-types" module imports from the following modules:

- "ietf-yang-types" and "ietf-inet-types" as defined in [RFC6991]
- "ietf-routing-types" as defined in [RFC8294]

In addition to [RFC6991] and [RFC8294], this module references the following documents in defining the types and YANG groupings: [RFC3272], [RFC4090], [RFC4202], [RFC4328], [RFC4561], [RFC4657], [RFC5817], [RFC6004], [RFC6511], [RFC7139], [RFC7308], [RFC7551], [RFC7571], [RFC7579], and [G.709].

```
<CODE BEGINS> file "ietf-te-types@2020-04-06.yang"

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

  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Data Types";
  }
  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6991: Common YANG Data Types";
  }
  import ietf-routing-types {
    prefix rt-types;
    reference
      "RFC 8294: Common YANG Data Types for the Routing Area";
  }

  organization
    "IETF Traffic Engineering Architecture and Signaling (TEAS)
     Working Group";
  contact
    "WG Web:   <https://datatracker.ietf.org/wg/teas/>
     WG List:  <mailto:teas@ietf.org>

     Editor:   Tarek Saad
               <mailto:tsaad@juniper.net>

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

     Editor:   Igor Bryskin
               <mailto:i_bryskin@yahoo.com>";
  description
    "This YANG module contains a collection of generally useful
     YANG data type definitions specific to TE.  The model fully
     conforms to the Network Management Datastore Architecture
     (NMDA).

     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 (RFC 2119) (RFC 8174) when, and only when,
     they appear in all capitals, as shown here.

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      authors of the code.  All rights reserved.

      Redistribution and use in source and binary forms, with or
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      forth in Section 4.c of the IETF Trust's Legal Provisions
      Relating to IETF Documents
      (https://trustee.ietf.org/license-info).

      This version of this YANG module is part of RFC 8776; see the
      RFC itself for full legal notices.";

  revision 2020-04-06 {
    description
      "Latest revision of TE types.";
    reference
      "RFC 8776: Common YANG Data Types for Traffic Engineering";
  }

  /**
   * Typedefs
   */

  typedef admin-group {
    type yang:hex-string {
      /* 01:02:03:04 */
      length "1..11";
    }
    description
      "Administrative group / resource class / color representation
       in 'hex-string' type.
       The most significant byte in the hex-string is the farthest
       to the left in the byte sequence.  Leading zero bytes in the
       configured value may be omitted for brevity.";
    reference
      "RFC 3630: Traffic Engineering (TE) Extensions to OSPF
       Version 2
       RFC 5305: IS-IS Extensions for Traffic Engineering
       RFC 7308: Extended Administrative Groups in MPLS Traffic
       Engineering (MPLS-TE)";
  }

  typedef admin-groups {
    type union {
      type admin-group;
      type extended-admin-group;
    }
    description
      "Derived types for TE administrative groups.";
  }

  typedef extended-admin-group {
    type yang:hex-string;
    description
      "Extended administrative group / resource class / color
       representation in 'hex-string' type.
       The most significant byte in the hex-string is the farthest
       to the left in the byte sequence.  Leading zero bytes in the
```

```
       configured value may be omitted for brevity.";
    reference
      "RFC 7308: Extended Administrative Groups in MPLS Traffic
       Engineering (MPLS-TE)";
  }

  typedef path-attribute-flags {
    type union {
      type identityref {
        base session-attributes-flags;
      }
      type identityref {
        base lsp-attributes-flags;
      }
    }
    description
      "Path attributes flags type.";
  }

  typedef performance-metrics-normality {
    type enumeration {
      enum unknown {
        value 0;
        description
          "Unknown.";
      }
      enum normal {
        value 1;
        description
          "Normal.  Indicates that the anomalous bit is not set.";
      }
      enum abnormal {
        value 2;
        description
          "Abnormal.  Indicates that the anomalous bit is set.";
      }
    }
    description
      "Indicates whether a performance metric is normal (anomalous
       bit not set), abnormal (anomalous bit set), or unknown.";
    reference
      "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions
       RFC 7823: Performance-Based Path Selection for Explicitly
       Routed Label Switched Paths (LSPs) Using TE Metric
       Extensions
       RFC 8570: IS-IS Traffic Engineering (TE) Metric Extensions";
  }

  typedef srlg {
    type uint32;
    description
      "SRLG type.";
    reference
      "RFC 4203: OSPF Extensions in Support of Generalized
       Multi-Protocol Label Switching (GMPLS)
       RFC 5307: IS-IS Extensions in Support of Generalized
       Multi-Protocol Label Switching (GMPLS)";
  }
```

```
typedef te-common-status {
  type enumeration {
    enum up {
      description
        "Enabled.";
    }
    enum down {
      description
        "Disabled.";
    }
    enum testing {
      description
        "In some test mode.";
    }
    enum preparing-maintenance {
      description
        "The resource is disabled in the control plane to prepare
         for a graceful shutdown for maintenance purposes.";
      reference
        "RFC 5817: Graceful Shutdown in MPLS and Generalized MPLS
         Traffic Engineering Networks";
    }
    enum maintenance {
      description
        "The resource is disabled in the data plane for maintenance
         purposes.";
    }
    enum unknown {
      description
        "Status is unknown.";
    }
  }
  description
    "Defines a type representing the common states of a TE
     resource.";
}

typedef te-bandwidth {
  type string {
    pattern '0[xX](0((\.0?)?[pP](\+)?0?|(\.0?))|'
          + '1(\.([\da-fA-F]{0,5}[02468aAcCeE]?)?)?[pP](\+)?(12[0-7]|'
          + '1[01]\d|0?\d?\d)?)|0[xX][\da-fA-F]{1,8}|\d+'
          + '(,(0[xX](0((\.0?)?[pP](\+)?0?|(\.0?))|'
          + '1(\.([\da-fA-F]{0,5}[02468aAcCeE]?)?)?[pP](\+)?(12[0-7]|'
          + '1[01]\d|0?\d?\d)?)|0[xX][\da-fA-F]{1,8}|\d+))*';
  }
  description
    "This is the generic bandwidth type.  It is a string containing
     a list of numbers separated by commas, where each of these
     numbers can be non-negative decimal, hex integer, or
     hex float:

     (dec | hex | float)[*(','(dec | hex | float))]

     For the packet-switching type, the string encoding follows
     the type 'bandwidth-ieee-float32' as defined in RFC 8294
     (e.g., 0x1p10), where the units are in bytes per second.
```

```
       For the Optical Transport Network (OTN) switching type,
       a list of integers can be used, such as '0,2,3,1', indicating
       two ODU0s and one ODU3.  ('ODU' stands for 'Optical Data
       Unit'.)  For Dense Wavelength Division Multiplexing (DWDM),
       a list of pairs of slot numbers and widths can be used,
       such as '0,2,3,3', indicating a frequency slot 0 with
       slot width 2 and a frequency slot 3 with slot width 3.
       Canonically, the string is represented as all lowercase and in
       hex, where the prefix '0x' precedes the hex number.";
    reference
      "RFC 8294: Common YANG Data Types for the Routing Area
       ITU-T Recommendation G.709: Interfaces for the
       optical transport network";
  }

  typedef te-ds-class {
    type uint8 {
      range "0..7";
    }
    description
      "The Differentiated Services Class-Type of traffic.";
    reference
      "RFC 4124: Protocol Extensions for Support of Diffserv-aware
       MPLS Traffic Engineering, Section 4.3.1";
  }

  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 RFCs 6370 and 5003.
       This attribute type is used solely to provide a globally
       unique context for TE topologies.";
    reference
      "RFC 5003: Attachment Individual Identifier (AII) Types for
       Aggregation
       RFC 6370: MPLS Transport Profile (MPLS-TP) Identifiers";
  }

  typedef te-hop-type {
    type enumeration {
      enum loose {
        description
          "A loose hop in an explicit path.";
      }
      enum strict {
        description
          "A strict hop in an explicit path.";
      }
    }
    description
      "Enumerated type for specifying loose or strict paths.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
       Section 4.3.3";
  }
```

```
  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
      "RFC 3630: Traffic Engineering (TE) Extensions to OSPF
       Version 2";
  }

  typedef te-label-direction {
    type enumeration {
      enum forward {
        description
          "Label allocated for the forward LSP direction.";
      }
      enum reverse {
        description
          "Label allocated for the reverse LSP direction.";
      }
    }
    description
      "Enumerated type for specifying the forward or reverse
       label.";
  }

  typedef te-link-direction {
    type enumeration {
      enum incoming {
        description
          "The explicit route represents an incoming link on
           a node.";
      }
      enum outgoing {
        description
          "The explicit route represents an outgoing link on
           a node.";
      }
    }
    description
      "Enumerated type for specifying the direction of a link on
       a node.";
  }

  typedef te-metric {
    type uint32;
    description
      "TE metric.";
    reference
```

```
      "RFC 3785: Use of Interior Gateway Protocol (IGP) Metric as a
       second MPLS Traffic Engineering (TE) Metric";
  }

  typedef te-node-id {
    type yang:dotted-quad;
    description
      "A type representing the identifier for a node in a TE
       topology.
       The identifier is represented as 4 octets in dotted-quad
       notation.
       This attribute MAY be mapped to the Router Address TLV
       described in Section 2.4.1 of RFC 3630, the TE Router ID
       described in Section 3 of RFC 6827, the Traffic Engineering
       Router ID TLV described in Section 4.3 of RFC 5305, or the
       TE Router ID TLV described in Section 3.2.1 of RFC 6119.
       The reachability of such a TE node MAY be achieved by a
       mechanism such as that described in Section 6.2 of RFC 6827.";
    reference
      "RFC 3630: Traffic Engineering (TE) Extensions to OSPF
       Version 2, Section 2.4.1
       RFC 5305: IS-IS Extensions for Traffic Engineering,
       Section 4.3
       RFC 6119: IPv6 Traffic Engineering in IS-IS, Section 3.2.1
       RFC 6827: Automatically Switched Optical Network (ASON)
       Routing for OSPFv2 Protocols, Section 3";
  }

  typedef te-oper-status {
    type te-common-status;
    description
      "Defines a type representing the operational status of
       a TE resource.";
  }

  typedef te-admin-status {
    type te-common-status;
    description
      "Defines a type representing the administrative status of
       a TE resource.";
  }

  typedef te-path-disjointness {
    type bits {
      bit node {
        position 0;
        description
          "Node disjoint.";
      }
      bit link {
        position 1;
        description
          "Link disjoint.";
      }
      bit srlg {
        position 2;
        description
          "SRLG (Shared Risk Link Group) disjoint.";
```

```
      }
    }
    description
      "Type of the resource disjointness for a TE tunnel path.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  typedef te-recovery-status {
    type enumeration {
      enum normal {
        description
          "Both the recovery span and the working span 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-succeeded {
        description
          "The reversion action has succeeded.";
      }
      enum reversion-failed {
        description
          "The reversion has failed.";
      }
      enum recovery-unavailable {
        description
          "The recovery is unavailable, as a result of either an
           operator's lockout command or a failure condition
           detected on the recovery span.";
      }
      enum recovery-admin {
        description
          "The operator has issued a command to switch the user
           traffic to the recovery span.";
      }
      enum wait-to-restore {
        description
          "The recovery domain is recovering from a failure/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
        "RFC 4427: Recovery (Protection and Restoration) Terminology
         for Generalized Multi-Protocol Label Switching (GMPLS)
         RFC 6378: 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.";
    }

    typedef te-topology-id {
      type union {
        type string {
          length "0";
          // empty string
        }
        type string {
          pattern '([a-zA-Z0-9\-_.]+:)*'
                + '/?([a-zA-Z0-9\-_.]+)(/[a-zA-Z0-9\-_.]+)*';
        }
      }
      description
        "An identifier for a topology.
         It is optional to have one or more prefixes at the beginning,
         separated by colons.  The prefixes can be 'network-types' as
```

```
        defined in the 'ietf-network' module in RFC 8345, to help the
        user better understand the topology before further inquiry
        is made.";
    reference
      "RFC 8345: A YANG Data Model for Network Topologies";
  }

  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 a local or remote link identifier
       as defined in RFCs 3630 and 5305.";
    reference
      "RFC 3630: Traffic Engineering (TE) Extensions to OSPF
       Version 2
       RFC 5305: IS-IS Extensions for Traffic Engineering";
  }

  /* TE features */

  feature p2mp-te {
    description
      "Indicates support for Point-to-Multipoint TE (P2MP-TE).";
    reference
      "RFC 4875: Extensions to Resource Reservation Protocol -
       Traffic Engineering (RSVP-TE) for Point-to-Multipoint TE
       Label Switched Paths (LSPs)";
  }

  feature frr-te {
    description
      "Indicates support for TE Fast Reroute (FRR).";
    reference
      "RFC 4090: Fast Reroute Extensions to RSVP-TE for LSP Tunnels";
  }

  feature extended-admin-groups {
    description
      "Indicates support for TE link extended administrative
       groups.";
    reference
      "RFC 7308: Extended Administrative Groups in MPLS Traffic
       Engineering (MPLS-TE)";
  }

  feature named-path-affinities {
    description
      "Indicates support for named path affinities.";
  }

  feature named-extended-admin-groups {
    description
```

```
      "Indicates support for named extended administrative groups.";
  }

  feature named-srlg-groups {
    description
      "Indicates support for named SRLG groups.";
  }

  feature named-path-constraints {
    description
      "Indicates support for named path constraints.";
  }

  feature path-optimization-metric {
    description
      "Indicates support for path optimization metrics.";
  }

  feature path-optimization-objective-function {
    description
      "Indicates support for path optimization objective functions.";
  }

  /*
   * Identities
   */

  identity session-attributes-flags {
    description
      "Base identity for the RSVP-TE session attributes flags.";
  }

  identity local-protection-desired {
    base session-attributes-flags;
    description
      "Local protection is desired.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
       Section 4.7.1";
  }

  identity se-style-desired {
    base session-attributes-flags;
    description
      "Shared explicit style, to allow the LSP to be established
       and share resources with the old LSP.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
  }

  identity local-recording-desired {
    base session-attributes-flags;
    description
      "Label recording is desired.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
       Section 4.7.1";
  }
```

```
  identity bandwidth-protection-desired {
    base session-attributes-flags;
    description
      "Requests FRR bandwidth protection on LSRs, if present.";
    reference
      "RFC 4090: Fast Reroute Extensions to RSVP-TE for LSP Tunnels";
  }

  identity node-protection-desired {
    base session-attributes-flags;
    description
      "Requests FRR node protection on LSRs, if present.";
    reference
      "RFC 4090: Fast Reroute Extensions to RSVP-TE for LSP Tunnels";
  }

  identity path-reevaluation-request {
    base session-attributes-flags;
    description
      "This flag indicates that a path re-evaluation (of the
       current path in use) is requested.  Note that this does
       not trigger any LSP reroutes but instead just signals a
       request to evaluate whether a preferable path exists.";
    reference
      "RFC 4736: Reoptimization of Multiprotocol Label Switching
       (MPLS) Traffic Engineering (TE) Loosely Routed Label Switched
       Path (LSP)";
  }

  identity soft-preemption-desired {
    base session-attributes-flags;
    description
      "Soft preemption of LSP resources is desired.";
    reference
      "RFC 5712: MPLS Traffic Engineering Soft Preemption";
  }

  identity lsp-attributes-flags {
    description
      "Base identity for LSP attributes flags.";
  }

  identity end-to-end-rerouting-desired {
    base lsp-attributes-flags;
    description
      "Indicates end-to-end rerouting behavior for an LSP
       undergoing establishment.  This MAY also be used to
       specify the behavior of end-to-end LSP recovery for
       established LSPs.";
    reference
      "RFC 4920: Crankback Signaling Extensions for MPLS and GMPLS
       RSVP-TE
       RFC 5420: Encoding of Attributes for MPLS LSP Establishment
       Using Resource Reservation Protocol Traffic Engineering
       (RSVP-TE)
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
```

```
  }

  identity boundary-rerouting-desired {
    base lsp-attributes-flags;
    description
      "Indicates boundary rerouting behavior for an LSP undergoing
       establishment.  This MAY also be used to specify
       segment-based LSP recovery through nested crankback for
       established LSPs.  The boundary Area Border Router (ABR) /
       Autonomous System Border Router (ASBR) can decide to forward
       the PathErr message upstream to either an upstream boundary
       ABR/ASBR or the ingress LSR.  Alternatively, it can try to
       select another egress boundary LSR.";
    reference
      "RFC 4920: Crankback Signaling Extensions for MPLS and GMPLS
       RSVP-TE
       RFC 5420: Encoding of Attributes for MPLS LSP Establishment
       Using Resource Reservation Protocol Traffic Engineering
       (RSVP-TE)
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity segment-based-rerouting-desired {
    base lsp-attributes-flags;
    description
      "Indicates segment-based rerouting behavior for an LSP
       undergoing establishment.  This MAY also be used to specify
       segment-based LSP recovery for established LSPs.";
    reference
      "RFC 4920: Crankback Signaling Extensions for MPLS and GMPLS
       RSVP-TE
       RFC 5420: Encoding of Attributes for MPLS LSP Establishment
       Using Resource Reservation Protocol Traffic Engineering
       (RSVP-TE)
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity lsp-integrity-required {
    base lsp-attributes-flags;
    description
      "Indicates that LSP integrity is required.";
    reference
      "RFC 4875: Extensions to Resource Reservation Protocol -
       Traffic Engineering (RSVP-TE) for Point-to-Multipoint TE
       Label Switched Paths (LSPs)
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity contiguous-lsp-desired {
    base lsp-attributes-flags;
    description
      "Indicates that a contiguous LSP is desired.";
    reference
      "RFC 5151: Inter-Domain MPLS and GMPLS Traffic Engineering --
       Resource Reservation Protocol-Traffic Engineering (RSVP-TE)
```

```
       Extensions
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity lsp-stitching-desired {
    base lsp-attributes-flags;
    description
      "Indicates that LSP stitching is desired.";
    reference
      "RFC 5150: Label Switched Path Stitching with Generalized
       Multiprotocol Label Switching Traffic Engineering (GMPLS TE)
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity pre-planned-lsp-flag {
    base lsp-attributes-flags;
    description
      "Indicates that the LSP MUST be provisioned in the
       control plane only.";
    reference
      "RFC 6001: Generalized MPLS (GMPLS) Protocol Extensions for
       Multi-Layer and Multi-Region Networks (MLN/MRN)
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity non-php-behavior-flag {
    base lsp-attributes-flags;
    description
      "Indicates that non-PHP (non-Penultimate Hop Popping) behavior
       for the LSP is desired.";
    reference
      "RFC 6511: Non-Penultimate Hop Popping Behavior and Out-of-Band
       Mapping for RSVP-TE Label Switched Paths
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity oob-mapping-flag {
    base lsp-attributes-flags;
    description
      "Indicates that signaling of the egress binding information is
       out of band (e.g., via the Border Gateway Protocol (BGP)).";
    reference
      "RFC 6511: Non-Penultimate Hop Popping Behavior and Out-of-Band
       Mapping for RSVP-TE Label Switched Paths
       RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
       Route Object (ERO)";
  }

  identity entropy-label-capability {
    base lsp-attributes-flags;
    description
      "Indicates entropy label capability.";
    reference
      "RFC 6790: The Use of Entropy Labels in MPLS Forwarding
```

```
        RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
        Route Object (ERO)";
    }

    identity oam-mep-entity-desired {
      base lsp-attributes-flags;
      description
        "OAM Maintenance Entity Group End Point (MEP) entities
         desired.";
      reference
        "RFC 7260: GMPLS RSVP-TE Extensions for Operations,
         Administration, and Maintenance (OAM) Configuration";
    }

    identity oam-mip-entity-desired {
      base lsp-attributes-flags;
      description
        "OAM Maintenance Entity Group Intermediate Points (MIP)
         entities desired.";
      reference
        "RFC 7260: GMPLS RSVP-TE Extensions for Operations,
         Administration, and Maintenance (OAM) Configuration";
    }

    identity srlg-collection-desired {
      base lsp-attributes-flags;
      description
        "SRLG collection desired.";
      reference
        "RFC 7570: Label Switched Path (LSP) Attribute in the Explicit
         Route Object (ERO)
         RFC 8001: RSVP-TE Extensions for Collecting Shared Risk
         Link Group (SRLG) Information";
    }

    identity loopback-desired {
      base lsp-attributes-flags;
      description
        "This flag indicates that a particular node on the LSP is
         required to enter loopback mode.  This can also be
         used to specify the loopback state of the node.";
      reference
        "RFC 7571: GMPLS RSVP-TE Extensions for Lock Instruct and
         Loopback";
    }

    identity p2mp-te-tree-eval-request {
      base lsp-attributes-flags;
      description
        "P2MP-TE tree re-evaluation request.";
      reference
        "RFC 8149: RSVP Extensions for Reoptimization of Loosely Routed
         Point-to-Multipoint Traffic Engineering Label Switched Paths
         (LSPs)";
    }

    identity rtm-set-desired {
      base lsp-attributes-flags;
```

```
    description
      "Residence Time Measurement (RTM) attribute flag requested.";
    reference
      "RFC 8169: Residence Time Measurement in MPLS Networks";
  }

  identity link-protection-type {
    description
      "Base identity for the link protection type.";
  }

  identity link-protection-unprotected {
    base link-protection-type;
    description
      "Unprotected link type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity link-protection-extra-traffic {
    base link-protection-type;
    description
      "Extra-Traffic protected link type.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity link-protection-shared {
    base link-protection-type;
    description
      "Shared protected link type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity link-protection-1-for-1 {
    base link-protection-type;
    description
      "One-for-one (1:1) protected link type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity link-protection-1-plus-1 {
    base link-protection-type;
    description
      "One-plus-one (1+1) protected link type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity link-protection-enhanced {
    base link-protection-type;
```

```
    description
      "A compound link protection type derived from the underlay
       TE tunnel protection configuration supporting the TE link.";
  }

  identity association-type {
    description
      "Base identity for the tunnel association.";
  }

  identity association-type-recovery {
    base association-type;
    description
      "Association type for recovery, used to associate LSPs of the
       same tunnel for recovery.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery
       RFC 6780: RSVP ASSOCIATION Object Extensions";
  }

  identity association-type-resource-sharing {
    base association-type;
    description
      "Association type for resource sharing, used to enable
       resource sharing during make-before-break.";
    reference
      "RFC 4873: GMPLS Segment Recovery
       RFC 6780: RSVP ASSOCIATION Object Extensions";
  }

  identity association-type-double-sided-bidir {
    base association-type;
    description
      "Association type for double-sided bidirectional LSPs,
       used to associate two LSPs of two tunnels that are
       independently configured on either endpoint.";
    reference
      "RFC 7551: RSVP-TE Extensions for Associated Bidirectional
       Label Switched Paths (LSPs)";
  }

  identity association-type-single-sided-bidir {
    base association-type;
    description
      "Association type for single-sided bidirectional LSPs,
       used to associate two LSPs of two tunnels, where one
       tunnel is configured on one side/endpoint and the other
       tunnel is dynamically created on the other endpoint.";
    reference
      "RFC 6780: RSVP ASSOCIATION Object Extensions
       RFC 7551: RSVP-TE Extensions for Associated Bidirectional
       Label Switched Paths (LSPs)";
  }

  identity objective-function-type {
    description
      "Base objective function type.";
```

```
  }

  identity of-minimize-cost-path {
    base objective-function-type;
    description
      "Objective function for minimizing path cost.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }

  identity of-minimize-load-path {
    base objective-function-type;
    description
      "Objective function for minimizing the load on one or more
       paths.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }

  identity of-maximize-residual-bandwidth {
    base objective-function-type;
    description
      "Objective function for maximizing residual bandwidth.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }

  identity of-minimize-agg-bandwidth-consumption {
    base objective-function-type;
    description
      "Objective function for minimizing aggregate bandwidth
       consumption.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }

  identity of-minimize-load-most-loaded-link {
    base objective-function-type;
    description
      "Objective function for minimizing the load on the link that
       is carrying the highest load.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }

  identity of-minimize-cost-path-set {
    base objective-function-type;
    description
      "Objective function for minimizing the cost on a path set.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }
```

```
  identity path-computation-method {
    description
      "Base identity for supported path computation mechanisms.";
  }

  identity path-locally-computed {
    base path-computation-method;
    description
      "Indicates a constrained-path LSP in which the
       path is computed by the local LER.";
    reference
      "RFC 3272: Overview and Principles of Internet Traffic
       Engineering, Section 5.4";
  }

  identity path-externally-queried {
    base path-computation-method;
    description
      "Constrained-path LSP in which the path is obtained by
       querying an external source, such as a PCE server.
       In the case that an LSP is defined to be externally queried,
       it may also have associated explicit definitions (provided
       to the external source to aid computation).  The path that is
       returned by the external source may require further local
       computation on the device.";
    reference
      "RFC 3272: Overview and Principles of Internet Traffic
       Engineering
       RFC 4657: Path Computation Element (PCE) Communication
       Protocol Generic Requirements";
  }

  identity path-explicitly-defined {
    base path-computation-method;
    description
      "Constrained-path LSP in which the path is
       explicitly specified as a collection of strict and/or loose
       hops.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels
       RFC 3272: Overview and Principles of Internet Traffic
       Engineering";
  }

  identity lsp-metric-type {
    description
      "Base identity for the LSP metric specification types.";
  }

  identity lsp-metric-relative {
    base lsp-metric-type;
    description
      "The metric specified for the LSPs to which this identity
       refers is specified as a value relative to the IGP metric
       cost to the LSP's tail end.";
    reference
      "RFC 4657: Path Computation Element (PCE) Communication
```

```
       Protocol Generic Requirements";
  }

  identity lsp-metric-absolute {
    base lsp-metric-type;
    description
      "The metric specified for the LSPs to which this identity
       refers is specified as an absolute value.";
    reference
      "RFC 4657: Path Computation Element (PCE) Communication
       Protocol Generic Requirements";
  }

  identity lsp-metric-inherited {
    base lsp-metric-type;
    description
      "The metric for the LSPs to which this identity refers is
       not specified explicitly; rather, it is directly inherited
       from the IGP cost.";
    reference
      "RFC 4657: Path Computation Element (PCE) Communication
       Protocol Generic Requirements";
  }

  identity te-tunnel-type {
    description
      "Base identity from which specific tunnel types are derived.";
  }

  identity te-tunnel-p2p {
    base te-tunnel-type;
    description
      "TE Point-to-Point (P2P) tunnel type.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
  }

  identity te-tunnel-p2mp {
    base te-tunnel-type;
    description
      "TE P2MP tunnel type.";
    reference
      "RFC 4875: Extensions to Resource Reservation Protocol -
       Traffic Engineering (RSVP-TE) for Point-to-Multipoint TE
       Label Switched Paths (LSPs)";
  }

  identity tunnel-action-type {
    description
      "Base identity from which specific tunnel action types
       are derived.";
  }

  identity tunnel-action-resetup {
    base tunnel-action-type;
    description
      "TE tunnel action that tears down the tunnel's current LSP
       (if any) and attempts to re-establish a new LSP.";
```

```
  }

  identity tunnel-action-reoptimize {
    base tunnel-action-type;
    description
      "TE tunnel action that reoptimizes the placement of the
       tunnel LSP(s).";
  }

  identity tunnel-action-switchpath {
    base tunnel-action-type;
    description
      "TE tunnel action that switches the tunnel's LSP to use the
       specified path.";
  }

  identity te-action-result {
    description
      "Base identity from which specific TE action results
       are derived.";
  }

  identity te-action-success {
    base te-action-result;
    description
      "TE action was successful.";
  }

  identity te-action-fail {
    base te-action-result;
    description
      "TE action failed.";
  }

  identity tunnel-action-inprogress {
    base te-action-result;
    description
      "TE action is in progress.";
  }

  identity tunnel-admin-state-type {
    description
      "Base identity for TE tunnel administrative states.";
  }

  identity tunnel-admin-state-up {
    base tunnel-admin-state-type;
    description
      "Tunnel's administrative state is up.";
  }

  identity tunnel-admin-state-down {
    base tunnel-admin-state-type;
    description
      "Tunnel's administrative state is down.";
  }

  identity tunnel-state-type {
```

```
    description
      "Base identity for TE tunnel states.";
  }

  identity tunnel-state-up {
    base tunnel-state-type;
    description
      "Tunnel's state is up.";
  }

  identity tunnel-state-down {
    base tunnel-state-type;
    description
      "Tunnel's state is down.";
  }

  identity lsp-state-type {
    description
      "Base identity for TE LSP states.";
  }

  identity lsp-path-computing {
    base lsp-state-type;
    description
      "State path computation is in progress.";
  }

  identity lsp-path-computation-ok {
    base lsp-state-type;
    description
      "State path computation was successful.";
  }

  identity lsp-path-computation-failed {
    base lsp-state-type;
    description
      "State path computation failed.";
  }

  identity lsp-state-setting-up {
    base lsp-state-type;
    description
      "State is being set up.";
  }

  identity lsp-state-setup-ok {
    base lsp-state-type;
    description
      "State setup was successful.";
  }

  identity lsp-state-setup-failed {
    base lsp-state-type;
    description
      "State setup failed.";
  }

  identity lsp-state-up {
```

```
    base lsp-state-type;
    description
      "State is up.";
  }

  identity lsp-state-tearing-down {
    base lsp-state-type;
    description
      "State is being torn down.";
  }

  identity lsp-state-down {
    base lsp-state-type;
    description
      "State is down.";
  }

  identity path-invalidation-action-type {
    description
      "Base identity for TE path invalidation action types.";
  }

  identity path-invalidation-action-drop {
    base path-invalidation-action-type;
    description
      "Upon invalidation of the TE tunnel path, the tunnel remains
       valid, but any packet mapped over the tunnel is dropped.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
       Section 2.5";
  }

  identity path-invalidation-action-teardown {
    base path-invalidation-action-type;
    description
      "TE path invalidation action teardown.";
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
       Section 2.5";
  }

  identity lsp-restoration-type {
    description
      "Base identity from which LSP restoration types are derived.";
  }

  identity lsp-restoration-restore-any {
    base lsp-restoration-type;
    description
      "Any LSP affected by a failure is restored.";
  }

  identity lsp-restoration-restore-all {
    base lsp-restoration-type;
    description
      "Affected LSPs are restored after all LSPs of the tunnel are
       broken.";
  }
```

```
  identity restoration-scheme-type {
    description
      "Base identity for LSP restoration schemes.";
  }

  identity restoration-scheme-preconfigured {
    base restoration-scheme-type;
    description
      "Restoration LSP is preconfigured prior to the failure.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity restoration-scheme-precomputed {
    base restoration-scheme-type;
    description
      "Restoration LSP is precomputed prior to the failure.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity restoration-scheme-presignaled {
    base restoration-scheme-type;
    description
      "Restoration LSP is presignaled prior to the failure.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity lsp-protection-type {
    description
      "Base identity from which LSP protection types are derived.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity lsp-protection-unprotected {
    base lsp-protection-type;
    description
      "'Unprotected' LSP protection type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity lsp-protection-reroute-extra {
    base lsp-protection-type;
    description
      "'(Full) Rerouting' LSP protection type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }
```

```
  identity lsp-protection-reroute {
    base lsp-protection-type;
    description
      "'Rerouting without Extra-Traffic' LSP protection type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity lsp-protection-1-for-n {
    base lsp-protection-type;
    description
      "'1:N Protection with Extra-Traffic' LSP protection type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity lsp-protection-1-for-1 {
    base lsp-protection-type;
    description
      "LSP protection '1:1 Protection Type'.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity lsp-protection-unidir-1-plus-1 {
    base lsp-protection-type;
    description
      "'1+1 Unidirectional Protection' LSP protection type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity lsp-protection-bidir-1-plus-1 {
    base lsp-protection-type;
    description
      "'1+1 Bidirectional Protection' LSP protection type.";
    reference
      "RFC 4872: RSVP-TE Extensions in Support of End-to-End
       Generalized Multi-Protocol Label Switching (GMPLS) Recovery";
  }

  identity lsp-protection-extra-traffic {
    base lsp-protection-type;
    description
      "Extra-Traffic LSP protection type.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity lsp-protection-state {
    description
      "Base identity of protection states for reporting purposes.";
```

```
  }

  identity normal {
    base lsp-protection-state;
    description
      "Normal state.";
  }

  identity signal-fail-of-protection {
    base lsp-protection-state;
    description
      "The protection transport entity has a signal fail condition
       that is of higher priority than the forced switchover
       command.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity lockout-of-protection {
    base lsp-protection-state;
    description
      "A Loss of Protection (LoP) command is active.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity forced-switch {
    base lsp-protection-state;
    description
      "A forced switchover command is active.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity signal-fail {
    base lsp-protection-state;
    description
      "There is a signal fail condition on either the working path
       or the protection path.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity signal-degrade {
    base lsp-protection-state;
    description
      "There is a signal degrade condition on either the working
       path or the protection path.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity manual-switch {
```

```
    base lsp-protection-state;
    description
      "A manual switchover command is active.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity wait-to-restore {
    base lsp-protection-state;
    description
      "A WTR timer is running.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity do-not-revert {
    base lsp-protection-state;
    description
      "A Do Not Revert (DNR) condition is active because of
       non-revertive behavior.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity failure-of-protocol {
    base lsp-protection-state;
    description
      "LSP protection is not working because of a protocol failure
       condition.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity protection-external-commands {
    description
      "Base identity from which protection-related external commands
       used for troubleshooting purposes are derived.";
  }

  identity action-freeze {
    base protection-external-commands;
    description
      "A temporary configuration action initiated by an operator
       command that prevents any switchover action from being taken
       and, as such, freezes the current state.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity clear-freeze {
    base protection-external-commands;
    description
      "An action that clears the active freeze state.";
```

```
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity action-lockout-of-normal {
    base protection-external-commands;
    description
      "A temporary configuration action initiated by an operator
       command to ensure that the normal traffic is not allowed
       to use the protection transport entity.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity clear-lockout-of-normal {
    base protection-external-commands;
    description
      "An action that clears the active lockout of the
       normal state.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity action-lockout-of-protection {
    base protection-external-commands;
    description
      "A temporary configuration action initiated by an operator
       command to ensure that the protection transport entity is
       temporarily not available to transport a traffic signal
       (either normal or Extra-Traffic).";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity action-forced-switch {
    base protection-external-commands;
    description
      "A switchover action initiated by an operator command to switch
       the Extra-Traffic signal, the normal traffic signal, or the
       null signal to the protection transport entity, unless a
       switchover command of equal or higher priority is in effect.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity action-manual-switch {
    base protection-external-commands;
    description
      "A switchover action initiated by an operator command to switch
       the Extra-Traffic signal, the normal traffic signal, or
       the null signal to the protection transport entity, unless
       a fault condition exists on other transport entities or a
       switchover command of equal or higher priority is in effect.";
```

```
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity action-exercise {
    base protection-external-commands;
    description
      "An action that starts testing whether or not APS communication
       is operating correctly.  It is of lower priority than any
       other state or command.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity clear {
    base protection-external-commands;
    description
      "An action that clears the active near-end lockout of a
       protection, forced switchover, manual switchover, WTR state,
       or exercise command.";
    reference
      "RFC 4427: Recovery (Protection and Restoration) Terminology
       for Generalized Multi-Protocol Label Switching (GMPLS)";
  }

  identity switching-capabilities {
    description
      "Base identity for interface switching capabilities.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity switching-psc1 {
    base switching-capabilities;
    description
      "Packet-Switch Capable-1 (PSC-1).";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity switching-evpl {
    base switching-capabilities;
    description
      "Ethernet Virtual Private Line (EVPL).";
    reference
      "RFC 6004: Generalized MPLS (GMPLS) Support for Metro Ethernet
       Forum and G.8011 Ethernet Service Switching";
  }

  identity switching-l2sc {
    base switching-capabilities;
    description
      "Layer-2 Switch Capable (L2SC).";
    reference
```

```
       "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
        Signaling Functional Description";
  }

  identity switching-tdm {
    base switching-capabilities;
    description
      "Time-Division-Multiplex Capable (TDM).";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity switching-otn {
    base switching-capabilities;
    description
      "OTN-TDM capable.";
    reference
      "RFC 7138: Traffic Engineering Extensions to OSPF for GMPLS
       Control of Evolving G.709 Optical Transport Networks";
  }

  identity switching-dcsc {
    base switching-capabilities;
    description
      "Data Channel Switching Capable (DCSC).";
    reference
      "RFC 6002: Generalized MPLS (GMPLS) Data Channel
       Switching Capable (DCSC) and Channel Set Label Extensions";
  }

  identity switching-lsc {
    base switching-capabilities;
    description
      "Lambda-Switch Capable (LSC).";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity switching-fsc {
    base switching-capabilities;
    description
      "Fiber-Switch Capable (FSC).";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-types {
    description
      "Base identity for encoding types.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-packet {
```

```
    base lsp-encoding-types;
    description
      "Packet LSP encoding.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-ethernet {
    base lsp-encoding-types;
    description
      "Ethernet LSP encoding.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-pdh {
    base lsp-encoding-types;
    description
      "ANSI/ETSI PDH LSP encoding.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-sdh {
    base lsp-encoding-types;
    description
      "SDH ITU-T G.707 / SONET ANSI T1.105 LSP encoding.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-digital-wrapper {
    base lsp-encoding-types;
    description
      "Digital Wrapper LSP encoding.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-lambda {
    base lsp-encoding-types;
    description
      "Lambda (photonic) LSP encoding.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-fiber {
    base lsp-encoding-types;
    description
      "Fiber LSP encoding.";
    reference
```

```
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-fiber-channel {
    base lsp-encoding-types;
    description
      "FiberChannel LSP encoding.";
    reference
      "RFC 3471: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Functional Description";
  }

  identity lsp-encoding-oduk {
    base lsp-encoding-types;
    description
      "G.709 ODUk (Digital Path) LSP encoding.";
    reference
      "RFC 4328: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Extensions for G.709 Optical Transport Networks
       Control";
  }

  identity lsp-encoding-optical-channel {
    base lsp-encoding-types;
    description
      "G.709 Optical Channel LSP encoding.";
    reference
      "RFC 4328: Generalized Multi-Protocol Label Switching (GMPLS)
       Signaling Extensions for G.709 Optical Transport Networks
       Control";
  }

  identity lsp-encoding-line {
    base lsp-encoding-types;
    description
      "Line (e.g., 8B/10B) LSP encoding.";
    reference
      "RFC 6004: Generalized MPLS (GMPLS) Support for Metro
       Ethernet Forum and G.8011 Ethernet Service Switching";
  }

  identity path-signaling-type {
    description
      "Base identity from which specific LSP path setup types
       are derived.";
  }

  identity path-setup-static {
    base path-signaling-type;
    description
      "Static LSP provisioning path setup.";
  }

  identity path-setup-rsvp {
    base path-signaling-type;
    description
      "RSVP-TE signaling path setup.";
```

```
    reference
      "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
  }

  identity path-setup-sr {
    base path-signaling-type;
    description
      "Segment-routing path setup.";
  }

  identity path-scope-type {
    description
      "Base identity from which specific path scope types are
       derived.";
  }

  identity path-scope-segment {
    base path-scope-type;
    description
      "Path scope segment.";
    reference
      "RFC 4873: GMPLS Segment Recovery";
  }

  identity path-scope-end-to-end {
    base path-scope-type;
    description
      "Path scope end to end.";
    reference
      "RFC 4873: GMPLS Segment Recovery";
  }

  identity route-usage-type {
    description
      "Base identity for route usage.";
  }

  identity route-include-object {
    base route-usage-type;
    description
      "'Include route' object.";
  }

  identity route-exclude-object {
    base route-usage-type;
    description
      "'Exclude route' object.";
    reference
      "RFC 4874: Exclude Routes - Extension to Resource ReserVation
       Protocol-Traffic Engineering (RSVP-TE)";
  }

  identity route-exclude-srlg {
    base route-usage-type;
    description
      "Excludes SRLGs.";
    reference
      "RFC 4874: Exclude Routes - Extension to Resource ReserVation
```

```
       Protocol-Traffic Engineering (RSVP-TE)";
  }

  identity path-metric-type {
    description
      "Base identity for the path metric type.";
  }

  identity path-metric-te {
    base path-metric-type;
    description
      "TE path metric.";
    reference
      "RFC 3785: Use of Interior Gateway Protocol (IGP) Metric as a
       second MPLS Traffic Engineering (TE) Metric";
  }

  identity path-metric-igp {
    base path-metric-type;
    description
      "IGP path metric.";
    reference
      "RFC 3785: Use of Interior Gateway Protocol (IGP) Metric as a
       second MPLS Traffic Engineering (TE) Metric";
  }

  identity path-metric-hop {
    base path-metric-type;
    description
      "Hop path metric.";
  }

  identity path-metric-delay-average {
    base path-metric-type;
    description
      "Average unidirectional link delay.";
    reference
      "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions";
  }

  identity path-metric-delay-minimum {
    base path-metric-type;
    description
      "Minimum unidirectional link delay.";
    reference
      "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions";
  }

  identity path-metric-residual-bandwidth {
    base path-metric-type;
    description
      "Unidirectional Residual Bandwidth, which is defined to be
       Maximum Bandwidth (RFC 3630) minus the bandwidth currently
       allocated to LSPs.";
    reference
      "RFC 3630: Traffic Engineering (TE) Extensions to OSPF
       Version 2
       RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions";
```

```
  }

  identity path-metric-optimize-includes {
    base path-metric-type;
    description
      "A metric that optimizes the number of included resources
       specified in a set.";
  }

  identity path-metric-optimize-excludes {
    base path-metric-type;
    description
      "A metric that optimizes to a maximum the number of excluded
       resources specified in a set.";
  }

  identity path-tiebreaker-type {
    description
      "Base identity for the path tiebreaker type.";
  }

  identity path-tiebreaker-minfill {
    base path-tiebreaker-type;
    description
      "Min-Fill LSP path placement.";
  }

  identity path-tiebreaker-maxfill {
    base path-tiebreaker-type;
    description
      "Max-Fill LSP path placement.";
  }

  identity path-tiebreaker-random {
    base path-tiebreaker-type;
    description
      "Random LSP path placement.";
  }

  identity resource-affinities-type {
    description
      "Base identity for resource class affinities.";
    reference
      "RFC 2702: Requirements for Traffic Engineering Over MPLS";
  }

  identity resource-aff-include-all {
    base resource-affinities-type;
    description
      "The set of attribute filters associated with a
       tunnel, all of which must be present for a link
       to be acceptable.";
    reference
      "RFC 2702: Requirements for Traffic Engineering Over MPLS
       RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
  }

  identity resource-aff-include-any {
```

```
    base resource-affinities-type;
    description
      "The set of attribute filters associated with a
       tunnel, any of which must be present for a link
       to be acceptable.";
    reference
      "RFC 2702: Requirements for Traffic Engineering Over MPLS
       RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
  }

  identity resource-aff-exclude-any {
    base resource-affinities-type;
    description
      "The set of attribute filters associated with a
       tunnel, any of which renders a link unacceptable.";
    reference
      "RFC 2702: Requirements for Traffic Engineering Over MPLS
       RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
  }

  identity te-optimization-criterion {
    description
      "Base identity for the TE optimization criteria.";
    reference
      "RFC 3272: Overview and Principles of Internet Traffic
       Engineering";
  }

  identity not-optimized {
    base te-optimization-criterion;
    description
      "Optimization is not applied.";
  }

  identity cost {
    base te-optimization-criterion;
    description
      "Optimized on cost.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }

  identity delay {
    base te-optimization-criterion;
    description
      "Optimized on delay.";
    reference
      "RFC 5541: Encoding of Objective Functions in the Path
       Computation Element Communication Protocol (PCEP)";
  }

  identity path-computation-srlg-type {
    description
      "Base identity for SRLG path computation.";
  }

  identity srlg-ignore {
```

```
    base path-computation-srlg-type;
    description
      "Ignores SRLGs in the path computation.";
  }

  identity srlg-strict {
    base path-computation-srlg-type;
    description
      "Includes a strict SRLG check in the path computation.";
  }

  identity srlg-preferred {
    base path-computation-srlg-type;
    description
      "Includes a preferred SRLG check in the path computation.";
  }

  identity srlg-weighted {
    base path-computation-srlg-type;
    description
      "Includes a weighted SRLG check in the path computation.";
  }

  /**
   * TE bandwidth groupings
   **/

  grouping te-bandwidth {
    description
      "This grouping defines the generic TE bandwidth.
       For some known data-plane technologies, specific modeling
       structures are specified.  The string-encoded 'te-bandwidth'
       type is used for unspecified technologies.
       The modeling structure can be augmented later for other
       technologies.";
    container te-bandwidth {
      description
        "Container that specifies TE bandwidth.  The choices
         can be augmented for specific data-plane technologies.";
      choice technology {
        default "generic";
        description
          "Data-plane technology type.";
        case generic {
          leaf generic {
            type te-bandwidth;
            description
              "Bandwidth specified in a generic format.";
          }
        }
      }
    }
  }

  /**
   * TE label groupings
   **/
```

```
  grouping te-label {
    description
      "This grouping defines the generic TE label.
       The modeling structure can be augmented for each technology.
       For unspecified technologies, 'rt-types:generalized-label'
       is used.";
    container te-label {
      description
        "Container that specifies the TE label.  The choices can
         be augmented for specific data-plane technologies.";
      choice technology {
        default "generic";
        description
          "Data-plane technology type.";
        case generic {
          leaf generic {
            type rt-types:generalized-label;
            description
              "TE label specified in a generic format.";
          }
        }
      }
      leaf direction {
        type te-label-direction;
        default "forward";
        description
          "Label direction.";
      }
    }
  }

  grouping te-topology-identifier {
    description
      "Augmentation for a TE topology.";
    container te-topology-identifier {
      description
        "TE topology identifier container.";
      leaf provider-id {
        type te-global-id;
        default "0";
        description
          "An identifier to uniquely identify a provider.
           If omitted, it assumes that the topology provider ID
           value = 0 (the default).";
      }
      leaf client-id {
        type te-global-id;
        default "0";
        description
          "An identifier to uniquely identify a client.
           If omitted, it assumes that the topology client ID
           value = 0 (the default).";
      }
      leaf topology-id {
        type te-topology-id;
        default "";
        description
          "When the datastore contains several topologies,
```

```
            'topology-id' distinguishes between them.  If omitted,
            the default (empty) string for this leaf is assumed.";
      }
    }
  }

  /**
   * TE performance metrics groupings
   **/

  grouping performance-metrics-one-way-delay-loss {
    description
      "Performance Metrics (PM) information in real time that can
       be applicable to links or connections.  PM defined in this
       grouping are applicable to generic TE PM as well as packet TE
       PM.";
    reference
      "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions
       RFC 7823: Performance-Based Path Selection for Explicitly
       Routed Label Switched Paths (LSPs) Using TE Metric
       Extensions
       RFC 8570: IS-IS Traffic Engineering (TE) Metric Extensions";
    leaf one-way-delay {
      type uint32 {
        range "0..16777215";
      }
      description
        "One-way delay or latency in microseconds.";
    }
    leaf one-way-delay-normality {
      type te-types:performance-metrics-normality;
      description
        "One-way delay normality.";
    }
  }

  grouping performance-metrics-two-way-delay-loss {
    description
      "PM information in real time that can be applicable to links or
       connections.  PM defined in this grouping are applicable to
       generic TE PM as well as packet TE PM.";
    reference
      "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions
       RFC 7823: Performance-Based Path Selection for Explicitly
       Routed Label Switched Paths (LSPs) Using TE Metric
       Extensions
       RFC 8570: IS-IS Traffic Engineering (TE) Metric Extensions";
    leaf two-way-delay {
      type uint32 {
        range "0..16777215";
      }
      description
        "Two-way delay or latency in microseconds.";
    }
    leaf two-way-delay-normality {
      type te-types:performance-metrics-normality;
      description
        "Two-way delay normality.";
```

```
    }
  }

  grouping performance-metrics-one-way-bandwidth {
    description
      "PM information in real time that can be applicable to links.
       PM defined in this grouping are applicable to generic TE PM
       as well as packet TE PM.";
    reference
      "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions
       RFC 7823: Performance-Based Path Selection for Explicitly
       Routed Label Switched Paths (LSPs) Using TE Metric
       Extensions
       RFC 8570: IS-IS Traffic Engineering (TE) Metric Extensions";
    leaf one-way-residual-bandwidth {
      type rt-types:bandwidth-ieee-float32;
      units "bytes per second";
      default "0x0p0";
      description
        "Residual bandwidth that subtracts tunnel reservations from
         Maximum Bandwidth (or link capacity) (RFC 3630) and
         provides an aggregated remainder across QoS classes.";
      reference
        "RFC 3630: Traffic Engineering (TE) Extensions to OSPF
         Version 2";
    }
    leaf one-way-residual-bandwidth-normality {
      type te-types:performance-metrics-normality;
      default "normal";
      description
        "Residual bandwidth normality.";
    }
    leaf one-way-available-bandwidth {
      type rt-types:bandwidth-ieee-float32;
      units "bytes per second";
      default "0x0p0";
      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 one-way-available-bandwidth-normality {
      type te-types:performance-metrics-normality;
      default "normal";
      description
        "Available bandwidth normality.";
    }
    leaf one-way-utilized-bandwidth {
      type rt-types:bandwidth-ieee-float32;
      units "bytes per second";
      default "0x0p0";
      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.";
```

```
    }
    leaf one-way-utilized-bandwidth-normality {
      type te-types:performance-metrics-normality;
      default "normal";
      description
        "Bandwidth utilization normality.";
    }
  }

  grouping one-way-performance-metrics {
    description
      "One-way PM throttle grouping.";
    leaf one-way-delay {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "One-way delay or latency in microseconds.";
    }
    leaf one-way-residual-bandwidth {
      type rt-types:bandwidth-ieee-float32;
      units "bytes per second";
      default "0x0p0";
      description
        "Residual bandwidth that subtracts tunnel reservations from
         Maximum Bandwidth (or link capacity) (RFC 3630) and
         provides an aggregated remainder across QoS classes.";
      reference
        "RFC 3630: Traffic Engineering (TE) Extensions to OSPF
         Version 2";
    }
    leaf one-way-available-bandwidth {
      type rt-types:bandwidth-ieee-float32;
      units "bytes per second";
      default "0x0p0";
      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 one-way-utilized-bandwidth {
      type rt-types:bandwidth-ieee-float32;
      units "bytes per second";
      default "0x0p0";
      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.";
    }
  }

  grouping two-way-performance-metrics {
    description
      "Two-way PM throttle grouping.";
```

```
    leaf two-way-delay {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "Two-way delay or latency in microseconds.";
    }
  }

  grouping performance-metrics-thresholds {
    description
      "Grouping for configurable thresholds for measured
       attributes.";
    uses one-way-performance-metrics;
    uses two-way-performance-metrics;
  }

  grouping performance-metrics-attributes {
    description
      "Contains PM attributes.";
    container performance-metrics-one-way {
      description
        "One-way link performance information in real time.";
      reference
        "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions
         RFC 7823: Performance-Based Path Selection for Explicitly
         Routed Label Switched Paths (LSPs) Using TE Metric
         Extensions
         RFC 8570: IS-IS Traffic Engineering (TE) Metric Extensions";
      uses performance-metrics-one-way-delay-loss;
      uses performance-metrics-one-way-bandwidth;
    }
    container performance-metrics-two-way {
      description
        "Two-way link performance information in real time.";
      reference
        "RFC 6374: Packet Loss and Delay Measurement for MPLS
         Networks";
      uses performance-metrics-two-way-delay-loss;
    }
  }

  grouping performance-metrics-throttle-container {
    description
      "Controls PM throttling.";
    container throttle {
      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
```

```
          "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions
           RFC 7823: Performance-Based Path Selection for Explicitly
           Routed Label Switched Paths (LSPs) Using TE Metric
           Extensions
           RFC 8570: IS-IS Traffic Engineering (TE) Metric Extensions";
        leaf one-way-delay-offset {
          type uint32 {
            range "0..16777215";
          }
          default "0";
          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;
          default "0";
          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 advertisement of the
             extended metric values.";
          reference
            "RFC 8570: IS-IS Traffic Engineering (TE) Metric
             Extensions, Section 6";
        }
        container threshold-out {
          uses performance-metrics-thresholds;
          description
            "If the measured parameter falls outside an upper bound
             for all but the minimum-delay metric (or a lower bound
             for the minimum-delay metric only) and the advertised
             value is not already outside that bound, an 'anomalous'
             announcement (anomalous bit set) will be triggered.";
        }
        container threshold-in {
          uses performance-metrics-thresholds;
          description
            "If the measured parameter falls inside an upper bound
             for all but the minimum-delay metric (or a lower bound
             for the minimum-delay metric only) and the advertised
             value is not already inside that bound, a 'normal'
             announcement (anomalous bit cleared) will be triggered.";
        }
        container threshold-accelerated-advertisement {
```

```
        description
          "When the difference between the last advertised value and
           the current measured value exceeds this threshold, an
           'anomalous' announcement (anomalous bit set) will be
           triggered.";
        uses performance-metrics-thresholds;
      }
    }
  }

  /**
   * TE tunnel generic groupings
   **/

  grouping explicit-route-hop {
    description
      "The explicit route entry grouping.";
    choice type {
      description
        "The explicit route entry type.";
      case numbered-node-hop {
        container numbered-node-hop {
          leaf node-id {
            type te-node-id;
            mandatory true;
            description
              "The identifier of a node in the TE topology.";
          }
          leaf hop-type {
            type te-hop-type;
            default "strict";
            description
              "Strict or loose hop.";
          }
          description
            "Numbered node route hop.";
          reference
            "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
             Section 4.3, EXPLICIT_ROUTE in RSVP-TE
             RFC 3477: Signalling Unnumbered Links in Resource
             ReSerVation Protocol - Traffic Engineering (RSVP-TE)";
        }
      }
      case numbered-link-hop {
        container numbered-link-hop {
          leaf link-tp-id {
            type te-tp-id;
            mandatory true;
            description
              "TE Link Termination Point (LTP) identifier.";
          }
          leaf hop-type {
            type te-hop-type;
            default "strict";
            description
              "Strict or loose hop.";
          }
          leaf direction {
```

```
            type te-link-direction;
            default "outgoing";
            description
              "Link route object direction.";
          }
          description
            "Numbered link explicit route hop.";
          reference
            "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
             Section 4.3, EXPLICIT_ROUTE in RSVP-TE
             RFC 3477: Signalling Unnumbered Links in Resource
             ReSerVation Protocol - Traffic Engineering (RSVP-TE)";
        }
      }
      case unnumbered-link-hop {
        container unnumbered-link-hop {
          leaf link-tp-id {
            type te-tp-id;
            mandatory true;
            description
              "TE LTP identifier.  The combination of the TE link ID
               and the TE node ID is used to identify an unnumbered
               TE link.";
          }
          leaf node-id {
            type te-node-id;
            mandatory true;
            description
              "The identifier of a node in the TE topology.";
          }
          leaf hop-type {
            type te-hop-type;
            default "strict";
            description
              "Strict or loose hop.";
          }
          leaf direction {
            type te-link-direction;
            default "outgoing";
            description
              "Link route object direction.";
          }
          description
            "Unnumbered link explicit route hop.";
          reference
            "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels,
             Section 4.3, EXPLICIT_ROUTE in RSVP-TE
             RFC 3477: Signalling Unnumbered Links in Resource
             ReSerVation Protocol - Traffic Engineering (RSVP-TE)";
        }
      }
      case as-number {
        container as-number-hop {
          leaf as-number {
            type inet:as-number;
            mandatory true;
            description
              "The Autonomous System (AS) number.";
```

```
          }
          leaf hop-type {
            type te-hop-type;
            default "strict";
            description
              "Strict or loose hop.";
          }
          description
            "AS explicit route hop.";
        }
      }
      case label {
        container label-hop {
          description
            "Label hop type.";
          uses te-label;
        }
        description
          "The label explicit route hop type.";
      }
    }
  }

  grouping record-route-state {
    description
      "The Record Route grouping.";
    leaf index {
      type uint32;
      description
        "Record Route hop index.  The index is used to
         identify an entry in the list.  The order of entries
         is defined by the user without relying on key values.";
    }
    choice type {
      description
        "The Record Route entry type.";
      case numbered-node-hop {
        container numbered-node-hop {
          description
            "Numbered node route hop container.";
          leaf node-id {
            type te-node-id;
            mandatory true;
            description
              "The identifier of a node in the TE topology.";
          }
          leaf-list flags {
            type path-attribute-flags;
            description
              "Path attributes flags.";
            reference
              "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels
               RFC 4090: Fast Reroute Extensions to RSVP-TE for LSP
               Tunnels
               RFC 4561: Definition of a Record Route Object (RRO)
               Node-Id Sub-Object";
          }
        }
```

```
          description
            "Numbered node route hop.";
        }
        case numbered-link-hop {
          container numbered-link-hop {
            description
              "Numbered link route hop container.";
            leaf link-tp-id {
              type te-tp-id;
              mandatory true;
              description
                "Numbered TE LTP identifier.";
            }
            leaf-list flags {
              type path-attribute-flags;
              description
                "Path attributes flags.";
              reference
                "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels
                 RFC 4090: Fast Reroute Extensions to RSVP-TE for LSP
                 Tunnels
                 RFC 4561: Definition of a Record Route Object (RRO)
                 Node-Id Sub-Object";
            }
          }
          description
            "Numbered link route hop.";
        }
        case unnumbered-link-hop {
          container unnumbered-link-hop {
            leaf link-tp-id {
              type te-tp-id;
              mandatory true;
              description
                "TE LTP identifier.  The combination of the TE link ID
                 and the TE node ID is used to identify an unnumbered
                 TE link.";
            }
            leaf node-id {
              type te-node-id;
              description
                "The identifier of a node in the TE topology.";
            }
            leaf-list flags {
              type path-attribute-flags;
              description
                "Path attributes flags.";
              reference
                "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels
                 RFC 4090: Fast Reroute Extensions to RSVP-TE for LSP
                 Tunnels
                 RFC 4561: Definition of a Record Route Object (RRO)
                 Node-Id Sub-Object";
            }
            description
              "Unnumbered link Record Route hop.";
            reference
              "RFC 3477: Signalling Unnumbered Links in Resource
```

```
             ReSerVation Protocol - Traffic Engineering (RSVP-TE)";
        }
        description
          "Unnumbered link route hop.";
      }
      case label {
        container label-hop {
          description
            "Label route hop type.";
          uses te-label;
          leaf-list flags {
            type path-attribute-flags;
            description
              "Path attributes flags.";
            reference
              "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels
               RFC 4090: Fast Reroute Extensions to RSVP-TE for LSP
               Tunnels
               RFC 4561: Definition of a Record Route Object (RRO)
               Node-Id Sub-Object";
          }
        }
        description
          "The label Record Route entry types.";
      }
    }
  }

  grouping label-restriction-info {
    description
      "Label set item information.";
    leaf restriction {
      type enumeration {
        enum inclusive {
          description
            "The label or label range is inclusive.";
        }
        enum exclusive {
          description
            "The label or label range is exclusive.";
        }
      }
      default "inclusive";
      description
        "Indicates whether the list item is inclusive or exclusive.";
    }
    leaf index {
      type uint32;
      description
        "The index of the label restriction list entry.";
    }
    container label-start {
      must "(not(../label-end/te-label/direction) and"
         + " not(te-label/direction))"
         + " or "
         + "(../label-end/te-label/direction = te-label/direction)"
         + " or "
         + "(not(te-label/direction) and"
```

```
          + " (../label-end/te-label/direction = 'forward'))"
          + " or "
          + "(not(../label-end/te-label/direction) and"
          + " (te-label/direction = 'forward'))" {
        error-message
          "'label-start' and 'label-end' must have the same "
        + "direction.";
      }
      description
        "This is the starting label if a label range is specified.
         This is the label value if a single label is specified,
         in which case the 'label-end' attribute is not set.";
      uses te-label;
    }
    container label-end {
      must "(not(../label-start/te-label/direction) and"
         + " not(te-label/direction))"
         + " or "
         + "(../label-start/te-label/direction = te-label/direction)"
         + " or "
         + "(not(te-label/direction) and"
         + " (../label-start/te-label/direction = 'forward'))"
         + " or "
         + "(not(../label-start/te-label/direction) and"
         + " (te-label/direction = 'forward'))" {
        error-message
          "'label-start' and 'label-end' must have the same "
        + "direction.";
      }
      description
        "This is the ending label if a label range is specified.
         This attribute is not set if a single label is specified.";
      uses te-label;
    }
    container label-step {
      description
        "The step increment between labels in the label range.
         The label start/end values will have to be consistent
         with the sign of label step.  For example,
         'label-start' < 'label-end' enforces 'label-step' > 0
         'label-start' > 'label-end' enforces 'label-step' < 0.";
      choice technology {
        default "generic";
        description
          "Data-plane technology type.";
        case generic {
          leaf generic {
            type int32;
            default "1";
            description
              "Label range step.";
          }
        }
      }
    }
    leaf range-bitmap {
      type yang:hex-string;
      description
```

```
        "When there are gaps between 'label-start' and 'label-end',
         this attribute is used to specify the positions
         of the used labels.  This is represented in big endian as
         'hex-string'.
         The most significant byte in the hex-string is the farthest
         to the left in the byte sequence.  Leading zero bytes in the
         configured value may be omitted for brevity.
         Each bit position in the 'range-bitmap' 'hex-string' maps
         to a label in the range derived from 'label-start'.

         For example, assuming that 'label-start' = 16000 and
         'range-bitmap' = 0x01000001, then:

         - bit position (0) is set, and the corresponding mapped
           label from the range is 16000 + (0 * 'label-step') or
           16000 for default 'label-step' = 1.
         - bit position (24) is set, and the corresponding mapped
           label from the range is 16000 + (24 * 'label-step') or
           16024 for default 'label-step' = 1.";
    }
  }

  grouping label-set-info {
    description
      "Grouping for the list of label restrictions specifying what
       labels may or may not be used.";
    container label-restrictions {
      description
        "The label restrictions container.";
      list label-restriction {
        key "index";
        description
          "The absence of the label restrictions container implies
           that all labels are acceptable; otherwise, only restricted
           labels are available.";
        reference
          "RFC 7579: General Network Element Constraint Encoding
           for GMPLS-Controlled Networks";
        uses label-restriction-info;
      }
    }
  }

  grouping optimization-metric-entry {
    description
      "Optimization metrics configuration grouping.";
    leaf metric-type {
      type identityref {
        base path-metric-type;
      }
      description
        "Identifies the 'metric-type' that the path computation
         process uses for optimization.";
    }
    leaf weight {
      type uint8;
      default "1";
      description
```

```
          "TE path metric normalization weight.";
      }
      container explicit-route-exclude-objects {
        when "../metric-type = "
           + "'te-types:path-metric-optimize-excludes'";
        description
          "Container for the 'exclude route' object list.";
        uses path-route-exclude-objects;
      }
      container explicit-route-include-objects {
        when "../metric-type = "
           + "'te-types:path-metric-optimize-includes'";
        description
          "Container for the 'include route' object list.";
        uses path-route-include-objects;
      }
    }

    grouping common-constraints {
      description
        "Common constraints grouping that can be set on
         a constraint set or directly on the tunnel.";
      uses te-bandwidth {
        description
          "A requested bandwidth to use for path computation.";
      }
      leaf link-protection {
        type identityref {
          base link-protection-type;
        }
        default "te-types:link-protection-unprotected";
        description
          "Link protection type required for the links included
           in the computed path.";
        reference
          "RFC 4202: Routing Extensions in Support of
           Generalized Multi-Protocol Label Switching (GMPLS)";
      }
      leaf setup-priority {
        type uint8 {
          range "0..7";
        }
        default "7";
        description
          "TE LSP requested setup priority.";
        reference
          "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
      }
      leaf hold-priority {
        type uint8 {
          range "0..7";
        }
        default "7";
        description
          "TE LSP requested hold priority.";
        reference
          "RFC 3209: RSVP-TE: Extensions to RSVP for LSP Tunnels";
      }
```

```
    leaf signaling-type {
      type identityref {
        base path-signaling-type;
      }
      default "te-types:path-setup-rsvp";
      description
        "TE tunnel path signaling type.";
    }
  }

  grouping tunnel-constraints {
    description
      "Tunnel constraints grouping that can be set on
       a constraint set or directly on the tunnel.";
    uses te-topology-identifier;
    uses common-constraints;
  }

  grouping path-constraints-route-objects {
    description
      "List of route entries to be included or excluded when
       performing the path computation.";
    container explicit-route-objects-always {
      description
        "Container for the 'exclude route' object list.";
      list route-object-exclude-always {
        key "index";
        ordered-by user;
        description
          "List of route objects to always exclude from the path
           computation.";
        leaf index {
          type uint32;
          description
            "Explicit Route Object index.  The index is used to
             identify an entry in the list.  The order of entries
             is defined by the user without relying on key values.";
        }
        uses explicit-route-hop;
      }
      list route-object-include-exclude {
        key "index";
        ordered-by user;
        description
          "List of route objects to include or exclude in the path
           computation.";
        leaf explicit-route-usage {
          type identityref {
            base route-usage-type;
          }
          default "te-types:route-include-object";
          description
            "Indicates whether to include or exclude the
             route object.  The default is to include it.";
        }
        leaf index {
          type uint32;
          description
```

```
            "Route object include-exclude index.  The index is used
             to identify an entry in the list.  The order of entries
             is defined by the user without relying on key values.";
        }
        uses explicit-route-hop {
          augment "type" {
            case srlg {
              container srlg {
                description
                  "SRLG container.";
                leaf srlg {
                  type uint32;
                  description
                    "SRLG value.";
                }
              }
              description
                "An SRLG value to be included or excluded.";
            }
            description
              "Augmentation for a generic explicit route for SRLG
               exclusion.";
          }
        }
      }
    }
  }

  grouping path-route-include-objects {
    description
      "List of route objects to be included when performing
       the path computation.";
    list route-object-include-object {
      key "index";
      ordered-by user;
      description
        "List of Explicit Route Objects to be included in the
         path computation.";
      leaf index {
        type uint32;
        description
          "Route object entry index.  The index is used to
           identify an entry in the list.  The order of entries
           is defined by the user without relying on key values.";
      }
      uses explicit-route-hop;
    }
  }

  grouping path-route-exclude-objects {
    description
      "List of route objects to be excluded when performing
       the path computation.";
    list route-object-exclude-object {
      key "index";
      ordered-by user;
      description
        "List of Explicit Route Objects to be excluded in the
```

```
         path computation.";
      leaf index {
        type uint32;
        description
          "Route object entry index.  The index is used to
           identify an entry in the list.  The order of entries
           is defined by the user without relying on key values.";
      }
      uses explicit-route-hop {
        augment "type" {
          case srlg {
            container srlg {
              description
                "SRLG container.";
              leaf srlg {
                type uint32;
                description
                  "SRLG value.";
              }
            }
            description
              "An SRLG value to be included or excluded.";
          }
          description
            "Augmentation for a generic explicit route for SRLG
             exclusion.";
        }
      }
    }
  }

  grouping generic-path-metric-bounds {
    description
      "TE path metric bounds grouping.";
    container path-metric-bounds {
      description
        "TE path metric bounds container.";
      list path-metric-bound {
        key "metric-type";
        description
          "List of TE path metric bounds.";
        leaf metric-type {
          type identityref {
            base path-metric-type;
          }
          description
            "Identifies an entry in the list of 'metric-type' items
             bound for the TE path.";
        }
        leaf upper-bound {
          type uint64;
          default "0";
          description
            "Upper bound on the end-to-end TE path metric.  A zero
             indicates an unbounded upper limit for the specific
             'metric-type'.";
        }
      }
```

```
    }
  }

  grouping generic-path-optimization {
    description
      "TE generic path optimization grouping.";
    container optimizations {
      description
        "The objective function container that includes
         attributes to impose when computing a TE path.";
      choice algorithm {
        description
          "Optimizations algorithm.";
        case metric {
          if-feature "path-optimization-metric";
          /* Optimize by metric */
          list optimization-metric {
            key "metric-type";
            description
              "TE path metric type.";
            uses optimization-metric-entry;
          }
          /* Tiebreakers */
          container tiebreakers {
            description
              "Container for the list of tiebreakers.";
            list tiebreaker {
              key "tiebreaker-type";
              description
                "The list of tiebreaker criteria to apply on an
                 equally favored set of paths, in order to pick
                 the best.";
              leaf tiebreaker-type {
                type identityref {
                  base path-metric-type;
                }
                description
                  "Identifies an entry in the list of tiebreakers.";
              }
            }
          }
        }
        case objective-function {
          if-feature "path-optimization-objective-function";
          /* Objective functions */
          container objective-function {
            description
              "The objective function container that includes
               attributes to impose when computing a TE path.";
            leaf objective-function-type {
              type identityref {
                base objective-function-type;
              }
              default "te-types:of-minimize-cost-path";
              description
                "Objective function entry.";
            }
          }
```

```
        }
      }
    }
  }

  grouping generic-path-affinities {
    description
      "Path affinities grouping.";
    container path-affinities-values {
      description
        "Path affinities represented as values.";
      list path-affinities-value {
        key "usage";
        description
          "List of named affinity constraints.";
        leaf usage {
          type identityref {
            base resource-affinities-type;
          }
          description
            "Identifies an entry in the list of value affinity
             constraints.";
        }
        leaf value {
          type admin-groups;
          default "";
          description
            "The affinity value.  The default is empty.";
        }
      }
    }
    container path-affinity-names {
      description
        "Path affinities represented as names.";
      list path-affinity-name {
        key "usage";
        description
          "List of named affinity constraints.";
        leaf usage {
          type identityref {
            base resource-affinities-type;
          }
          description
            "Identifies an entry in the list of named affinity
             constraints.";
        }
        list affinity-name {
          key "name";
          leaf name {
            type string;
            description
              "Identifies a named affinity entry.";
          }
          description
            "List of named affinities.";
        }
      }
    }
```

```
  }

  grouping generic-path-srlgs {
    description
      "Path SRLG grouping.";
    container path-srlgs-lists {
      description
        "Path SRLG properties container.";
      list path-srlgs-list {
        key "usage";
        description
          "List of SRLG values to be included or excluded.";
        leaf usage {
          type identityref {
            base route-usage-type;
          }
          description
            "Identifies an entry in a list of SRLGs to either
             include or exclude.";
        }
        leaf-list values {
          type srlg;
          description
            "List of SRLG values.";
        }
      }
    }
    container path-srlgs-names {
      description
        "Container for the list of named SRLGs.";
      list path-srlgs-name {
        key "usage";
        description
          "List of named SRLGs to be included or excluded.";
        leaf usage {
          type identityref {
            base route-usage-type;
          }
          description
            "Identifies an entry in a list of named SRLGs to either
             include or exclude.";
        }
        leaf-list names {
          type string;
          description
            "List of named SRLGs.";
        }
      }
    }
  }

  grouping generic-path-disjointness {
    description
      "Path disjointness grouping.";
    leaf disjointness {
      type te-path-disjointness;
      description
        "The type of resource disjointness.
```

```
          When configured for a primary path, the disjointness level
          applies to all secondary LSPs.  When configured for a
          secondary path, the disjointness level overrides the level
          configured for the primary path.";
    }
  }

  grouping common-path-constraints-attributes {
    description
      "Common path constraints configuration grouping.";
    uses common-constraints;
    uses generic-path-metric-bounds;
    uses generic-path-affinities;
    uses generic-path-srlgs;
  }

  grouping generic-path-constraints {
    description
      "Global named path constraints configuration grouping.";
    container path-constraints {
      description
        "TE named path constraints container.";
      uses common-path-constraints-attributes;
      uses generic-path-disjointness;
    }
  }

  grouping generic-path-properties {
    description
      "TE generic path properties grouping.";
    container path-properties {
      config false;
      description
        "The TE path properties.";
      list path-metric {
        key "metric-type";
        description
          "TE path metric type.";
        leaf metric-type {
          type identityref {
            base path-metric-type;
          }
          description
            "TE path metric type.";
        }
        leaf accumulative-value {
          type uint64;
          description
            "TE path metric accumulative value.";
        }
      }
      uses generic-path-affinities;
      uses generic-path-srlgs;
      container path-route-objects {
        description
          "Container for the list of route objects either returned by
           the computation engine or actually used by an LSP.";
        list path-route-object {
```

```
          key "index";
          ordered-by user;
          description
            "List of route objects either returned by the computation
             engine or actually used by an LSP.";
          leaf index {
            type uint32;
            description
              "Route object entry index.  The index is used to
               identify an entry in the list.  The order of entries
               is defined by the user without relying on key
               values.";
          }
          uses explicit-route-hop;
        }
      }
    }
  }
}

<CODE ENDS>
```

5. Packet TE Types YANG Module

The "ietf-te-packet-types" module imports from the "ietf-te-types" module defined in Section 4 of this document.

```
<CODE BEGINS> file "ietf-te-packet-types@2020-04-06.yang"

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

  /* Import TE generic types */

  import ietf-te-types {
    prefix te-types;
    reference
      "RFC 8776: Common YANG Data Types for Traffic Engineering";
  }

  organization
    "IETF Traffic Engineering Architecture and Signaling (TEAS)
     Working Group";
  contact
    "WG Web:   <https://datatracker.ietf.org/wg/teas/>
     WG List:  <mailto:teas@ietf.org>

     Editor:   Tarek Saad
               <mailto:tsaad@juniper.net>

     Editor:   Rakesh Gandhi
               <mailto:rgandhi@cisco.com>

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

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

     Editor:   Igor Bryskin
               <mailto:i_bryskin@yahoo.com>";
  description
    "This YANG module contains a collection of generally useful YANG
     data type definitions specific to MPLS TE.  The model fully
     conforms to the Network Management Datastore Architecture
     (NMDA).

     Copyright (c) 2020 IETF Trust and the persons identified as
     authors of the code.  All rights reserved.

     Redistribution and use in source and binary forms, with or
     without modification, is permitted pursuant to, and subject to
     the license terms contained in, the Simplified BSD License set
     forth in Section 4.c of the IETF Trust's Legal Provisions
     Relating to IETF Documents
     (https://trustee.ietf.org/license-info).

     This version of this YANG module is part of RFC 8776; see the
     RFC itself for full legal notices.";

  revision 2020-04-06 {
    description
```

```
      "Latest revision of TE MPLS types.";
    reference
      "RFC 8776: Common YANG Data Types for Traffic Engineering";
  }

  /**
   * Typedefs
   */

  typedef te-bandwidth-requested-type {
    type enumeration {
      enum specified {
        description
          "Bandwidth is explicitly specified.";
      }
      enum auto {
        description
          "Bandwidth is automatically computed.";
      }
    }
    description
      "Enumerated type for specifying whether bandwidth is
       explicitly specified or automatically computed.";
  }

  typedef te-class-type {
    type uint8;
    description
      "Diffserv-TE Class-Type.  Defines a set of Traffic Trunks
       crossing a link that is governed by a specific set of
       bandwidth constraints.  Class-Type is used for the purposes
       of link bandwidth allocation, constraint-based routing, and
       admission control.";
    reference
      "RFC 4124: Protocol Extensions for Support of Diffserv-aware
       MPLS Traffic Engineering";
  }

  typedef bc-type {
    type uint8 {
      range "0..7";
    }
    description
      "Diffserv-TE bandwidth constraints as defined in RFC 4124.";
    reference
      "RFC 4124: Protocol Extensions for Support of Diffserv-aware
       MPLS Traffic Engineering";
  }

  typedef bandwidth-kbps {
    type uint64;
    units "Kbps";
    description
      "Bandwidth values, expressed in kilobits per second.";
  }

  typedef bandwidth-mbps {
    type uint64;
```

```
    units "Mbps";
    description
      "Bandwidth values, expressed in megabits per second.";
  }

  typedef bandwidth-gbps {
    type uint64;
    units "Gbps";
    description
      "Bandwidth values, expressed in gigabits per second.";
  }

  identity backup-protection-type {
    description
      "Base identity for the backup protection type.";
  }

  identity backup-protection-link {
    base backup-protection-type;
    description
      "Backup provides link protection only.";
  }

  identity backup-protection-node-link {
    base backup-protection-type;
    description
      "Backup offers node (preferred) or link protection.";
  }

  identity bc-model-type {
    description
      "Base identity for the Diffserv-TE Bandwidth Constraints
       Model type.";
    reference
      "RFC 4124: Protocol Extensions for Support of Diffserv-aware
       MPLS Traffic Engineering";
  }

  identity bc-model-rdm {
    base bc-model-type;
    description
      "Russian Dolls Bandwidth Constraints Model type.";
    reference
      "RFC 4127: Russian Dolls Bandwidth Constraints Model for
                 Diffserv-aware MPLS Traffic Engineering";
  }

  identity bc-model-mam {
    base bc-model-type;
    description
      "Maximum Allocation Bandwidth Constraints Model type.";
    reference
      "RFC 4125: Maximum Allocation Bandwidth Constraints Model for
                 Diffserv-aware MPLS Traffic Engineering";
  }

  identity bc-model-mar {
    base bc-model-type;
```

```
    description
      "Maximum Allocation with Reservation Bandwidth Constraints
       Model type.";
    reference
      "RFC 4126: Max Allocation with Reservation Bandwidth
       Constraints Model for Diffserv-aware MPLS Traffic Engineering
       & Performance Comparisons";
  }

  grouping performance-metrics-attributes-packet {
    description
      "Contains PM attributes.";
    uses te-types:performance-metrics-attributes {
      augment "performance-metrics-one-way" {
        leaf one-way-min-delay {
          type uint32 {
            range "0..16777215";
          }
          description
            "One-way minimum delay or latency in microseconds.";
        }
        leaf one-way-min-delay-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "One-way minimum delay or latency normality.";
        }
        leaf one-way-max-delay {
          type uint32 {
            range "0..16777215";
          }
          description
            "One-way maximum delay or latency in microseconds.";
        }
        leaf one-way-max-delay-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "One-way maximum delay or latency normality.";
        }
        leaf one-way-delay-variation {
          type uint32 {
            range "0..16777215";
          }
          description
            "One-way delay variation in microseconds.";
          reference
            "RFC 5481: Packet Delay Variation Applicability
             Statement, Section 4.2";
        }
        leaf one-way-delay-variation-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "One-way delay variation normality.";
          reference
            "RFC 7471: OSPF Traffic Engineering (TE) Metric
             Extensions
```

```
            RFC 7823: Performance-Based Path Selection for
            Explicitly Routed Label Switched Paths (LSPs) Using
            TE Metric Extensions
            RFC 8570: IS-IS Traffic Engineering (TE) Metric
            Extensions";
        }
        leaf one-way-packet-loss {
          type decimal64 {
            fraction-digits 6;
            range "0..50.331642";
          }
          description
            "One-way packet loss as a percentage of the total traffic
             sent over a configurable interval.  The finest precision
             is 0.000003%, where the maximum is 50.331642%.";
          reference
            "RFC 8570: IS-IS Traffic Engineering (TE) Metric
             Extensions, Section 4.4";
        }
        leaf one-way-packet-loss-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "Packet loss normality.";
          reference
            "RFC 7471: OSPF Traffic Engineering (TE) Metric
             Extensions
             RFC 7823: Performance-Based Path Selection for
             Explicitly Routed Label Switched Paths (LSPs) Using
             TE Metric Extensions
             RFC 8570: IS-IS Traffic Engineering (TE) Metric
             Extensions";
        }
        description
          "PM one-way packet-specific augmentation for a generic PM
           grouping.";
      }
      augment "performance-metrics-two-way" {
        leaf two-way-min-delay {
          type uint32 {
            range "0..16777215";
          }
          default "0";
          description
            "Two-way minimum delay or latency in microseconds.";
        }
        leaf two-way-min-delay-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "Two-way minimum delay or latency normality.";
          reference
            "RFC 7471: OSPF Traffic Engineering (TE) Metric
             Extensions
             RFC 7823: Performance-Based Path Selection for
             Explicitly Routed Label Switched Paths (LSPs) Using
             TE Metric Extensions
             RFC 8570: IS-IS Traffic Engineering (TE) Metric
```

```
            Extensions";
        }
        leaf two-way-max-delay {
          type uint32 {
            range "0..16777215";
          }
          default "0";
          description
            "Two-way maximum delay or latency in microseconds.";
        }
        leaf two-way-max-delay-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "Two-way maximum delay or latency normality.";
          reference
            "RFC 7471: OSPF Traffic Engineering (TE) Metric
             Extensions
             RFC 7823: Performance-Based Path Selection for
             Explicitly Routed Label Switched Paths (LSPs) Using
             TE Metric Extensions
             RFC 8570: IS-IS Traffic Engineering (TE) Metric
             Extensions";
        }
        leaf two-way-delay-variation {
          type uint32 {
            range "0..16777215";
          }
          default "0";
          description
            "Two-way delay variation in microseconds.";
          reference
            "RFC 5481: Packet Delay Variation Applicability
             Statement, Section 4.2";
        }
        leaf two-way-delay-variation-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "Two-way delay variation normality.";
          reference
            "RFC 7471: OSPF Traffic Engineering (TE) Metric
             Extensions
             RFC 7823: Performance-Based Path Selection for
             Explicitly Routed Label Switched Paths (LSPs) Using
             TE Metric Extensions
             RFC 8570: IS-IS Traffic Engineering (TE) Metric
             Extensions";
        }
        leaf two-way-packet-loss {
          type decimal64 {
            fraction-digits 6;
            range "0..50.331642";
          }
          default "0";
          description
            "Two-way packet loss as a percentage of the total traffic
             sent over a configurable interval.  The finest precision
```

```
              is 0.000003%.";
        }
        leaf two-way-packet-loss-normality {
          type te-types:performance-metrics-normality;
          default "normal";
          description
            "Two-way packet loss normality.";
        }
        description
          "PM two-way packet-specific augmentation for a generic PM
           grouping.";
        reference
          "RFC 7471: OSPF Traffic Engineering (TE) Metric Extensions
           RFC 7823: Performance-Based Path Selection for
           Explicitly Routed Label Switched Paths (LSPs) Using
           TE Metric Extensions
           RFC 8570: IS-IS Traffic Engineering (TE) Metric
           Extensions";
      }
    }
  }

  grouping one-way-performance-metrics-packet {
    description
      "One-way packet PM throttle grouping.";
    leaf one-way-min-delay {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "One-way minimum delay or latency in microseconds.";
    }
    leaf one-way-max-delay {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "One-way maximum delay or latency in microseconds.";
    }
    leaf one-way-delay-variation {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "One-way delay variation in microseconds.";
    }
    leaf one-way-packet-loss {
      type decimal64 {
        fraction-digits 6;
        range "0..50.331642";
      }
      default "0";
      description
        "One-way packet loss as a percentage of the total traffic
         sent over a configurable interval.  The finest precision is
```

```
          0.000003%.";
    }
  }

  grouping two-way-performance-metrics-packet {
    description
      "Two-way packet PM throttle grouping.";
    leaf two-way-min-delay {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "Two-way minimum delay or latency in microseconds.";
    }
    leaf two-way-max-delay {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "Two-way maximum delay or latency in microseconds.";
    }
    leaf two-way-delay-variation {
      type uint32 {
        range "0..16777215";
      }
      default "0";
      description
        "Two-way delay variation in microseconds.";
    }
    leaf two-way-packet-loss {
      type decimal64 {
        fraction-digits 6;
        range "0..50.331642";
      }
      default "0";
      description
        "Two-way packet loss as a percentage of the total traffic
         sent over a configurable interval.  The finest precision is
         0.000003%.";
    }
  }

  grouping performance-metrics-throttle-container-packet {
    description
      "Packet PM threshold grouping.";
    uses te-types:performance-metrics-throttle-container {
      augment "throttle/threshold-out" {
        uses one-way-performance-metrics-packet;
        uses two-way-performance-metrics-packet;
        description
          "PM threshold-out packet augmentation for a
           generic grouping.";
      }
      augment "throttle/threshold-in" {
        uses one-way-performance-metrics-packet;
        uses two-way-performance-metrics-packet;
```

```
        description
          "PM threshold-in packet augmentation for a
           generic grouping.";
      }
      augment "throttle/threshold-accelerated-advertisement" {
        uses one-way-performance-metrics-packet;
        uses two-way-performance-metrics-packet;
        description
          "PM accelerated advertisement packet augmentation for a
           generic grouping.";
      }
    }
  }
}

<CODE ENDS>
```

6. IANA Considerations

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

URI: urn:ietf:params:xml:ns:yang:ietf-te-types
Registrant Contact: The IESG.
XML: N/A; the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-te-packet-types
Registrant Contact: The IESG.
XML: N/A; the requested URI is an XML namespace.

This document registers two YANG modules in the "YANG Module Names" registry [RFC6020].

Name: ietf-te-types
Namespace: urn:ietf:params:xml:ns:yang:ietf-te-types
Prefix: te-types
Reference: RFC 8776

Name: ietf-te-packet-types
Namespace: urn:ietf:params:xml:ns:yang:ietf-te-packet-types
Prefix: te-packet-types
Reference: RFC 8776

7. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

The Network Configuration Access Control Model (NACM) [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

The YANG module in this document defines common TE type definitions (e.g., typedef, identity, and grouping statements) in YANG data modeling language to be imported and used by other TE modules. When imported and used, the resultant schema will have data nodes that can be writable or readable. Access to such data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations.

The security considerations spelled out in the YANG 1.1 specification [RFC7950] apply for this document as well.

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