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Updated Common YANG Data Types for Traffic Engineering

Abstract

   This document defines few additional common data types and groupings
   in YANG data modeling language to be imported by modules that model
   Traffic Engineering (TE) configuration and state capabilities.

   This document updates RFC 8776 with a new revision of the module
   ietf-te-types.

Status of This Memo

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

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   at any time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on 12 January 2023.

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1. Introduction

After the pubblication of [RFC8776], the need to add a new typedef
and a new grouping to ietf-te-types YANG module has arisen.

These definitions have been developed in [I-D.ietf-teas-yang-te] and
[I-D.ietf-teas-yang-l3-te-topo] and are quite mature: [I-D.ietf-
teas-yang-te] in particular is ready from WG Last Call.

However, these defintions have broader applicability than the I-D
where they have originated, so it makes sense to move them within
the ietf-te-types YANG module.

1.1. Requirements Notation

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.

1.2. Terminology

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

1.3. Prefixes in Data Node Names

In this document, names of data nodes and other data model objects, added to the ietf-te-types YANG module do not need to be prefixed.

The revision of the ietf-te-types YANG module uses the prefixes defined in section 1.2 of [RFC8776].

2. Overview

The module ietf-te-types has been updated to add the following YANG identies, types and groupings which can be reused by TE YANG models:

bandwidth-scientific-notation This types represents the bandwidth in bit-per-second, using the scientific notation (e.g., 10e3).

encoding-and-switching-type This is a common grouping to define the LSP encoding and switching types.

3. TE Types YANG Module Revision

This section provides the updated revision of the "ietf-te-types" YANG module.

NOTE: Only the typedef bandwidth-scientific-notation and the grouping encoding-and-switching-type have been added in this module revision. Please focus your review on this part.

RFC Editor: remove the note above and this note

```
<CODE BEGINS> file "ietf-te-types@2022-03-25.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
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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).
```

```
revision 2022-03-25 {
  description
    "Added:
    - typedef bandwidth-scientific-notation;
    - grouping encoding-and-switching-type.";
  reference
    "RFC XXXX: Updated Common YANG Data Types for Traffic
    Engineering";
}
// RFC Editor: replace XXXX with actual RFC number, update date
// information and remove this note
revision 2020-06-10 {
  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";
}

// NOTE: The typedef bandwidth-scientific-notation below has been
// added in this module revision
// RFC Editor: remove the note above and this note

typedef bandwidth-scientific-notation {
  type string {
    pattern
      '0(\.0?)?([eE](\+)?0?)?|'
    + '[1-9](\.[0-9]{0,6})?[eE](\+)?(9[0-6]|[1-8][0-9]|0?[0-9])?';
  }
  units "bps";
  description
    "Bandwidth values, expressed using the scientific notation
     in bits per second.
     The encoding format is the external decimal-significant
     character sequences specified in IEEE 754 and ISO/IEC C99
     for 32-bit decimal floating-point numbers:
     (-1)**(S) * 10**(Exponent) * (Significant),
     where Significant uses 7 digits.
     An implementation for this representation may use decimal32
     or binary32. The range of the Exponent is from -95 to +96
     for decimal32, and from -38 to +38 for binary32.
     As a bandwidth value, the format is restricted to be
     normalized, non-negative, and non-fraction:
     n.dddddde{+}dd, N.DDDDDDE{+}DD, 0e0 or 0E0,
     where 'd' and 'D' are decimal digits; 'n' and 'N' are
     non-zeror decimal digits; 'e' and 'E' indicate a power of ten.
     Some examples are 0e0, 1e10, and 9.953e9.";
  reference
    "IEEE Std 754-2008: IEEE Standard for Floating-Point
     Arithmetic.
```

```
      ISO/IEC C99: Information technology - Programming
      Languages - C.";
}

/* 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;
        }
      }
    }
  }
}

// NOTE: The grouping encoding-and-switching-type below has been
// added in this module revision
// RFC Editor: remove the note above and this note

grouping encoding-and-switching-type {
  description
    "Common grouping to define the LSP encoding and
     switching types";
  leaf encoding {
```

```
      type identityref {
        base te-types:lsp-encoding-types;
      }
      description
        "LSP encoding type.";
      reference
        "RFC3945";
    }
   leaf switching-type {
      type identityref {
        base te-types:switching-capabilities;
      }
      description
        "LSP switching type.";
      reference
        "RFC3945";
    }
  }
}
```

<CODE ENDS>

                    Figure 1: TE Types YANG module

4. IANA Considerations

   This document updates the ietf-te-types YANG module registered by
   [RFC8776].

   Therefore this document does not require any IANA actions.

5. Security Considerations

   The security considerations defined in section 7 of [RFC8776]
   applies to the revision of the ietf-te-types YANG module.

   This document just adds new typedefs and groupings to the YANG
   modules defined in [RFC8776] and therefore it does not introduce
   additional considerations.

6. References

6.1. Normative References

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   [RFC8174]   Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC
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6.2. Informative References

   [I-D.ietf-teas-yang-l3-te-topo] Liu, X., Bryskin, I., Beeram, V. P.,
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                Draft, draft-ietf-teas-yang-l3-te-topo-13, 10 July 2022,
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