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A Traffic Engineering MIB

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Abstract

   This memo defines a portion of the Management Information Base (MIB)
   for use with network management protocols in the Internet community.
   In particular, it describes managed objects for Traffic Engineered
   Tunnels, for example, Multi-Protocol Label Switched Paths.

Changes from previous version

    (Note to RFC Editor: This section to be removed before publication.)

     o Incorporated more of Dave Thaler's review comments
       - Added explanation how the IF MIB module and/or the IP tunnel
         MIB module can be extended
       - Added explanation of how TimeTicks wraps can be dealt with
       - Updated DESCRIPTION of teTunnelSourceAddressType and
         teTunnelDestinationAddressType.
       - Created two new conformance groups for path computation servers
         that implement the full set of teTunnelSourceAddressTypes.

Specification of Requirements

    The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
    "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
    document are to be interpreted as described in RFC 2119 [3].

1. **Introduction**

   This memo defines a portion of the Management Information Base (MIB)
   for use with network management protocols in the Internet community.
   In particular, it describes managed objects for Traffic Engineered
   Tunnels, for example, Multi-Protocol Label Switched Paths ([1], [2]).
   The MIB module that this memo defines allows one to configure TE
   Tunnels, assign one or more paths to a Tunnel, and monitor
   operational aspects of the Tunnel, such as the number of octets and
   packets that have passed through the Tunnel.

   As it stands, this MIB module can only be used to configure or
   monitor a TE Tunnel at its ingress. The extension of this module for
   use at other points of a Tunnel is for further study.

2. **The Internet-Standard Management Framework**

   For a detailed overview of the documents that describe the current
   Internet-Standard Management Framework, please refer to section 7 of
   RFC 3410 [4].

   Managed objects are accessed via a virtual information store, termed
   the Management Information Base or MIB. MIB objects are generally
   accessed through the Simple Network Management Protocol (SNMP).
   Objects in the MIB are defined using the mechanisms defined in the
   Structure of Management Information (SMI). This memo specifies a MIB
   module that is compliant to the SMIv2, which is described in STD 58,
   RFC 2578 [5], STD 58, RFC 2579 [6] and STD 58, RFC 2580 [7].

3. **Overview of the MIB Module**

   The Traffic Engineering MIB module consists of four parts:
      1) Traffic Engineering information;
      2) a table of Traffic Engineering Tunnels;
      3) a table of Paths that tunnels take;
      4) a table of Hops that make up a tunnel path.

   The MIB module also has statements for minimal and full compliance.

   The following subsections give an overview of each part. All objects
   are mandatory. For minimal compliance, all objects MAY be
   implemented read only; for full compliance, all objects must be
   implemented to their stated MAX-ACCESS capabilities. Notifications
   are optional.

3.1. Traffic Engineering Information

This part contains information about the Link State Protocols used to
carry TE information, the signalling protocols used to set up Traffic
Tunnels, the number of Traffic Tunnels that have been configured and
that are operational, and a mapping of Administrative Group (called
Resource Classes in [1]) numbers to names.

3.2. Traffic Tunnel Information

This part contains a table of Traffic Tunnels and information about
each one. This information includes the Tunnel name, its
configuration information, its operational information, and the
active path(s) that the Tunnel takes.

Configuration information includes the end points of the Traffic
Tunnel, and the number of configured paths for the Traffic Tunnel.

Operational information includes the current state (up/down), the
count of octets and packets sent on the Traffic Tunnel, how long it
has been up, and how many state transitions the Traffic Tunnel has
had.

Operational path information includes the number of operational
paths, the number of path changes, and when the last path change was.

3.3. Path Information

A Tunnel is a logical entity. An instantiation of a Tunnel is one or
more Paths; each Path has a route (also called Explicit Route) or
sequence of hops. A Path is indexed by a dual index: the primary
index is that of the Tunnel to which this Path belongs; the secondary
index is of the Path itself.

The configured information for a Path consists of the constraints for
the Path and a configured route.

The operational information consists of the Path status, as well as
the computed route (i.e., the route that was computed to satisfy the
constraints), and the actual path as recorded by the signaling
protocol.

3.4. Hop Information

A path consists of a sequence of hops; a hop can be loose (meaning
that the path eventually traverses the specified node) or strict
(meaning that the specified node and possibly link must be the next
node in the path). A hop can be specified as an IPv4 address, an

IPv6 address, an Autonomous System number or an unnumbered interface
index [8].

The Hop Table contains all hops for all paths on a given router. It
is organized as follows. There is a primary index that identifies a
list of hops and a secondary index that identifies individual hops.
Thus, to get the sequence of recorded hops for a path, one looks up
the path's tePathRecordedRoute, which is a primary index into the Hop
Table. Then to get the list of actual hops in order for the recorded
path, one uses a secondary index of 1, 2, ...

3.5. Relationship with Other MIB Modules

A TE Tunnel can extend objects from two other MIB modules; one is the
Interfaces MIB [11], and the other is the IP Tunnel MIB [12]. The
mechanism for doing so is to assign the TE Tunnel index
(teTunnelIndex) with a valid ifIndex value in ifTable.

If a TE Tunnel is deemed an interface, a new interface object is
created and assigned an ifIndex value in ifTable. Then a TE Tunnel
object is created, setting teTunnelIndex to the same value as the
interface index.

If (and only if) a TE Tunnel is considered an interface, it may also
be considered an IP tunnel (if the encapsulation of the TE Tunnel is
IP). In that case, the interface associated with the TE Tunnel
should have its ifType set to tunnel(131).

If a TE Tunnel is not considered an interface, then the TE Tunnel
index (teTunnelIndex) SHOULD be set to a value at least 2^24, so that
it is distinct from normal interfaces.

4. Creating, Modifying and Deleting a TE Tunnel

To create a TE Tunnel, one first obtains a free Tunnel index using
the object teNextTunnelIndex. One then creates the Tunnel, including
all parameters, either as createAndGo or createAndWait. Then, TE
Paths for this Tunnel can be created using the teTunnelNextPathIndex
object, again as createAndGo or createAndWait. A particular Path is
computed and signaled when both the Path and the enclosing Tunnel
have RowStatus 'active'.

To build a Path's configured route, one first gets a free PathHop
index using teNextPathHopIndex, then builds the route hop-by-hop
using the secondary index, setting the AddrType, Address, and HopType
for each Hop. Finally, one sets the tePathConfiguredRoute in the
Path to the PathHop index obtained.

Modifying certain properties of a TE Tunnel or a TE Path may require
setting the RowStatus of the Tunnel (or Path) to 'notInService'
before making the changes, and then setting the RowStatus of the
Tunnel (or Path) back to 'active' to re-signal all Paths of the
Tunnel (or the modified Path).

A TE Tunnel and all its Paths can be deleted by setting the Tunnel's
RowStatus to 'destroy'. A specific Path within a Tunnel can be
destroyed by setting just the Path's RowStatus to 'destroy'.

[5]. MIB Specification

```
TE-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE,
    NOTIFICATION-TYPE, mib-2,
    Integer32, Gauge32, Counter32,
    Counter64, Unsigned32, TimeTicks     FROM SNMPv2-SMI

    RowStatus, StorageType, TimeStamp,
    TruthValue                           FROM SNMPv2-TC

    SnmpAdminString                      FROM SNMP-FRAMEWORK-MIB

    MODULE-COMPLIANCE, OBJECT-GROUP,
    NOTIFICATION-GROUP                   FROM SNMPv2-CONF

    TeHopAddress, TeHopAddressType,
    MplsBitRate                          FROM MPLS-TC-STD-MIB;

teMIB MODULE-IDENTITY
    LAST-UPDATED "200401290000Z"         -- 29 January 2004
    ORGANIZATION "IETF Traffic Engineering Working Group"
    CONTACT-INFO "
                Editor:       Kireeti Kompella
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                The IETF Traffic Engineering Working Group is
                chaired by Jim Boyle and Ed Kern.

                WG Mailing List information:
```

```
                       General Discussion: te-wg@ops.ietf.org
                          To Subscribe:     te-wg-request@ops.ietf.org
                             In Body:       subscribe
                          Archive:          ftp://ops.ietf.org/pub/lists

                       Comments on the MIB module should be sent to the
                       mailing list.  The archives for this mailing list
                       should be consulted for previous discussion on
                       this MIB.
                      "
          DESCRIPTION  "The Traffic Engineering MIB module.

                       Copyright (C) The Internet Society (2004).  This
                       version of this MIB module is part of RFC xxxx;
                       see the RFC itself for full legal notices.
                      "
                                        -- RFC Editor, pls fill in RFC xxxx

          -- revision history

          REVISION     "200401290000Z"          -- 29 January 2004
          DESCRIPTION  "Initial version, published as RFC xxxx."
                                        -- RFC Editor, pls assign RFC xxxx
          ::= { mib-2 nnn }              -- To be assigned by IANA

     -- Top level objects

     teMIBNotifications  OBJECT IDENTIFIER ::= { teMIB 0 }
     teMIBObjects        OBJECT IDENTIFIER ::= { teMIB 1 }
     teMIBConformance    OBJECT IDENTIFIER ::= { teMIB 2 }

     -- *************************************************************
     --
     -- TE MIB Objects
     --

     -- TE Info

     teInfo OBJECT IDENTIFIER ::= { teMIBObjects 1 }

     teDistProtocol    OBJECT-TYPE
         SYNTAX        BITS {
                           other(0),
                           isis(1),
                           ospf(2)
                       }
         MAX-ACCESS    read-only
         STATUS        current
```

```
       DESCRIPTION "IGP used to distribute Traffic Engineering
                    information and topology to each device for the
                    purpose of automatic path computation.  More than
                    one IGP may be used to distribute TE information.
                    "
       ::= { teInfo 1 }

   teSignalingProto OBJECT-TYPE
       SYNTAX       BITS {
                          other(0),
                          rsvpte(1),
                          crldp(2),
                          static(3)    -- static configuration
                    }
       MAX-ACCESS   read-only
       STATUS       current
       DESCRIPTION "Traffic Engineering signaling protocols supported
                    by this device.  More than one protocol may be
                    supported.
                    "
       REFERENCE   "For a description of RSVP-TE, see RFC 3209;
                    for CR-LDP, see RFC 3212.
                    "
       ::= { teInfo 2 }

   teNotificationEnable OBJECT-TYPE
       SYNTAX       TruthValue
       MAX-ACCESS   read-write
       STATUS       current
       DESCRIPTION "If this object is true, then it enables the
                    generation of notifications from this MIB module.
                    Otherwise notifications are not generated.
                    "
       DEFVAL { false }
       ::= { teInfo 3 }

   teNextTunnelIndex OBJECT-TYPE
       SYNTAX       Unsigned32
       MAX-ACCESS   read-only
       STATUS       current
       DESCRIPTION "An integer which may be used as a new Index in the
                    teTunnelTable.

                    The special value of 0 indicates that no more new
                    entries can be created in that table.

                    When this MIB module is used for configuration, this
                    object always contains a legal value (if non-zero)
```

                    for an index that is not currently used in that
                    table. The Command Generator (Network Management
                    Application) reads this variable and uses the
                    (non-zero) value read when creating a new row with
                    an SNMP SET. When the SET is performed, the Command
                    Responder (agent) must determine whether the value
                    is indeed still unused; Two Network Management
                    Applications may attempt to create a row
                    (configuration entry) simultaneously and use the
                    same value. If it is currently unused, the SET
                    succeeds and the Command Responder (agent) changes
                    the value of this object, according to an
                    implementation-specific algorithm. If the value is
                    in use, however, the SET fails. The Network
                    Management Application must then re-read this
                    variable to obtain a new usable value.
                    "
        ::= { teInfo 4 }

    teNextPathHopIndex OBJECT-TYPE
        SYNTAX   Unsigned32
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "An integer which may be used as a new Index in the
                    tePathHopTable.

                    The special value of 0 indicates that no more new
                    entries can be created in that table.

                    When this MIB module is used for configuration, this
                    object always contains a legal value (if non-zero)
                    for an index that is not currently used in that
                    table. The Command Generator (Network Management
                    Application) reads this variable and uses the
                    (non-zero) value read when creating a new row with
                    an SNMP SET. When the SET is performed, the Command
                    Responder (agent) must determine whether the value
                    is indeed still unused; Two Network Management
                    Applications may attempt to create a row
                    (configuration entry) simultaneously and use the
                    same value. If it is currently unused, the SET
                    succeeds and the Command Responder (agent) changes
                    the value of this object, according to an
                    implementation-specific algorithm. If the value is
                    in use, however, the SET fails. The Network
                    Management Application must then re-read this
                    variable to obtain a new usable value.
                    "

```
        ::= { teInfo 5 }

    teConfiguredTunnels OBJECT-TYPE
        SYNTAX        Gauge32
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION "Number of currently configured Tunnels."
        ::= { teInfo 6 }

    teActiveTunnels  OBJECT-TYPE
        SYNTAX        Gauge32
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION "Number of currently active Tunnels."
        ::= { teInfo 7 }

    tePrimaryTunnels OBJECT-TYPE
        SYNTAX        Gauge32
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION "Number of currently active Tunnels running on
                     their primary paths.
                    "
        ::= { teInfo 8 }

    teAdminGroupTable OBJECT-TYPE
        SYNTAX        SEQUENCE OF TeAdminGroupEntry
        MAX-ACCESS    not-accessible
        STATUS        current
        DESCRIPTION "A mapping of configured administrative groups.  Each
                     entry represents an Administrative Group, and
                     provides a name and index for the group.
                     Administrative groups are used to label links in the
                     Traffic Engineering topology in order to place
                     constraints (include and exclude) on Tunnel paths.

                     A groupName can only be linked to one group number.
                     The groupNumber is the number assigned to the
                     administrative group which is used in constraints,
                     like tePathIncludeAny, tePathIncludeAll, etc.
                    "
        ::= { teInfo 9 }

    teAdminGroupEntry OBJECT-TYPE
        SYNTAX        TeAdminGroupEntry
        MAX-ACCESS    not-accessible
        STATUS        current
        DESCRIPTION "A mapping between a configured group number and
```

```
                    its human-readable name.  The group number should
                    be between 1 and 32, inclusive.  Group number n
                    represents bit number (n-1) in the bit vector for
                    Include/Exclude constraints.

                    All entries in this table MUST be kept in stable
                    storage so that they will re-appear in case of a
                    restart/reboot.
                    "
    INDEX          { teAdminGroupNumber }
    ::= { teAdminGroupTable 1 }

TeAdminGroupEntry ::=
    SEQUENCE {
        teAdminGroupNumber     Integer32,
        teAdminGroupName       SnmpAdminString,
        teAdminGroupRowStatus RowStatus
    }

teAdminGroupNumber OBJECT-TYPE
    SYNTAX        Integer32 (1..32)
    MAX-ACCESS   not-accessible
    STATUS        current
    DESCRIPTION "Index of the administrative group."
    ::= { teAdminGroupEntry 1 }

teAdminGroupName OBJECT-TYPE
    SYNTAX        SnmpAdminString (SIZE (1..32))
    MAX-ACCESS   read-create
    STATUS        current
    DESCRIPTION "Name of the administrative group."
    ::= { teAdminGroupEntry 2 }

teAdminGroupRowStatus OBJECT-TYPE
    SYNTAX        RowStatus
    MAX-ACCESS   read-create
    STATUS        current
    DESCRIPTION "The status of this conceptual row.

                    The value of this object has no effect on whether
                    other objects in this conceptual row can be
                    modified.
                    "
    ::= { teAdminGroupEntry 3 }

-- Tunnel Table

teTunnelTable     OBJECT-TYPE
```

```
        SYNTAX      SEQUENCE OF TeTunnelEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION "Table of Configured Traffic Tunnels."
        ::= { teMIBObjects 2 }

    teTunnelEntry    OBJECT-TYPE
        SYNTAX      TeTunnelEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION "Entry containing information about a particular
                     Traffic Tunnel.
                    "
        INDEX       { teTunnelIndex }
        ::= { teTunnelTable 1 }

    TeTunnelEntry ::=
        SEQUENCE {
            teTunnelIndex                  Unsigned32,
            teTunnelName                   SnmpAdminString,
            teTunnelNextPathIndex          Unsigned32,
         -- Conceptual row information:
            teTunnelRowStatus              RowStatus,
            teTunnelStorageType            StorageType,
         -- Address information:
            teTunnelSourceAddressType      TeHopAddressType,
            teTunnelSourceAddress          TeHopAddress,
            teTunnelDestinationAddressType TeHopAddressType,
            teTunnelDestinationAddress     TeHopAddress,
         -- State/performance information:
            teTunnelState                  INTEGER,
            teTunnelDiscontinuityTimer     TimeStamp,
            teTunnelOctets                 Counter64,
            teTunnelPackets                Counter64,
            teTunnelLPOctets               Counter32,
            teTunnelLPPackets              Counter32,
            teTunnelAge                    TimeTicks,
            teTunnelTimeUp                 TimeTicks,
            teTunnelPrimaryTimeUp          TimeTicks,
            teTunnelTransitions            Counter32,
            teTunnelLastTransition         TimeTicks,
            teTunnelPathChanges            Counter32,
            teTunnelLastPathChange         TimeTicks,
            teTunnelConfiguredPaths        Gauge32,
            teTunnelStandbyPaths           Gauge32,
            teTunnelOperationalPaths       Gauge32
        }
```

    teTunnelIndex   OBJECT-TYPE
        SYNTAX   Unsigned32 (1..4294967295)
        MAX-ACCESS   not-accessible
        STATUS   current
        DESCRIPTION "A unique index that identifies a Tunnel. If the TE
                     Tunnel is considered an interface, then this index
                     must match the interface index of the corresponding
                     interface. Otherwise, this index must be at least
                     2^24, so that it does not overlap with any existing
                     interface index.
                    "
        ::= { teTunnelEntry 1 }

    teTunnelName   OBJECT-TYPE
        SYNTAX   SnmpAdminString (SIZE (1..32))
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "Name of the Traffic Tunnel.

                     Note that the name of a Tunnel MUST be unique.
                     When a SET request contains a name that is already
                     in use for another entry, then the implementation
                     must return an inconsistentValue error.

                     The value of this object cannot be changed if the
                     if the value of the corresponding teTunnelRowStatus
                     object is 'active'.
                    "
        ::= { teTunnelEntry 2 }

    teTunnelNextPathIndex   OBJECT-TYPE
        SYNTAX   Unsigned32
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "An integer which may be used as a new Index for the
                     next Path in this Tunnel.

                     The special value of 0 indicates that no more Paths
                     can be created for this Tunnel, or that no more new
                     entries can be created in tePathTable.

                     When this MIB module is used for configuration, this
                     object always contains a legal value (if non-zero)
                     for an index that is not currently used in that
                     table. The Command Generator (Network Management
                     Application) reads this variable and uses the
                     (non-zero) value read when creating a new row with
                     an SNMP SET. When the SET is performed, the Command

                       Responder (agent) must determine whether the value
                       is indeed still unused; Two Network Management
                       Applications may attempt to create a row
                       (configuration entry) simultaneously and use the
                       same value. If it is currently unused, the SET
                       succeeds and the Command Responder (agent) changes
                       the value of this object, according to an
                       implementation-specific algorithm. If the value is
                       in use, however, the SET fails. The Network
                       Management Application must then re-read this
                       variable to obtain a new usable value.
                       "
        ::= { teTunnelEntry 3 }

    teTunnelRowStatus OBJECT-TYPE
        SYNTAX   RowStatus
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "The status of this conceptual row.

                       When the value of this object is 'active', then
                       the values for the corresponding objects
                       teTunnelName, teTunnelSourceAddressType,
                       teTunnelSourceAddress,
                       teTunnelDestinationAddressType and
                       teTunnelDestinationAddress cannot be changed.
                       "
        ::= { teTunnelEntry 4 }

    teTunnelStorageType OBJECT-TYPE
        SYNTAX   StorageType
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "The storage type for this conceptual row.

                       Conceptual rows having the value 'permanent' need
                       not allow write-access to any columnar objects
                       in the row.
                       "
        ::= { teTunnelEntry 5 }

    teTunnelSourceAddressType OBJECT-TYPE
        SYNTAX   TeHopAddressType
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "The type of Traffic Engineered Tunnel hop address
                       for the source of this Tunnel. Typically, this
                       address type is IPv4 or IPv6, with a prefix length

                    of 32 or 128 respectively. If the TE Tunnel path
                    is being computed by a path computation server,
                    however, it is possible to use more flexible source
                    address types, such as AS numbers or prefix lengths
                    less than host address lengths.

                    The value of this object cannot be changed if the
                    if the value of the corresponding teTunnelRowStatus
                    object is 'active'.
                    "
        ::= { teTunnelEntry 6 }

    teTunnelSourceAddress OBJECT-TYPE
        SYNTAX   TeHopAddress
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "Source Traffic Engineered Tunnel hop address of
                    this Tunnel.

                    The type of this address is determined by the value
                    of the corresponding teTunnelSourceAddressType.

                    Note that source and destination addresses of a
                    Tunnel can be different address types.

                    The value of this object cannot be changed if the
                    if the value of the corresponding teTunnelRowStatus
                    object is 'active'.
                    "
        ::= { teTunnelEntry 7 }

    teTunnelDestinationAddressType OBJECT-TYPE
        SYNTAX   TeHopAddressType
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "The type of Traffic Engineered Tunnel hop address
                    for the destination of this Tunnel.

                    The value of this object cannot be changed if the
                    if the value of the corresponding teTunnelRowStatus
                    object is 'active'.
                    "
        ::= { teTunnelEntry 8 }

    teTunnelDestinationAddress OBJECT-TYPE
        SYNTAX   TeHopAddress
        MAX-ACCESS   read-create
        STATUS   current

        DESCRIPTION "Destination Traffic Engineered Tunnel hop address
                    of this Tunnel.

                    The type of this address is determined by the value
                    of the corresponding teTunnelDestinationAddressType.

                    Note that source and destination addresses of a
                    Tunnel can be different address types.

                    The value of this object cannot be changed if the
                    if the value of the corresponding teTunnelRowStatus
                    object is 'active'.
                    "
        ::= { teTunnelEntry 9 }

    teTunnelState   OBJECT-TYPE
        SYNTAX   INTEGER {
                        unknown(1),
                        up(2),
                        down(3),
                        testing(4)
                      }
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "The operational state of the Tunnel."
        ::= { teTunnelEntry 10 }

    teTunnelDiscontinuityTimer OBJECT-TYPE
        SYNTAX   TimeStamp
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "The value of sysUpTime on the most recent occasion
                    at which any one or more of this tunnel's counters
                    suffered a discontinuity. The relevant counters
                    are teTunnelOctets, teTunnelPackets,
                    teTunnelLPOctets and teTunnelLPPackets. If no such
                    discontinuities have occurred since the last
                    re-initialization of the local management subsystem,
                    then this object contains a zero value.
                    "
        ::= { teTunnelEntry 11 }

    teTunnelOctets   OBJECT-TYPE
        SYNTAX   Counter64
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "The number of octets that have been forwarded over
                    the Tunnel.

```
                        Discontinuities in the value of this counter can
                        occur at re-initialization of the management system,
                        and at other times as indicated by the value of
                        teTunnelDiscontinuityTimer.
                        "
        ::= { teTunnelEntry 12 }

    teTunnelPackets  OBJECT-TYPE
        SYNTAX        Counter64
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION "The number of packets that have been forwarded over
                        the Tunnel.

                        Discontinuities in the value of this counter can
                        occur at re-initialization of the management system,
                        and at other times as indicated by the value of
                        teTunnelDiscontinuityTimer.
                        "
        ::= { teTunnelEntry 13 }

    teTunnelLPOctets OBJECT-TYPE
        SYNTAX        Counter32
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION "The number of octets that have been forwarded over
                        the Tunnel.

                        Discontinuities in the value of this counter can
                        occur at re-initialization of the management system,
                        and at other times as indicated by the value of
                        teTunnelDiscontinuityTimer.
                        "
        ::= { teTunnelEntry 14 }

    teTunnelLPPackets OBJECT-TYPE
        SYNTAX        Counter32
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION "The number of packets that have been forwarded over
                        the Tunnel.

                        Discontinuities in the value of this counter can
                        occur at re-initialization of the management system,
                        and at other times as indicated by the value of
                        teTunnelDiscontinuityTimer.
                        "
        ::= { teTunnelEntry 15 }
```

    teTunnelAge   OBJECT-TYPE
        SYNTAX   TimeTicks
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "The age (i.e., time from creation of this conceptual
                     row till now) of this Tunnel in hundredths of a
                     second. Note that since TimeTicks wrap in about 16
                     months, this value is best used in interval
                     measurements.
                    "
        ::= { teTunnelEntry 16 }

    teTunnelTimeUp   OBJECT-TYPE
        SYNTAX   TimeTicks
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "The total time in hundredths of a second that this
                     Tunnel has been operational. Note that since
                     TimeTicks wrap in about 16 months, this value is
                     best used in interval measurements.

                     An example usage of this object is to compute the
                     percentage up time over a period of time, by
                     obtaining values of teTunnelAge and teTunnelTimeUp
                     at two points in time, and computing the following
                     ratio: ((teTunnelTimeUp2 - teTunnelTimeUp1)/
                     (teTunnelAge2 - teTunnelAge1)) * 100 %. In doing
                     so, the management station must account for
                     wrapping of the values of teTunnelAge and
                     teTunnelTimeUp between the two measurements.
                    "
        ::= { teTunnelEntry 17 }

    teTunnelPrimaryTimeUp OBJECT-TYPE
        SYNTAX   TimeTicks
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "The total time in hundredths of a second that this
                     Tunnel's primary path has been operational. Note
                     that since TimeTicks wrap in about 16 months, this
                     value is best used in interval measurements.

                     An example usage of this field is to compute what
                     percentage of time that a TE Tunnel was on the
                     primary path over a period of time, by computing
                     ((teTunnelPrimaryTimeUp2 - teTunnelPrimaryTimeUp1)/
                     (teTunnelTimeUp2 - teTunnelTimeUp1))*100 %. In
                     doing so, the management station must account for

                         wrapping of the values of teTunnelPrimaryTimeUp and
                          teTunnelTimeUp between the two measurements.
                          "
         ::= { teTunnelEntry 18 }

    teTunnelTransitions OBJECT-TYPE
         SYNTAX   Counter32
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION "The number of operational state transitions
                       (up -> down and down -> up) this Tunnel has
                       undergone.
                       "
         ::= { teTunnelEntry 19 }

    teTunnelLastTransition OBJECT-TYPE
         SYNTAX   TimeTicks
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION "The time in hundredths of a second since the last
                       operational state transition occurred on this
                       Tunnel.

                       Note that if the last transition was over 16
                       months ago, this value will be inaccurate.
                       "
         ::= { teTunnelEntry 20 }

    teTunnelPathChanges OBJECT-TYPE
         SYNTAX   Counter32
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION "The number of path changes this Tunnel has had."
         ::= { teTunnelEntry 21 }

    teTunnelLastPathChange OBJECT-TYPE
         SYNTAX   TimeTicks
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION "The time in hundredths of a second since the last
                       path change occurred on this Tunnel.

                       Note that if the last transition was over 16
                       months ago, this value will be inaccurate.
                       "
         ::= { teTunnelEntry 22 }

    teTunnelConfiguredPaths OBJECT-TYPE

```
      SYNTAX        Gauge32
      MAX-ACCESS    read-only
      STATUS        current
      DESCRIPTION "The number of paths configured for this Tunnel."
      ::= { teTunnelEntry 23 }

   teTunnelStandbyPaths OBJECT-TYPE
      SYNTAX        Gauge32
      MAX-ACCESS    read-only
      STATUS        current
      DESCRIPTION "The number of standby paths configured for this
                   Tunnel.
                  "
      ::= { teTunnelEntry 24 }

   teTunnelOperationalPaths OBJECT-TYPE
      SYNTAX        Gauge32
      MAX-ACCESS    read-only
      STATUS        current
      DESCRIPTION "The number of operational paths for this Tunnel.
                   This includes the path currently active, as
                   well as operational standby paths.
                  "
      ::= { teTunnelEntry 25 }

   -- ************************************************************
   --
   -- Tunnel Path Table
   --

   tePathTable      OBJECT-TYPE
      SYNTAX        SEQUENCE OF TePathEntry
      MAX-ACCESS    not-accessible
      STATUS        current
      DESCRIPTION "Table of Configured Traffic Tunnels."
      ::= { teMIBObjects 3 }

   tePathEntry      OBJECT-TYPE
      SYNTAX        TePathEntry
      MAX-ACCESS    not-accessible
      STATUS        current
      DESCRIPTION "Entry containing information about a particular
                   Traffic Tunnel.  Each Traffic Tunnel can have zero
                   or more Traffic Paths.

                   Since a Traffic Path can only exist over an existing
                   Trafic Tunnel, it means that all tePathEntries with
                   a value of n for teTunnelIndex MUST be removed by
```

```
                    the implementation when the corresponding
                    teTunnelEntry with a value of n for teTunnelIndex
                    is removed.
                   "
        INDEX        { teTunnelIndex, tePathIndex }
        ::= { tePathTable 1 }

    TePathEntry ::=
        SEQUENCE {
            tePathIndex                 Unsigned32,
            tePathName                  SnmpAdminString,
         -- Conceptual row information
            tePathRowStatus             RowStatus,
            tePathStorageType           StorageType,
         -- Path properties
            tePathType                  INTEGER,
            tePathConfiguredRoute       Unsigned32,
            tePathBandwidth             MplsBitRate,
            tePathIncludeAny            Unsigned32,
            tePathIncludeAll            Unsigned32,
            tePathExclude               Unsigned32,
            tePathSetupPriority         Integer32,
            tePathHoldPriority          Integer32,
            tePathProperties            BITS,
         -- Path status
            tePathOperStatus            INTEGER,
            tePathAdminStatus           INTEGER,
            tePathComputedRoute         Unsigned32,
            tePathRecordedRoute         Unsigned32
        }

    tePathIndex       OBJECT-TYPE
        SYNTAX        Unsigned32 (1..4294967295)
        MAX-ACCESS    not-accessible
        STATUS        current
        DESCRIPTION "An index that uniquely identifies a path within
                    a Tunnel.

                    The combination of <teTunnelIndex, tePathIndex> thus
                    uniquely identifies a path among all paths on this
                    router.
                   "
        ::= { tePathEntry 1 }

    tePathName        OBJECT-TYPE
        SYNTAX        SnmpAdminString (SIZE(0..32))
        MAX-ACCESS    read-create
        STATUS        current
```

         DESCRIPTION "The name of this path.

                     A pathName must be unique within the set of paths
                     over a single tunnel. If a SET request is received
                     with a duplicate name, then the implementation MUST
                     return an inconsistentValue error.

                     The value of this object cannot be changed if the
                     if the value of the corresponding teTunnelRowStatus
                     object is 'active'.
                     "
         ::= { tePathEntry 2 }

    tePathRowStatus OBJECT-TYPE
         SYNTAX   RowStatus
         MAX-ACCESS   read-create
         STATUS   current
         DESCRIPTION "The status of this conceptual row.

                     When the value of this object is 'active', then
                     the value of tePathName cannot be changed. All
                     other writable objects may be changed; however,
                     these changes may affect traffic going over the TE
                     tunnel, or require the path to be computed and/or
                     re-signalled.
                     "
         ::= { tePathEntry 3 }

    tePathStorageType OBJECT-TYPE
         SYNTAX   StorageType
         MAX-ACCESS   read-create
         STATUS   current
         DESCRIPTION "The storage type for this conceptual row.

                     Conceptual rows having the value 'permanent' need
                     not allow write-access to any columnar objects
                     in the row.
                     "
         ::= { tePathEntry 4 }

    tePathType OBJECT-TYPE
         SYNTAX   INTEGER {
                         other(1),
                         primary(2),
                         standby(3),
                         secondary(4)
                       }
         MAX-ACCESS   read-create

```
         STATUS        current
         DESCRIPTION "The type for this PathEntry, i.e., whether this path
                      is a primary path, a standby path, or a secondary
                      path.
                     "
         ::= { tePathEntry 5 }


   tePathConfiguredRoute OBJECT-TYPE
         SYNTAX        Unsigned32
         MAX-ACCESS    read-create
         STATUS        current
         DESCRIPTION "The route that this TE path is configured to follow,
                      i.e., an ordered list of hops.  The value of this
                      object gives the primary index into the Hop Table;
                      the secondary index is the hop count in the path, so
                      to get the route, one could get the first hop with
                      index <tePathConfiguredRoute, 1> in the Hop Table,
                      and do a getnext to get subsequent hops.
                     "
         ::= { tePathEntry 6 }


   tePathBandwidth  OBJECT-TYPE
         SYNTAX        MplsBitRate
         UNITS         "Kilobits per second"
         MAX-ACCESS    read-create
         STATUS        current
         DESCRIPTION "The configured bandwidth for this Tunnel,
                      in units of thousands of bits per second (Kbps).
                     "
         DEFVAL      { 0 }
         ::= { tePathEntry 7 }


   tePathIncludeAny OBJECT-TYPE
         SYNTAX        Unsigned32
         MAX-ACCESS    read-create
         STATUS        current
         DESCRIPTION "This is a configured set of administrative groups
                      specified as a bit vector (i.e., bit n is 1 if group
                      n is in the set, where n = 0 is the LSB).  For each
                      link that this path goes through, the link must have
                      at least one of the groups specified in IncludeAny
                      to be acceptable.  If IncludeAny is zero, all links
                      are acceptable.
                     "
         DEFVAL      { 0 }
         ::= { tePathEntry 8 }


   tePathIncludeAll OBJECT-TYPE
```

```
         SYNTAX       Unsigned32
         MAX-ACCESS   read-create
         STATUS       current
         DESCRIPTION "This is a configured set of administrative groups
                      specified as a bit vector (i.e., bit n is 1 if group
                      n is in the set, where n = 0 is the LSB).  For each
                      link that this path goes through, the link must have
                      all of the groups specified in IncludeAny to be
                      acceptable.  If IncludeAny is zero, all links are
                      acceptable.
                     "
         DEFVAL      { 0 }
         ::= { tePathEntry 9 }

     tePathExclude    OBJECT-TYPE
         SYNTAX       Unsigned32
         MAX-ACCESS   read-create
         STATUS       current
         DESCRIPTION "This is a configured set of administrative groups
                      specified as a bit vector (i.e., bit n is 1 if group
                      n is in the set, where n = 0 is the LSB).  For each
                      link that this path goes through, the link MUST have
                      groups associated with it, and the intersection of
                      the link's groups and the 'exclude' set MUST be
                      null.
                     "
         DEFVAL      { 0 }
         ::= { tePathEntry 10 }

     tePathSetupPriority OBJECT-TYPE
         SYNTAX       Integer32 (0..7)
         MAX-ACCESS   read-create
         STATUS       current
         DESCRIPTION "The setup priority configured for this path, with 0
                      as the highest priority and 7 the lowest.
                     "
         DEFVAL      { 7 }
         ::= { tePathEntry 11 }

     tePathHoldPriority OBJECT-TYPE
         SYNTAX       Integer32 (0..7)
         MAX-ACCESS   read-create
         STATUS       current
         DESCRIPTION "The hold priority configured for this path, with 0
                      as the highest priority and 7 the lowest.
                     "
         DEFVAL      { 0 }
         ::= { tePathEntry 12 }
```

    tePathProperties OBJECT-TYPE
        SYNTAX   BITS {
                            recordRoute(0),
                            cspf(1),
                            makeBeforeBreak(2),
                            mergeable(3),
                            fastReroute(4),
                            protected(5)
                        }
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "The set of configured properties for this path,
                        expressed as a bit map. For example, if the path
                        supports 'make before break', then bit 2 is set.
                        "
        ::= { tePathEntry 13 }

    tePathOperStatus OBJECT-TYPE
        SYNTAX   INTEGER {
                            unknown(0),
                            down(1),
                            testing(2),
                            dormant(3),
                            ready(4),
                            operational(5)
                        }
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION "The operational status of the path:
                        unknown:
                        down: signaling failed
                        testing: administratively set aside for testing
                        dormant: not signaled (for a backup tunnel)
                        ready: signaled but not yet carrying traffic
                        operational: signaled and carrying traffic.
                        "
        ::= { tePathEntry 14 }

    tePathAdminStatus OBJECT-TYPE
        SYNTAX   INTEGER {
                            normal(1),
                            testing(2)
                        }
        MAX-ACCESS   read-create
        STATUS   current
        DESCRIPTION "The operational status of the path:
                        normal: used normally for forwarding
                        testing: administratively set aside for testing.

```
                           "
           ::= { tePathEntry 15 }


    tePathComputedRoute OBJECT-TYPE
        SYNTAX       Unsigned32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION "The route computed for for this path, perhaps using
                     some form of Constraint-based Routing.  The
                     algorithm is implementation dependent.

                     This object returns the computed route as an ordered
                     list of hops.  The value of this object gives the
                     primary index into the Hop Table; the secondary
                     index is the hop count in the path, so to get the
                     route, one could get the first hop with index
                     <tePathComputedRoute, 1> in the Hop Table, and do a
                     getnext to get subsequent hops.

                     A value of zero (0) means there is no computedRoute.
                     "
           ::= { tePathEntry 16 }

    tePathRecordedRoute OBJECT-TYPE
        SYNTAX       Unsigned32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION "The route actually used for this path, as recorded
                     by the signaling protocol.  This is again an ordered
                     list of hops; each hop is expected to be strict.

                     The value of this object gives the primary index
                     into the Hop Table; the secondary index is the hop
                     count in the path, so to get the route, one can get
                     the first hop with index <tePathRecordedRoute, 1>
                     in the Hop Table, and do a getnext to get subsequent
                     hops.

                     A value of zero (0) means there is no recordedRoute.
                     "
            ::= { tePathEntry 17 }

    -- ***********************************************************
    --
    -- Tunnel Path Hop Table
    --

    tePathHopTable   OBJECT-TYPE
```

```
        SYNTAX       SEQUENCE OF TePathHopEntry
        MAX-ACCESS   not-accessible
        STATUS       current
        DESCRIPTION "Table of Tunnel Path Hops."
        ::= { teMIBObjects 4 }

    tePathHopEntry   OBJECT-TYPE
        SYNTAX       TePathHopEntry
        MAX-ACCESS   not-accessible
        STATUS       current
        DESCRIPTION "Entry containing information about a particular
                     hop.
                    "
        INDEX       { teHopListIndex, tePathHopIndex }
        ::= { tePathHopTable 1 }

    TePathHopEntry ::=
        SEQUENCE {
            teHopListIndex              Unsigned32,
            tePathHopIndex              Unsigned32,
         -- Conceptual row information
            tePathHopRowStatus          RowStatus,
            tePathHopStorageType        StorageType,
            tePathHopAddrType           TeHopAddressType,
            tePathHopAddress            TeHopAddress,
            tePathHopType               INTEGER
        }

    teHopListIndex   OBJECT-TYPE
        SYNTAX       Unsigned32 (1..4294967295)
        MAX-ACCESS   not-accessible
        STATUS       current
        DESCRIPTION "An index that identifies a list of hops.  This is
                     the primary index to accesses hops.
                    "
        ::= { tePathHopEntry 1 }

    tePathHopIndex   OBJECT-TYPE
        SYNTAX       Unsigned32 (1..4294967295)
        MAX-ACCESS   not-accessible
        STATUS       current
        DESCRIPTION "An index that identifies a particular hop among the
                     list of hops for a path.  An index of i identifies
                     the ith hop.  This is the secondary index for a hop
                     entry.
                    "
        ::= { tePathHopEntry 2 }
```

```
    tePathHopRowStatus OBJECT-TYPE
        SYNTAX        RowStatus
        MAX-ACCESS    read-create
        STATUS        current
        DESCRIPTION "The status of this conceptual row.

                     Any field in this table can be changed, even if the
                     value of this object is 'active'.  However, such a
                     change may cause traffic to be rerouted or even
                     disrupted.
                    "
        ::= { tePathHopEntry 3 }

    tePathHopStorageType OBJECT-TYPE
        SYNTAX        StorageType
        MAX-ACCESS    read-create
        STATUS        current
        DESCRIPTION "The storage type for this conceptual row.

                     Conceptual rows having the value 'permanent' need
                     not allow write-access to any columnar objects
                     in the row.
                    "
        ::= { tePathHopEntry 4 }

    tePathHopAddrType OBJECT-TYPE
        SYNTAX        TeHopAddressType
        MAX-ACCESS    read-create
        STATUS        current
        DESCRIPTION "The type of Traffic Engineered Tunnel hop Address
                     of this hop.

                     The value of this object cannot be changed if the
                     if the value of the corresponding tePathRowStatus
                     object is 'active'.
                    "
        ::= { tePathHopEntry 5 }

    tePathHopAddress OBJECT-TYPE
        SYNTAX        TeHopAddress
        MAX-ACCESS    read-create
        STATUS        current
        DESCRIPTION "Traffic Engineered Tunnel hop Address of this hop.

                     The type of this address is determined by the value
                     of the corresponding tePathHopAddressType.

                     The value of this object cannot be changed if the
```

```
                    if the value of the corresponding teTunnelRowStatus
                    object is 'active'.
                   "
        ::= { tePathHopEntry 6 }

    tePathHopType     OBJECT-TYPE
        SYNTAX        INTEGER {
                        unknown(0),
                        loose(1),
                        strict(2)
                    }
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION "The type of hop:
                    unknown:
                    loose:     this hop is a LOOSE hop.
                    strict:    this hop is a STRICT hop.
                   "
        ::= { tePathHopEntry 7 }

    -- ***************************************************************
    --
    -- TE Notifications
    --

    teTunnelUp        NOTIFICATION-TYPE
        OBJECTS       { teTunnelName,
                         tePathName }  -- TunnelPath
        STATUS        current
        DESCRIPTION "A teTunnelUp notification is generated when the
                    Tunnel indexed by teTunnelName transitions to the
                    'up' state.

                    A tunnel is up when at least one of its paths is up.
                    The tePathName is the name of the path whose
                    transition to up made the tunnel go up.

                    This notification MUST be limited to at most one
                    every minute, in case the tunnel flaps up and down.
                   "
        ::= { teMIBNotifications 1 }

    teTunnelDown      NOTIFICATION-TYPE
        OBJECTS       { teTunnelName,
                         tePathName }  -- TunnelPath
        STATUS        current
        DESCRIPTION "A teTunnelDown notification is generated when the
                    Tunnel indexed by teTunnelName transitions to the
```

```
                      'down' state.

                      A tunnel is up when at least one of its paths is up.
                      The tePathName is the name of the path whose
                      transition to down made the tunnel go down.

                      This notification MUST be limited to at most one
                      every minute, in case the tunnel flaps up and down.
                      "
          ::= { teMIBNotifications 2 }

    teTunnelChanged  NOTIFICATION-TYPE
        OBJECTS       { teTunnelName,
                         tePathName }  -- toTunnelPath
        STATUS        current
        DESCRIPTION "A teTunnelChanged notification is generated when an
                      active path on the Tunnel indexed by teTunnelName
                      changes, or a new path becomes active.  The value
                      of tePathName is the new active path.

                      This notification MUST be limited to at most one
                      every minute, in case the tunnel changes quickly.
                      "
          ::= { teMIBNotifications 3 }

    teTunnelRerouted NOTIFICATION-TYPE
        OBJECTS       { teTunnelName,
                         tePathName }  -- toTunnelPath
        STATUS        current
        DESCRIPTION "A teTunnelRerouted notification is generated when
                      an active path for the Tunnel indexed by
                      teTunnelName stays the same, but its route changes.

                      This notification MUST be limited to at most one
                      every minute, in case the tunnel reroutes quickly.
                      "
          ::= { teMIBNotifications 4 }

    -- End of TE-MIB objects

    -- ************************************************************
    --
    -- TE Compliance Statements
    --

    teGroups
        OBJECT IDENTIFIER ::= { teMIBConformance 1 }
```

```
teModuleCompliance
    OBJECT IDENTIFIER ::= { teMIBConformance 2 }

-- *************************************************************
--
-- TE object groups
--

teTrafficEngineeringGroup OBJECT-GROUP
    OBJECTS {
        teTunnelName,
        teTunnelNextPathIndex,
        teTunnelRowStatus,
        teTunnelStorageType,
        teTunnelSourceAddressType,
        teTunnelSourceAddress,
        teTunnelDestinationAddressType,
        teTunnelDestinationAddress,
        teTunnelState,
        teTunnelDiscontinuityTimer,
        teTunnelOctets,
        teTunnelPackets,
        teTunnelLPOctets,
        teTunnelLPPackets,
        teTunnelAge,
        teTunnelTimeUp,
        teTunnelPrimaryTimeUp,
        teTunnelTransitions,
        teTunnelLastTransition,
        teTunnelPathChanges,
        teTunnelLastPathChange,
        teTunnelConfiguredPaths,
        teTunnelStandbyPaths,
        teTunnelOperationalPaths,
        tePathBandwidth,
        tePathIncludeAny,
        tePathIncludeAll,
        tePathExclude,
        tePathSetupPriority,
        tePathHoldPriority,
        tePathProperties,
        tePathOperStatus,
        tePathAdminStatus,
        tePathComputedRoute,
        tePathRecordedRoute,
        teDistProtocol,
        teSignalingProto,
        teNotificationEnable,
```

```
            teNextTunnelIndex,
            teNextPathHopIndex,
            teAdminGroupName,
            teAdminGroupRowStatus,
            teConfiguredTunnels,
            teActiveTunnels,
            tePrimaryTunnels,
            tePathName,
            tePathType,
            tePathRowStatus,
            tePathStorageType,
            tePathConfiguredRoute,
            tePathHopRowStatus,
            tePathHopStorageType,
            tePathHopAddrType,
            tePathHopAddress,
            tePathHopType
        }
        STATUS       current
        DESCRIPTION "Objects for Traffic Engineering in this MIB module."

        ::= { teGroups 1 }

    teNotificationGroup NOTIFICATION-GROUP
       NOTIFICATIONS {
            teTunnelUp,
            teTunnelDown,
            teTunnelChanged,
            teTunnelRerouted
        }
        STATUS       current
        DESCRIPTION "Notifications specified in this MIB module."
        ::= { teGroups 2 }

    -- ****************************************************************
    --
    -- TE compliance statements
    --
    --    There are four compliance statements: read-only and full
    --    compliance for regular TE devices, and read-only and full
    --    compliance for path computation servers.
    --

    teModuleReadOnlyCompliance MODULE-COMPLIANCE
        STATUS       current
        DESCRIPTION "When this MIB module is implemented without support
                     for read-create (i.e. in read-only mode), then such
                     an implementation can claim read-only compliance.
```

                   Such a device can then be monitored but can not be
                   configured with this MIB module.
                   "

         MODULE   -- enclosing module, i.e., TE-MIB

            MANDATORY-GROUPS {
                teTrafficEngineeringGroup
            }

            GROUP   teNotificationGroup
            DESCRIPTION "Implementation of this group is optional."

            OBJECT   teNotificationEnable
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teAdminGroupName
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teAdminGroupRowStatus
            SYNTAX   RowStatus { active(1) }
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelName
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelRowStatus
            SYNTAX   RowStatus { active(1) }
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelStorageType
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelSourceAddressType
            SYNTAX   TeHopAddressType { ipv4(1), ipv6(2) }
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required. An
                        implementation is only required to support
                        IPv4 and IPv6 host addresses."

            OBJECT   teTunnelSourceAddress
            MIN-ACCESS   read-only

```
            DESCRIPTION "Write access is not required."

            OBJECT       teTunnelDestinationAddressType
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       teTunnelDestinationAddress
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathName
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathRowStatus
            SYNTAX       RowStatus { active(1) }
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathStorageType
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathType
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathConfiguredRoute
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathBandwidth
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathIncludeAny
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathIncludeAll
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathExclude
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT       tePathSetupPriority
```

```
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

         OBJECT       tePathHoldPriority
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

         OBJECT       tePathProperties
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

         OBJECT       tePathAdminStatus
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

         OBJECT       tePathHopRowStatus
         SYNTAX       RowStatus { active(1) }
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

         OBJECT       tePathHopStorageType
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

         OBJECT       tePathHopAddrType
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

         OBJECT       tePathHopAddress
         MIN-ACCESS   read-only
         DESCRIPTION "Write access is not required."

      ::= { teModuleCompliance 1 }

   teModuleFullCompliance MODULE-COMPLIANCE
      STATUS       current
      DESCRIPTION "When this MIB module is implemented with support for
                   read-create, then such an implementation can claim
                   full compliance. Such devices can then be both
                   monitored and configured with this MIB module.
                  "

      MODULE       -- enclosing module, i.e., TE-MIB

         MANDATORY-GROUPS {
             teTrafficEngineeringGroup
         }
```

```
            GROUP         teNotificationGroup
            DESCRIPTION "Implementation of this group is optional."


            OBJECT        teAdminGroupRowStatus
            SYNTAX        RowStatus { active(1) }
            WRITE-SYNTAX RowStatus { createAndGo(4), destroy(6) }
            DESCRIPTION "Support for notInService, createAndWait and
                         notReady is not required.
                        "

            OBJECT        teTunnelRowStatus
            SYNTAX        RowStatus { active(1), notInService(2) }
            WRITE-SYNTAX RowStatus { active(1), notInService(2),
                                     createAndGo(4), destroy(6)
                                   }
            DESCRIPTION "Support for createAndWait and notReady is not
                         required.
                        "

            OBJECT        teTunnelSourceAddressType
            SYNTAX        TeHopAddressType { ipv4(1), ipv6(2) }
            DESCRIPTION "Write access is required.  An implementation is
                         only required to support IPv4 and IPv6 host
                         addresses.
                        "

            OBJECT        tePathRowStatus
            SYNTAX        RowStatus { active(1), notInService(2) }
            WRITE-SYNTAX RowStatus { active(1), notInService(2),
                                     createAndGo(4), destroy(6)
                                   }
            DESCRIPTION "Support for createAndWait and notReady is not
                         required.
                        "

            OBJECT        tePathHopRowStatus
            SYNTAX        RowStatus { active(1), notInService(2) }
            WRITE-SYNTAX RowStatus { active(1), notInService(2),
                                     createAndGo(4), destroy(6)
                                   }
            DESCRIPTION "Support for createAndWait and notReady is not
                         required.
                        "

        ::= { teModuleCompliance 2 }
```

    teModuleServerReadOnlyCompliance MODULE-COMPLIANCE
        STATUS   current
        DESCRIPTION "When this MIB module is implemented by a path
                     computation server without support for read-create
                     (i.e. in read-only mode), then such an
                     implementation can claim read-only compliance. Such
                     a device can then be monitored but can not be
                     configured with this MIB module.
                     "

        MODULE   -- enclosing module, i.e., TE-MIB

            MANDATORY-GROUPS {
                teTrafficEngineeringGroup
            }

            GROUP   teNotificationGroup
            DESCRIPTION "Implementation of this group is optional."

            OBJECT   teNotificationEnable
            MIN-ACCESS read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teAdminGroupName
            MIN-ACCESS read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teAdminGroupRowStatus
            SYNTAX   RowStatus { active(1) }
            MIN-ACCESS read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelName
            MIN-ACCESS read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelRowStatus
            SYNTAX   RowStatus { active(1) }
            MIN-ACCESS read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelStorageType
            MIN-ACCESS read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelSourceAddressType
            MIN-ACCESS read-only
            DESCRIPTION "Write access is not required. A path

                        computation server SHOULD implement all types
                        of tunnel source address types.
                    "

            OBJECT   teTunnelSourceAddress
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelDestinationAddressType
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   teTunnelDestinationAddress
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathName
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathRowStatus
            SYNTAX   RowStatus { active(1) }
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathStorageType
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathType
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathConfiguredRoute
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathBandwidth
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathIncludeAny
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

            OBJECT   tePathIncludeAll
            MIN-ACCESS   read-only
            DESCRIPTION "Write access is not required."

```
            OBJECT        tePathExclude
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathSetupPriority
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathHoldPriority
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathProperties
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathAdminStatus
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathHopRowStatus
            SYNTAX        RowStatus { active(1) }
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathHopStorageType
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathHopAddrType
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

            OBJECT        tePathHopAddress
            MIN-ACCESS    read-only
            DESCRIPTION "Write access is not required."

        ::= { teModuleCompliance 3 }

    teModuleServerFullCompliance MODULE-COMPLIANCE
        STATUS        current
        DESCRIPTION "When this MIB module is implemented by a path
                     computation server with support for read-create,
                     then such an implementation can claim full
                     compliance.
                    "

        MODULE        -- enclosing module, i.e., TE-MIB
```

```
             MANDATORY-GROUPS {
                 teTrafficEngineeringGroup
             }

             GROUP         teNotificationGroup
             DESCRIPTION "Implementation of this group is optional."


             OBJECT        teAdminGroupRowStatus
             SYNTAX        RowStatus { active(1) }
             WRITE-SYNTAX RowStatus { createAndGo(4), destroy(6) }
             DESCRIPTION "Support for notInService, createAndWait and
                         notReady is not required.
                         "

             OBJECT        teTunnelRowStatus
             SYNTAX        RowStatus { active(1), notInService(2) }
             WRITE-SYNTAX RowStatus { active(1), notInService(2),
                                     createAndGo(4), destroy(6)
                                   }
             DESCRIPTION "Support for createAndWait and notReady is not
                         required.
                         "

             OBJECT        teTunnelSourceAddressType
             DESCRIPTION "Write access is required.  An implementation
                         of a path computation server SHOULD support all
                         types of tunnel source address types.
                         "

             OBJECT        tePathRowStatus
             SYNTAX        RowStatus { active(1), notInService(2) }
             WRITE-SYNTAX RowStatus { active(1), notInService(2),
                                     createAndGo(4), destroy(6)
                                   }
             DESCRIPTION "Support for createAndWait and notReady is not
                         required.
                         "

             OBJECT        tePathHopRowStatus
             SYNTAX        RowStatus { active(1), notInService(2) }
             WRITE-SYNTAX RowStatus { active(1), notInService(2),
                                     createAndGo(4), destroy(6)
                                   }
             DESCRIPTION "Support for createAndWait and notReady is not
                         required.
                         "
```

```
     ::= { teModuleCompliance 4 }

END
```

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8. Security Considerations

This MIB module relates to the configuration and management of
Traffic Engineering tunnels. The unauthorized manipulation of fields
in the following tables: teAdminGroupTable, teTunnelTable,
tePathTable, and tePathHopTable may lead to tunnels flapping, tunnel
paths being changed, or traffic being disrupted. In addition, if
these tables are read by unauthorized parties, the information can be
used to trace traffic patterns, traffic volumes, and tunnels paths;
this may be considered proprietary and confidential information by
some providers.

There are a number of management objects defined in this MIB module
with a MAX-ACCESS clause of read-write and/or read-create. Such
objects may be considered sensitive or vulnerable in some network
environments. The support for SET operations in a non-secure
environment without proper protection can have a negative effect on
network operations. These are the tables and objects and their
sensitivity/vulnerability:

teAdminGroupTable: changing this will affect the semantics of include
and exclude constraints, and hence traffic taking unintended routes;

teTunnelTable: changing this affects many properties of traffic
tunnels;

tePathTable: changing this affects the constraints (including
bandwidth) of tunnel paths, as well as the status of the path;

tePathHopTable: changing this affects the route followed by a traffic
tunnel path.

Some of the readable objects in this MIB module (i.e., objects with a
MAX-ACCESS other than not-accessible) may be considered sensitive or
vulnerable in some network environments. It is thus important to
control even GET and/or NOTIFY access to these objects and possibly
to even encrypt the values of these objects when sending them over
the network via SNMP. These are the tables and objects and their
sensitivity/vulnerability:

   teTunnelTable: describes tunnel endpoints and traffic volumes;
   tePathTable: describes path properties;

tePathHopTable: describes path routes.

SNMP versions prior to SNMPv3 did not include adequate security.
Even if the network itself is secure (for example by using IPSec),
even then, there is no control as to who on the secure network is
allowed to access and GET/SET (read/change/create/delete) the objects
in this MIB module.

It is RECOMMENDED that implementers consider the security features as
provided by the SNMPv3 framework (see [4], section 8), including full
support for the SNMPv3 cryptographic mechanisms (for authentication
and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is NOT
RECOMMENDED. Instead, it is RECOMMENDED to deploy SNMPv3 and to
enable cryptographic security. It is then a customer/operator
responsibility to ensure that the SNMP entity giving access to an
instance of this MIB module is properly configured to give access to
the objects only to those principals (users) that have legitimate
rights to indeed GET or SET (change/create/delete) them.

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