Network Working Group
Request for Comments: 3970
Category: Standards Track

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January 2005

A Traffic Engineering (TE) MIB

Status of This Memo

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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 (TE) Tunnels; for example, Multi-Protocol Label Switched Paths.

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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 (TE) Tunnels; for example, Multi-Protocol Label Switched Paths ([7], [8]). The MIB module defined by this memo allows one to configure TE Tunnels, to assign one or more paths to a Tunnel, and to 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 ingress is then expected to use some protocol (such as RSVP-TE) to signal the other routers in the path the information they need to set up the tunnel. The extension of this module for use at other points of a Tunnel is for further study.

1.1. 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 [1].

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 [8].

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 [2], STD 58, RFC 2579 [3] and STD 58, RFC 2580 [4].

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, and
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 signaling 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 [7]) 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 the Path belongs; the secondary index is that 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, 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 the 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 [5].

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 [10], and the other is the IP Tunnel MIB [11]. 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 by 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 by 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 by using teNextPathHopIndex, and 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 that Path's RowStatus to 'destroy'.

5. MIB Specification

This MIB module IMPORTs objects from RFCs 2578 [2], 2579 [3], 2580 [3], 3411 [6], and 3811 [5] and it also has REFERENCE clauses to RFCs 3209 [8] and 3212 [12].

```
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 "200501040000Z"         -- 01 January 2005
    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 (2005).  This
                      version of this MIB module is part of RFC 3970;
                      see the RFC itself for full legal notices.
                     "

        -- revision history

        REVISION     "200501040000Z"         -- 01 January 2005
        DESCRIPTION  "Initial version, published as RFC 3970."
        ::= { mib-2 122 }

    -- 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 that 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 that 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 used in constraints,
                    such as tePathIncludeAny or tePathIncludeAll.
                   "
```

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

   teTunnelSourceAddress OBJECT-TYPE
       SYNTAX       TeHopAddress
       MAX-ACCESS   read-create
       STATUS       current
       DESCRIPTION "The 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 the source and destination addresses of a
                    Tunnel can be different address types.

                    The value of this object cannot be changed
                    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 value of the corresponding teTunnelRowStatus
                    object is 'active'.
```

```
                    "
        ::= { teTunnelEntry 8 }

    teTunnelDestinationAddress OBJECT-TYPE
        SYNTAX       TeHopAddress
        MAX-ACCESS   read-create
        STATUS       current
        DESCRIPTION "The 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 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 because 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 because
                    TimeTicks wrap in about 16 months, this value is
                    best used in interval measurements.

                    An example of usage of this object would be 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 because TimeTicks wrap in about 16 months, this
```

```
                    value is best used in interval measurements.

                    An example of usage of this field would be 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.

                     Path changes may be caused by network events or by
                     reconfiguration that affects the path.
                    "
        ::= { 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.

                    As a Traffic Path can only exist over an existing
                    Traffic Tunnel, 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 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-signaled.
                   "
        ::= { 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 IncludeAll to be
                     acceptable.  If IncludeAll 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 as 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 as 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 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 access 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 value of the corresponding tePathRowStatus
                    object is 'active'.
                   "
       ::= { tePathHopEntry 5 }
```

```
   tePathHopAddress OBJECT-TYPE
       SYNTAX       TeHopAddress
       MAX-ACCESS   read-create
       STATUS       current
       DESCRIPTION "The 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 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 be monitored but cannot 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 the implementation can claim
                     full compliance.  Such devices can 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 the implementation
                   can claim read-only compliance.  Such
                   a device can be monitored but cannot 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 the 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
```

6. References

6.1. Normative References

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6.2. Informative References

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7. Security Considerations

This MIB module relates to the configuration and management of Traffic Engineering tunnels. The unauthorized manipulation of fields in the tables teAdminGroupTable, teTunnelTable, tePathTable, and tePathHopTable may lead to tunnel 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 tunnel 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 thus traffic takes 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 [9], 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.

Acknowledgments

It was Tony Li's suggestion that the author embark on this MIB. Many thanks to him and to Der-Hwa Gan for their input and help.

Many thanks, too, to Bert Wijnen for his incredible help, both with improving the correctness, structure, and readability of the MIB module, and with the text of the RFC. Thanks also to Adrian Farrel for his detailed review.

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Acknowledgement

Funding for the RFC Editor function is currently provided by the Internet Society.