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MPLS Transport Profile (MPLS-TP) Traffic Engineering (TE) Management Information Base (MIB)

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 additional managed objects and textual conventions for tunnels, identifiers, and Label Switching Routers to support Multiprotocol Label Switching (MPLS) MIB modules for transport networks.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7453.

Table of Contents

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 additional textual conventions and managed objects for tunnels, identifiers, and Label Switching Routers to support Multiprotocol Label Switching (MPLS) MIB modules for transport networks. MIB modules defined in this document extend the existing MPLS MIB objects in such a way that they support the MPLS Transport Profile (MPLS-TP) but also other MPLS networks. Hence, "MPLS-TP" is not included in the MIB module names.

As described in the MPLS Traffic Engineering (TE) MIB definition [RFC3812], MPLS traffic engineering is concerned with the creation and management of MPLS tunnels. This term is a shorthand for a combination of one or more LSPs linking an ingress and an egress LSR. Several types of point-to-point MPLS tunnels may be constructed between a pair of LSRs A and B:

- Unidirectional with a single LSP (say, from A to B).

- Associated bidirectional consisting of two separately routed LSPs, one linking A to B and the other linking B to A. Together, the pair provides a single logical bidirectional transport path.

- Co-routed bidirectional consisting of an associated bidirectional tunnel but with the second LSP from B to A following the reverse of the path of the LSP from A to B, in terms of both nodes and links.

Tunnels may be either statically configured by management action or dynamically created using an LSP management protocol.

The existing MPLS TE MIB [RFC3812] and the GMPLS TE MIB [RFC4802] address only a subset of the combinations of statically and dynamically configured tunnel types, catering to statically configured unidirectional tunnels together with dynamically configured unidirectional and co-routed bidirectional tunnels. They are also restricted to two endpoint LSRs identified by IP addresses.

The MPLS-TP TE MIB defined in this document extends the MIB modules defined in [RFC3812] to cover all six combinations (that is, adding support for statically configured associated and co-routed bidirectional plus dynamically configured associated bidirectional tunnels). It also extends support to endpoints that have identifiers other than IP addresses.

This support is provided by a suite of four MIB modules that are to be used in conjunction with the MIB modules defined in [RFC3812] and the companion document [RFC3813] for MPLS-TP tunnel management.

At the time of writing, SNMP SET is no longer recommended as a way to configure MPLS networks as described in [RFC3812]. However, since the MIB modules specified in this document extend and are intended to work in parallel with the MIB modules for MPLS specified in [RFC3812], certain objects defined here are specified with MAX-ACCESS of read-write or read-create so that specifications of the base tables in [RFC3812] and the extensions in this document are consistent. Although the examples described in Section 9 specify means to configure MPLS-TP Tunnels in a similar way to the examples in [RFC3812], this should be seen as indicating how the MIB values would be returned if the specified circumstances were configured by alternative means.

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 [RFC3410].

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 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

3. Overview

3.1. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3.2. Terminology

This document uses terminology from the "Multiprotocol Label Switching Architecture" [RFC3031], "Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) Management Information Base (MIB)" [RFC3812], "Multiprotocol Label Switching (MPLS) Label Switching Router (LSR) Management Information Base (MIB)" [RFC3813], and"MPLS Transport Profile (MPLS-TP) Identifiers" [RFC6370].

3.3. Acronyms

CC: Country Code
ICC: ITU Carrier Code
LSP: Label Switched Path
LSR: Label Switching Router
MPLS-TP: MPLS Transport Profile
TE: Traffic Engineering
TP: Transport Profile

4. Motivations

"Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) Management Information Base (MIB)" [RFC3812] provides support for Traffic Engineering tunnels. In MPLS, the actual transport of packets is provided by Label Switched Paths (LSPs). A transport service may be composed of multiple LSPs. In order to clearly identify the MPLS-TP service, as defined in [RFC6370], we use the term "MPLS-TP Tunnel" or simply "tunnel". However, with MPLS-TP, the characteristics of the tunnels were enhanced. For example, MPLS-TP Tunnels are bidirectional in nature and could be used with non-IP identifiers for the tunnel endpoints. As the existing MPLS-TE-STD-MIB and GMPLS-TE-STD-MIB were defined mainly to support unidirectional tunnels and signaled co-routed bidirectional tunnel definitions, respectively, these existing MIB modules are not sufficient to capture all the characteristics of the tunnels. Hence, enhancing the MIB modules to support MPLS-TP Tunnels is required. As most of the attributes of MPLS Traffic Engineering tunnels are also applicable to MPLS-TP Tunnels, it is optimal to reuse and extend the existing MIB module definition instead of defining a new MIB module.

This document defines four additional MIB modules, namely, MPLS-TE-EXT-STD-MIB, MPLS-TC-EXT-STD-MIB, MPLS-ID-STD-MIB, and MPLS-LSR-EXT-STD-MIB. As these additional MIB modules are required for MPLS-TP functionality, these are all defined in this document, instead of being documented separately.

5. Feature List

The MIBs in this document satisfy the following requirements and constraints:

The MIB modules, taken together, support statically configured and dynamically signaled point-to-point, co-routed bidirectional and associated bidirectional tunnels.

- The MPLS tunnels need not be interfaces, but it is possible to configure an MPLS-TP Tunnel as an interface. The same ifType 150, as defined in Section 8 of [RFC3812], will be used for MPLS-TP Tunnels as well.

- The mplsTunnelTable [RFC3812] is also to be used for MPLS-TP Tunnels.

- New MPLS-TP-specific textual conventions and identifiers are required.

- The mplsTunnelTable is sparsely extended to support objects specific to MPLS-TP Tunnels.

- A node configuration table (mplsTunnelExtNodeConfigTable), as detailed in Section 6.2.1, below, is used to translate the Global_ID::Node_ID or ICC_Operator_ID::Node_ID to the local identifier in order to index the mplsTunnelTable.

- The mplsXCTable is sparsely extended to support objects specific to MPLS-TP XC (Cross Connect).

- The MIB module supports persistent, as well as non-persistent, tunnels.

6. Outline

Traffic Engineering support for the MPLS-TP Tunnels requires the setup of the co-routed or associated bidirectional tunnel. The tables and MIB modules that are mentioned in the below subsections support the functionality described in [RFC5654] and [RFC6370]. These tables support both IP-compatible and ICC-based tunnel configurations.

Figure 1, below, depicts how the table references are followed in this MIB.

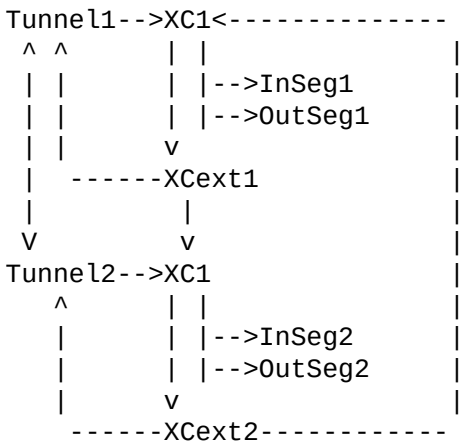

Figure 1: Table References of MIB Modules

6.1. MIB Module Extensions

Four MIB modules are extended to support MPLS-TP Tunnels, namely, MPLS-TE-EXT-STD-MIB, MPLS-TC-EXT-STD-MIB, MPLS-ID-STD-MIB, and MPLS-LSR-EXT-STD-MIB. The following section provides the summary of changes.

6.1.1. Summary of MIB Module Changes

- Node configuration table (mplsTunnelExtNodeConfigTable) for setting the local identifier for Tunnel Ingress and Egress identifiers.

- Node IP map table (mplsTunnelExtNodeIpMapTable) for querying the local identifier for a given Global_ID and Node_ID.

- Node ICC map table (mplsTunnelExtNodeIccMapTable) for querying the local identifier for a given ICC_Operator_ID and Node_ID.

- Tunnel extension table (mplsTunnelExtTable) for setting up MPLS-TP Tunnels with sparse extension of mplsTunnelTable.

- Textual conventions and object definitions for MPLS-TP Tunnels.

- Cross-connect extension table (mplsXCExtTable) for setting up the MPLS-TP LSPs.

  These tables are described in the subsequent sections.

6.2. MPLS-TE-EXT-STD-MIB

The TE MIB module extensions and details of the tables are described in the following sections.

6.2.1. mplsTunnelExtNodeConfigTable

The mplsTunnelExtNodeConfigTable is used to assign a local identifier for a given ICC_Operator_ID::Node_ID or Global_ID::Node_ID combination as defined in [RFC6923] and [RFC6370], respectively. The CC is a string of two characters, each being an uppercase Basic Latin alphabetic (i.e., A-Z). The ICC is a string of one to six characters, each an uppercase Basic Latin alphabetic (i.e., A-Z) or numeric (i.e., 0-9). All of the characters are encoded using [T.50] as described in [RFC6370].

In the IP-compatible mode, Global_ID::Node_ID, is used to uniquely identify a node. For each ICC_Operator_ID::Node_ID or Global_ID::Node_ID, there is a unique entry in the table representing a node. As the regular TE tunnels use the IP address as the LSR ID, the local identifier should be below the first valid IP address, which is 16777216[1.0.0.0]. Every node is assigned a local identifier within a range of 0 to 16777215. This local identifier is used for indexing into mplsTunnelTable as mplsTunnelIngressLSRId and mplsTunnelEgressLSRId.

For IP-compatible environments, an MPLS-TP Tunnel is indexed by Tunnel Index, Tunnel Instance, Source Global_ID, Source Node_ID, Destination Global_ID, and Destination Node_ID.

For ICC-based environments, an MPLS-TP Tunnel is indexed by Tunnel Index, Tunnel Instance, Source CC, Source ICC, Source Node_ID, Destination CC, Destination ICC, and Destination Node_ID.

As mplsTunnelTable is indexed by mplsTunnelIndex, mplsTunnelInstance, mplsTunnelIngressLSRId, and mplsTunnelEgressLSRId, the MPLS-TP tunnel identifiers cannot be used directly.

The mplsTunnelExtNodeConfigTable will be used to store an entry for ICC_Operator_ID::Node_ID or Global_ID::Node_ID with a local identifier to be used as the LSR ID in mplsTunnelTable.

6.2.2. mplsTunnelExtNodeIpMapTable

The read-only mplsTunnelExtNodeIpMapTable is used to query the local identifier assigned and stored in mplsTunnelExtNodeConfigTable for a given Global_ID::Node_ID. In order to query the local identifier, in

the IP-compatible mode, this table is indexed with Global_ID::Node_ID. In the IP-compatible mode for a TP tunnel, Global_ID::Node_ID is used.

A separate query is made to get the local identifier of both Ingress and Egress Global_ID::Node_ID identifiers. These local identifiers are used as mplsTunnelIngressLSRId and mplsTunnelEgressLSRId when indexing mplsTunnelTable.

6.2.3. mplsTunnelExtNodeIccMapTable

The read-only mplsTunnelExtNodeIccMapTable is used to query the local identifier assigned and stored in the mplsTunnelExtNodeConfigTable for a given ICC_Operator_ID::Node_ID.

A separate query is made to get the local identifier of both Ingress and Egress ICC_Operator_ID::Node_ID. These local identifiers are used as mplsTunnelIngressLSRId and mplsTunnelEgressLSRId when indexing mplsTunnelTable.

6.2.4. mplsTunnelExtTable

This table sparsely extends the mplsTunnelTable in order to support MPLS-TP Tunnels with additional objects. All the additional attributes specific to supporting a TP tunnel are contained in this extended table and could be accessed with the mplsTunnelTable indices.

The gmplsTunnelReversePerfTable [RFC4802] should be used to provide per-tunnel packet performance information for the reverse direction of a bidirectional tunnel. It can be seen as supplementing the mplsTunnelPerfTable, which augments the mplsTunnelTable.

6.3. MPLS-TC-EXT-STD-MIB

This MIB module contains textual conventions for LSPs of MPLS-based transport networks.

6.4. MPLS-ID-STD-MIB

This MIB module contains identifier object definitions for MPLS Traffic Engineering in transport networks.

6.5. MPLS-LSR-EXT-STD-MIB

This MIB module contains generic object definitions (including the mplsXCExtTable -- cross-connect extension table -- for setting up the MPLS-TP LSPs with sparse extension of mplsXCTable) for MPLS LSRs in transport networks.

6.6. The Use of RowPointer

This document follows the RowPointer usage as described in Section 10 of [RFC3812].

A new RowPointer object, mplsTunnelExtOppositeDirPtr, is added to mplsTunnelExtTable of MPLS-TE-EXT-STD-MIB module. This RowPointer object points to the tunnel entry in the opposite direction.

Two additional RowPointers objects, mplsXCExtTunnelPointer and mplsXCExtOppositeDirXCPtr, are added to the mplsXCExtTable of MPLS-LSR-EXT-STD-MIB. The RowPointer mplsXCExtTunnelPointer is a read-only object used to indicate the back pointer to the tunnel entry. The RowPointer mplsXCExtOppositeDirXCPtr object points to the opposite-direction XC entry.

If either of these RowPointers return zeroDotZero, it implies that there is no entry associated with the RowPointer object.

7. MIB Modules' Interdependencies

This section provides an overview of the relationships between the MPLS-TP TE MIB module and other MPLS MIB modules.

The arrows in the following diagram show a "depends on" relationship. A relationship of "MIB module A depends on MIB module B" means that MIB module A uses an object, object identifier, or textual convention defined in MIB module B, or that MIB module A contains a pointer (index or RowPointer) to an object in MIB module B.

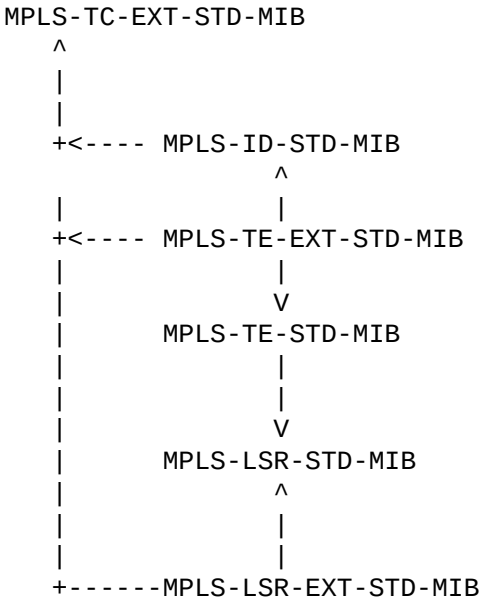

Figure 2: MIB Modules' Interdependencies

Thus:

- All the new MPLS extension MIB modules depend on MPLS-TC-EXT-STD-MIB.

- MPLS-ID-STD-MIB contains references to objects in MPLS-TE-STD-MIB [RFC3812].

- MPLS-TE-EXT-STD-MIB contains references to objects in MPLS-TE-STD-MIB [RFC3812].

- MPLS-LSR-EXT-STD-MIB contains references to objects in MPLS-LSR-STD-MIB [RFC3813].

The mplsTunnelExtTable sparsely extends the mplsTunnelTable of MPLS-TE-STD-MIB [RFC3812]. This helps in associating the reverse-direction tunnel information.

The mplsXCExtTable sparsely extends the mplsXCTable of MPLS-LSR-STD-MIB [RFC3813]. This helps in pointing back to the tunnel entry for easy tunnel access from the XC entry.

Note that all of the MIB modules shown above in the figure also have a dependency on MPLS-TC-STD-MIB.

8. Dependencies between MIB Module Tables

The tables in MPLS-TE-EXT-STD-MIB are related as shown on the diagram below. The arrows indicate a reference from one table to another.

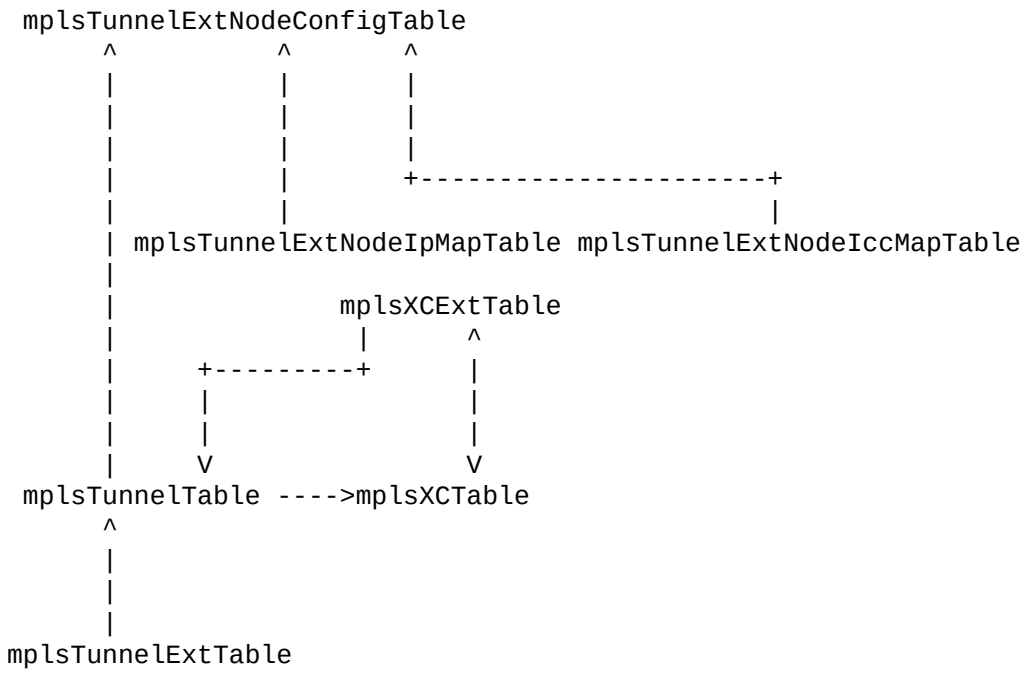

Figure 3: Dependencies between MIB Module Tables

An existing mplsTunnelTable uses the mplsTunnelExtNodeConfigTable table to map the Global_ID::Node_ID and/or ICC_Operator_ID::Node_ID with the local number in order to accommodate in the existing tunnel table's ingress/egress LSR ID.

The new mplsTunnelExtTable provides the reverse-direction LSP information for the existing tunnel table so that bidirectional LSPs can be created.

The mplsXCExtTable sparsely extends the mplsLsrXCTable to provide backward reference to tunnel entry.

9. Example of MPLS-TP Tunnel Setup

In this section, we provide an example of configuring MPLS-TP bidirectional tunnels with IP tunnel identifiers. This example provides the usage of the MPLS-TP Tunnel MIB along with the extended MIB modules introduced in this document.

Do note that a MPLS-TP Tunnel could be set up statically as well as signaled via the control plane. This example considers accessing MIB objects on a head-end for static and signaled MPLS-TP Tunnels. This section shows the configuration of the forward- and reverse-direction MPLS-TP LSPs that run between East and West, and vice versa. Only objects relevant to MPLS-TP Tunnels are illustrated here.

In mplsTunnelExtNodeConfigTable:

```
{
-- Non-IP Ingress LSR_ID (Index to the table)

  mplsTunnelExtNodeConfigLocalId              = 1,

  mplsTunnelExtNodeConfigGlobalId             = 1234,
  mplsTunnelExtNodeConfigNodeId               = 10,
-- Mandatory parameters needed to activate the row go here
  mplsTunnelExtNodeConfigRowStatus          = createAndGo (4)

-- Non-IP Egress LSR ID (Index to the table)
  mplsTunnelExtNodeConfigLocalId              = 2,
  mplsTunnelExtNodeConfigGlobalId             = 1234,
  mplsTunnelExtNodeConfigNodeId               = 20,
-- Mandatory parameters needed to activate the row go here
  mplsTunnelExtNodeConfigRowStatus          = createAndGo (4)
}
```

This will create an entry in the mplsTunnelExtNodeConfigTable for a Global_ID::Node_ID. The Ingress and Egress LSR are represented by separate entries.

The following read-only mplsTunnelExtNodeIpMapTable table is populated automatically upon creating an entry in mplsTunnelExtNodeConfigTable, and this table is used to retrieve the local identifier for the given Global_ID::Node_ID.

In mplsTunnelExtNodeIpMapTable:

```
{
-- Global_ID (Index to the table)
  mplsTunnelExtNodeIpMapGlobalId              = 1234,
-- Node Identifier (Index to the table)
  mplsTunnelExtNodeIpMapNodeId                = 10,
  mplsTunnelExtNodeIpMapLocalId               = 1

-- Global_ID (Index to the table)
  mplsTunnelExtNodeIpMapGlobalId              = 1234,
```

```
   -- Node Identifier (Index to the table)
     mplsTunnelExtNodeIpMapNodeId               = 20,
     mplsTunnelExtNodeIpMapLocalId              = 2
   }
```

9.1. Example of MPLS-TP Static Co-routed Bidirectional Tunnel Setup

The following denotes the co-routed bidirectional tunnel "head" entry.

9.1.1. mplsTunnelEntry

In mplsTunnelTable:

```
   {
     mplsTunnelIndex              = 1,
     mplsTunnelInstance           = 1,
   -- Local map number created in mplsTunnelExtNodeConfigTable for
   -- Ingress LSR ID
     mplsTunnelIngressLSRId       = 1,

   -- Local map number created in mplsTunnelExtNodeConfigTable for
   -- Egress LSR ID
     mplsTunnelEgressLSRId        = 2,
     mplsTunnelName               = "TP co-routed bidirectional LSP",
     mplsTunnelDescr              = "East to West",
     mplsTunnelIsIf               = true (1),
   --  RowPointer MUST point to the first accessible column
     mplsTunnelXCPointer          =
                                mplsXCLspId.4.0.0.0.1.1.0.4.0.0.0.1,
     mplsTunnelSignallingProto    = none (1),
     mplsTunnelSetupPrio          = 0,
     mplsTunnelHoldingPrio        = 0,
     mplsTunnelSessionAttributes  = 0,
     mplsTunnelLocalProtectInUse  = false (0),
   --  RowPointer MUST point to the first accessible column
     mplsTunnelResourcePointer    = mplsTunnelResourceMaxRate.5,
     mplsTunnelInstancePriority   = 1,
     mplsTunnelHopTableIndex      = 1,
     mplsTunnelIncludeAnyAffinity = 0,
     mplsTunnelIncludeAllAffinity = 0,
     mplsTunnelExcludeAnyAffinity = 0,
     mplsTunnelRole               = head (1),
   -- Mandatory parameters needed to activate the row go here
     mplsTunnelRowStatus          = createAndGo (4)
   }
```

9.1.2. mplsTunnelExtEntry

```
-- An MPLS extension table
In mplsTunnelExtTable:
{
  -- This opposite-direction tunnel pointer may point to 0.0
  -- if co-routed bidirectional tunnel is managed by single tunnel
  -- entry
  mplsTunnelExtOppositeDirTnlPtr       = 0.0
  -- Set both the Ingress and Egress LocalId objects to TRUE, as
  -- this tunnel entry uses the local identifiers.
  mplsTunnelExtIngressLSRLocalIdValid  = true,
  mplsTunnelExtEgressLSRLocalIdValid = true
}
```

Next, we must create the appropriate in-segment and out-segment entries. These are done in [RFC3813] using the mplsInSegmentTable and mplsOutSegmentTable.

9.1.3. Forward-Direction mplsOutSegmentEntry

For the forward direction:

```
In mplsOutSegmentTable:
{
   mplsOutSegmentIndex          = 0x0000001,
   mplsOutSegmentInterface      = 13, -- outgoing interface
   mplsOutSegmentPushTopLabel   = true(1),
   mplsOutSegmentTopLabel       = 22, -- outgoing label

   -- RowPointer MUST point to the first accessible column.
   mplsOutSegmentTrafficParamPtr   = 0.0,
   mplsOutSegmentRowStatus         = createAndGo (4)
}
```

9.1.4. Reverse-Direction mplsInSegmentEntry

For the reverse direction:

```
In mplsInSegmentTable:
{
   mplsInSegmentIndex           = 0x0000001
   mplsInSegmentLabel           = 21, -- incoming label
   mplsInSegmentNPop            = 1,
   mplsInSegmentInterface       = 13, -- incoming interface
```

```
      -- RowPointer MUST point to the first accessible column.
      mplsInSegmentTrafficParamPtr    = 0.0,
      mplsInSegmentRowStatus          = createAndGo (4)
   }
```

Next, two cross-connect entries are created in the mplsXCTable of the MPLS-LSR-STD-MIB [RFC3813], thereby associating the newly created segments together.

9.1.5. Forward-Direction mplsXCEntry

```
   In mplsXCTable:
   {
      mplsXCIndex                = 0x01,
      mplsXCInSegmentIndex       = 0x00000000,
      mplsXCOutSegmentIndex      = 0x00000001,
      mplsXCLspId                = 0x0102 -- unique ID

      -- only a single outgoing label
      mplsXCLabelStackIndex      = 0x00,
      mplsXCRowStatus            = createAndGo(4)

   }
```

9.1.6. Reverse-Direction mplsXCEntry

```
   In mplsXCTable:
   {
      mplsXCIndex                = 0x01,
      mplsXCInSegmentIndex       = 0x00000001,
      mplsXCOutSegmentIndex      = 0x00000000,
      mplsXCLspId                = 0x0102 -- unique ID
      -- only a single outgoing label
      mplsXCLabelStackIndex      = 0x00,
      mplsXCRowStatus            = createAndGo(4)
   }
```

This table entry is extended by an entry in the mplsXCExtTable. Note that the nature of the 'extends' relationship is a sparse augmentation so that the entry in the mplsXCExtTable has the same index values as the entry in the mplsXCTable.

9.1.7. Forward-Direction mplsXCExtEntry

```
In mplsXCExtTable (0x01, 0x00000000, 0x00000001)
{
  -- Back pointer from XC table to Tunnel table
  mplsXCExtTunnelPointer         = mplsTunnelName.1.1.1.2
  mplsXCExtOppositeDirXCPtr         =
                              mplsXCLspId.4.0.0.0.1.4.0.0.0.1.1.0
}
```

9.1.8. Reverse-Direction mplsXCExtEntry

Next, for the reverse direction:

```
In mplsXCExtTable (0x01, 0x00000001, 0x00000000)
{
  -- Back pointer from XC table to Tunnel table
  mplsXCExtTunnelPointer         = mplsTunnelName.1.1.1.2
  mplsXCExtOppositeDirXCPtr         =
                              mplsXCLspId.4.0.0.0.1.1.0.4.0.0.0.1
}
```

9.2. Example of MPLS-TP Static Associated Bidirectional Tunnel Setup

The MPLS-TP associated bidirectional tunnel is implemented by two different unidirectional tunnels (Forward and Reverse LSPs), and these are associated together using mplsTunnelExtTable. Two different tunnel entries to provide the forward and reverse directions MAY be used for co-routed bidirectional tunnels as well.

The following denotes the associated bidirectional forward tunnel "head" entry:

9.2.1. Forward-Direction mplsTunnelEntry

```
  In mplsTunnelTable:

{
  mplsTunnelIndex              = 1,
  mplsTunnelInstance           = 1,
-- Local map number created in mplsTunnelExtNodeConfigTable for
-- Ingress LSR ID
  mplsTunnelIngressLSRId       = 1,
```

```
   -- Local map number created in mplsTunnelExtNodeConfigTable for
   -- Egress LSR ID
     mplsTunnelEgressLSRId        = 2,
     mplsTunnelName               = "TP associated bidirectional
                                     forward LSP",
     mplsTunnelDescr              = "East to West",
     mplsTunnelIsIf               = true (1),
   --  RowPointer MUST point to the first accessible column
     mplsTunnelXCPointer          =
                                mplsXCLspId.4.0.0.0.1.1.0.4.0.0.0.1,
     mplsTunnelSignallingProto    = none (1),
     mplsTunnelSetupPrio          = 0,
     mplsTunnelHoldingPrio        = 0,
     mplsTunnelSessionAttributes  = 0,
     mplsTunnelLocalProtectInUse  = false (0),
   --  RowPointer MUST point to the first accessible column
     mplsTunnelResourcePointer    = mplsTunnelResourceMaxRate.5,
     mplsTunnelInstancePriority   = 1,
     mplsTunnelHopTableIndex      = 1,
     mplsTunnelIncludeAnyAffinity = 0,

     mplsTunnelIncludeAllAffinity = 0,
     mplsTunnelExcludeAnyAffinity = 0,
     mplsTunnelRole               = head (1),
   -- Mandatory parameters needed to activate the row go here
     mplsTunnelRowStatus          = createAndGo (4)
   }
```

9.2.2. Forward-Direction mplsTunnelExtEntry

```
   For the associated bidirectional forward LSP,
   in mplsTunnelExtTable:

   {
     mplsTunnelExtOppositeDirPtr       = mplsTunnelName.2.1.2.1
    -- Set both the Ingress and Egress LocalId objects to TRUE, as
    -- this tunnel entry uses the local identifiers.
     mplsTunnelExtIngressLSRLocalIdValid  = true,
     mplsTunnelExtEgressLSRLocalIdValid = true
   }
```

9.2.3. Forward-Direction mplsOutSegmentTable

```
For the forward direction:

In mplsOutSegmentTable:
{
   mplsOutSegmentIndex          = 0x0000001,
   mplsOutSegmentInterface      = 13, -- outgoing interface
   mplsOutSegmentPushTopLabel   = true(1),
   mplsOutSegmentTopLabel       = 22, -- outgoing label

   -- RowPointer MUST point to the first accessible column.
   mplsOutSegmentTrafficParamPtr   = 0.0,
   mplsOutSegmentRowStatus         = createAndGo (4)
}
```

9.2.4. Forward-Direction mplsXCEntry

```
In mplsXCTable:
{
   mplsXCIndex                = 0x01,
   mplsXCInSegmentIndex       = 0x00000000,
   mplsXCOutSegmentIndex      = 0x00000001,
   mplsXCLspId                = 0x0102 -- unique ID
   -- only a single outgoing label
   mplsXCLabelStackIndex      = 0x00,
   mplsXCRowStatus            = createAndGo(4)
}
```

9.2.5. Forward-Direction mplsXCExtEntry

```
In mplsXCExtTable (0x01, 0x00000000, 0x00000001)
{
  -- Back pointer from XC table to Tunnel table
  mplsXCExtTunnelPointer         = mplsTunnelName.1.1.1.2
  mplsXCExtOppositeDirXCPtr         =
                              mplsXCLspId.4.0.0.0.1.4.0.0.0.1.1.0
}
```

9.2.6. Reverse-Direction mplsTunnelEntry

The following denotes the configured associated bidirectional reverse tunnel "tail" entry:

In mplsTunnelTable:

```
{
  mplsTunnelIndex              = 2,
  mplsTunnelInstance           = 1,
-- Local map number created in mplsTunnelExtNodeConfigTable for
-- Ingress LSR ID
  mplsTunnelIngressLSRId       = 2,
-- Local map number created in mplsTunnelExtNodeConfigTable for
-- Egress LSR ID
  mplsTunnelEgressLSRId        = 1,
  mplsTunnelName               = "TP associated bidirectional
                                  reverse LSP",
  mplsTunnelDescr              = "West to East",
  mplsTunnelIsIf               = true (1),
--  RowPointer MUST point to the first accessible column
  mplsTunnelXCPointer          =
                              mplsXCLspId.4.0.0.0.1.4.0.0.0.1.1.0,
  mplsTunnelSignallingProto    = none (1),
  mplsTunnelSetupPrio          = 0,
  mplsTunnelHoldingPrio        = 0,
  mplsTunnelSessionAttributes  = 0,
  mplsTunnelLocalProtectInUse  = false (0),

--  RowPointer MUST point to the first accessible column
  mplsTunnelResourcePointer    = mplsTunnelResourceMaxRate.5,
  mplsTunnelInstancePriority   = 1,
  mplsTunnelHopTableIndex      = 1,
  mplsTunnelIncludeAnyAffinity = 0,
  mplsTunnelIncludeAllAffinity = 0,
  mplsTunnelExcludeAnyAffinity = 0,
  mplsTunnelRole               = head (1),
-- Mandatory parameters needed to activate the row go here

  mplsTunnelRowStatus          = createAndGo (4)
}
```

9.2.7. Reverse-Direction mplsTunnelExtEntry

For the associated bidirectional reverse LSP,
in mplsTunnelExtTable:

```
{
  mplsTunnelExtOppositeDirPtr       = mplsTunnelName.1.1.1.2
  -- Set both the Ingress and Egress LocalId objects to TRUE, as
  -- this tunnel entry uses the local identifiers.
  mplsTunnelExtIngressLSRLocalIdValid  = true,
  mplsTunnelExtEgressLSRLocalIdValid = true
}
```

9.2.8. Reverse-Direction mplsInSegmentEntry

Next, we must create the appropriate in-segment and out-segment entries. These are done in [RFC3813] using the mplsInSegmentTable and mplsOutSegmentTable.

In mplsInSegmentTable:

```
{
   mplsInSegmentIndex           = 0x0000001
   mplsInSegmentLabel           = 21, -- incoming label
   mplsInSegmentNPop            = 1,
   mplsInSegmentInterface       = 13, -- incoming interface

   -- RowPointer MUST point to the first accessible column.
   mplsInSegmentTrafficParamPtr    = 0.0,
   mplsInSegmentRowStatus          = createAndGo (4)
}
```

Next, two cross-connect entries are created in the mplsXCTable of the MPLS-LSR-STD-MIB [RFC3813], thereby associating the newly created segments together.

9.2.9. Reverse-Direction mplsXCEntry

In mplsXCTable:

```
{
   mplsXCIndex                = 0x01,
   mplsXCInSegmentIndex       = 0x00000001,
   mplsXCOutSegmentIndex      = 0x00000000,
   mplsXCLspId                = 0x0102 -- unique ID
   -- only a single outgoing label
   mplsXCLabelStackIndex      = 0x00,

   mplsXCRowStatus            = createAndGo(4)
}
```

This table entry is extended by an entry in the mplsXCExtTable. Note that the nature of the 'extends' relationship is a sparse augmentation so that the entry in the mplsXCExtTable has the same index values as the entry in the mplsXCTable.

9.2.10. Reverse-Direction mplsXCExtEntry

Next, for the reverse direction:

```
In mplsXCExtTable (0x01, 0x00000001, 0x00000000)
{
  -- Back pointer from XC table to Tunnel table
  mplsXCExtTunnelPointer         = mplsTunnelName.2.1.2.1
  mplsXCExtOppositeDirXCPtr         =
                           mplsXCLspId.4.0.0.0.1.1.0.4.0.0.0.1
}
```

9.3. Example of MPLS-TP Signaled Co-routed Bidirectional Tunnel Setup

The following denotes the co-routed bidirectional tunnel "head" entry. In intermediate and tail-end nodes, the tunnel table and its associated tables are created by the local management subsystem (e.g., agent) when the MPLS-TP Tunnel is signaled successfully. Refer to [RFC3812] and [RFC4802] for examples of signaled tunnel table configuration.

9.3.1. mplsTunnelEntry

In mplsTunnelTable:

```
{
  mplsTunnelIndex              = 1,
  mplsTunnelInstance           = 0,
-- Local map number created in mplsTunnelExtNodeConfigTable for
-- Ingress LSR-Id.  For the intermediate and tail-end nodes,
-- the local management entity is expected to pick the first
-- available local identifier that is not used in mplsTunnelTable.
  mplsTunnelIngressLSRId       = 1,

-- Local map number created in mplsTunnelExtNodeConfigTable for
-- Egress LSR ID
  mplsTunnelEgressLSRId        = 2,
  mplsTunnelName               = "TP co-routed bidirectional LSP",
  mplsTunnelDescr              = "East to West",
  mplsTunnelIsIf               = true (1),
```

```
   --  RowPointer MUST point to the first accessible column
     mplsTunnelXCPointer          =
                                mplsXCLspId.4.0.0.0.1.1.0.4.0.0.0.1,
     mplsTunnelSignallingProto    = none (1),
     mplsTunnelSetupPrio          = 0,
     mplsTunnelHoldingPrio        = 0,
     mplsTunnelSessionAttributes  = 0,
     mplsTunnelLocalProtectInUse  = false (0),
   --  RowPointer MUST point to the first accessible column
     mplsTunnelResourcePointer    = mplsTunnelResourceMaxRate.5,
     mplsTunnelInstancePriority   = 1,
     mplsTunnelHopTableIndex      = 1,
     mplsTunnelIncludeAnyAffinity = 0,
     mplsTunnelIncludeAllAffinity = 0,
     mplsTunnelExcludeAnyAffinity = 0,
     mplsTunnelRole               = head (1),
   -- Mandatory parameters needed to activate the row go here
     mplsTunnelRowStatus          = createAndGo (4)
   }
```

9.3.2. mplsTunnelExtEntry

```
   -- An MPLS extension table
   In mplsTunnelExtTable:
   {
     -- This opposite-direction tunnel pointer may point to 0.0
     -- if co-routed bidirectional tunnel is managed by a single
     -- tunnel entry
     mplsTunnelExtOppositeDirTnlPtr       = 0.0
     -- Set both the Ingress and Egress LocalId objects to TRUE, as
     -- this tunnel entry uses the local identifiers.
     mplsTunnelExtIngressLSRLocalIdValid  = true,
     mplsTunnelExtEgressLSRLocalIdValid = true
   }
```

Next, we must create the appropriate in-segment and out-segment entries. These are done in [RFC3813] using the mplsInSegmentTable and mplsOutSegmentTable.

9.3.3. Forward-Direction mplsOutSegmentEntry

The forward-direction mplsOutSegmentTable will be populated automatically based on the information received from the signaling protocol.

9.3.4. Reverse-Direction mplsInSegmentEntry

The reverse-direction mplsOutSegmentTable will be populated automatically based on the information received from the signaling protocol.

Next, two cross-connect entries are created in the mplsXCTable of the MPLS-LSR-STD-MIB [RFC3813], thereby associating the newly created segments together.

9.3.5. Forward-Direction mplsXCEntry

The forward-direction mplsXCEntry will be populated as soon as the forward-path label information is available.

9.3.6. Reverse-Direction mplsXCEntry

The reverse-direction mplsXCEntry will be populated as soon as the reverse-path label information is available.

This table entry is extended by an entry in the mplsXCExtTable. Note that the nature of the 'extends' relationship is a sparse augmentation so that the entry in the mplsXCExtTable has the same index values as the entry in the mplsXCTable.

9.3.7. Forward-Direction mplsXCExtEntry

Once the forward path information is negotiated using the signaling protocol, the forward-direction mplsXCExtEntry will be created for associating the opposite-direction XC entry and tunnel table entry.

9.3.8. Reverse-Direction mplsXCExtEntry

Once the reverse path information is negotiated using the signaling protocol, the reverse-direction mplsXCExtEntry will be created for associating the opposite-direction XC entry and tunnel table entry.

10. MPLS Textual Convention Extension MIB Definitions

```
   MPLS-TC-EXT-STD-MIB DEFINITIONS ::= BEGIN

   IMPORTS
      MODULE-IDENTITY, Unsigned32
         FROM SNMPv2-SMI               -- RFC 2578

      TEXTUAL-CONVENTION
         FROM SNMPv2-TC                -- RFC 2579

      mplsStdMIB
         FROM MPLS-TC-STD-MIB          -- RFC 3811

      ;

   mplsTcExtStdMIB MODULE-IDENTITY

      LAST-UPDATED
         "201502020000Z" -- February 2, 2015
      ORGANIZATION
         "Multiprotocol Label Switching (MPLS) Working Group"
      CONTACT-INFO
         "
                Venkatesan Mahalingam
                Dell Inc,
                5450 Great America Parkway,
                Santa Clara, CA 95054, USA
          Email: venkat.mahalingams@gmail.com

                Kannan KV Sampath
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                Sam Aldrin
                Huawei Technologies
                2330 Central Express Way,
                Santa Clara, CA 95051, USA
          Email:  aldrin.ietf@gmail.com

                Thomas D. Nadeau
          Email: tnadeau@lucidvision.com
         "
      DESCRIPTION
         "This MIB module contains Textual Conventions for LSPs of MPLS-
          based transport networks.
```

```
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      -- Revision history.

      REVISION
         "201502020000Z" -- February 2, 2015
      DESCRIPTION
           "MPLS Textual Convention Extensions"

      ::= { mplsStdMIB 17 }

   MplsGlobalId ::= TEXTUAL-CONVENTION
      STATUS      current
      DESCRIPTION
           "This object contains the Textual Convention for an IP-based
            operator-unique identifier (Global_ID).  The Global_ID can
            contain the 2-octet or 4-octet value of the operator's
            Autonomous System Number (ASN).

            When the Global_ID is derived from a 2-octet ASN,
            the two high-order octets of this 4-octet identifier
            MUST be set to zero (0x00).  Further, ASN 0 is reserved.
            The size of the Global_ID string MUST be zero if
            the Global_ID is invalid.

            Note that a Global_ID of zero is limited to entities
            contained within a single operator and MUST NOT be used
            across a Network-to-Network Interface (NNI).  A non-zero
            Global_ID MUST be derived from an ASN owned by
            the operator."
      REFERENCE
           "MPLS Transport Profile (MPLS-TP) Identifiers, RFC 6370,
            Section 3"
      SYNTAX  OCTET STRING (SIZE (4))

   MplsCcId ::= TEXTUAL-CONVENTION
   STATUS      current
   DESCRIPTION
        "The CC (Country Code) is a string of two characters, each
         being an uppercase Basic Latin alphabetic (i.e., A-Z).
```

```
        The characters are encoded using ITU-T Recommendation T.50.
        The size of the CC string MUST be zero if the CC identifier
        is invalid."
    REFERENCE
         "MPLS-TP Identifiers Following ITU-T Conventions,
         RFC 6923, Section 3.
         International Reference Alphabet (IRA) (Formerly
         International Alphabet No. 5 or IA5) - Information
         technology - 7-bit coded character set for information
         exchange, ITU-T Recommendation T.50, September 1992."
    SYNTAX  OCTET STRING (SIZE (0|2))

    MplsIccId ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
         "The ICC is a string of one to six characters, each
         an uppercase Basic Latin alphabetic (i.e., A-Z) or
         numeric (i.e., 0-9).  The characters are encoded
         using ITU-T Recommendation T.50.  The size of
         the ICC string MUST be zero if the ICC identifier
         is invalid."
    REFERENCE
         "MPLS-TP Identifiers Following ITU-T Conventions,
         RFC 6923, Section 3.
         International Reference Alphabet (IRA) (Formerly
         International Alphabet No. 5 or IA5) - Information
         technology - 7-bit coded character set for information
         exchange, ITU-T Recommendation T.50, September 1992."
    SYNTAX  OCTET STRING (SIZE (0|1..6))

    MplsNodeId ::= TEXTUAL-CONVENTION
       DISPLAY-HINT "d"
       STATUS      current
       DESCRIPTION
           "The Node_ID is assigned within the scope of
            the Global_ID/ICC_Operator_ID.

            When IPv4 addresses are in use, the value of this object
            can be derived from the LSR's IPv4 loopback address.
            When IPv6 addresses are in use, the value of this object
            can be a 32-bit value unique within the scope of
            a Global_ID.

            Note that, when IP reachability is not needed, the 32-bit
            Node_ID is not required to have any association
            with the IPv4 address space.  The value of 0 indicates
            an invalid Node_ID."
```

```
      REFERENCE
           "MPLS Transport Profile (MPLS-TP) Identifiers, RFC 6370,
            Section 4"
      SYNTAX  Unsigned32 (0|1..4294967295)

     -- MPLS-TC-EXT-STD-MIB module ends
     END
```

11. MPLS Identifier MIB Definitions

```
   MPLS-ID-STD-MIB DEFINITIONS ::= BEGIN

   IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE
       FROM SNMPv2-SMI                                  -- RFC 2578
    MODULE-COMPLIANCE, OBJECT-GROUP
       FROM SNMPv2-CONF                                 -- RFC 2580
    mplsStdMIB
       FROM MPLS-TC-STD-MIB                             -- RFC 3811
    MplsGlobalId, MplsCcId, MplsIccId, MplsNodeId
       FROM MPLS-TC-EXT-STD-MIB
    ;

  mplsIdStdMIB MODULE-IDENTITY
    LAST-UPDATED
        "201502020000Z" -- February 2, 2015
    ORGANIZATION
       "Multiprotocol Label Switching (MPLS) Working Group"

    CONTACT-INFO
       "
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             5450 Great America Parkway,
             Santa Clara, CA 95054, USA
         Email: venkat.mahalingams@gmail.com

             Kannan KV Sampath
             Redeem,
             India
         Email: kannankvs@gmail.com

             Sam Aldrin
             Huawei Technologies
             2330 Central Express Way,
             Santa Clara, CA 95051, USA
         Email:  aldrin.ietf@gmail.com
```

```
            Thomas D. Nadeau
        Email: tnadeau@lucidvision.com
      "
    DESCRIPTION
        "This MIB module contains identifier object definitions for
         MPLS Traffic Engineering in transport networks.

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         authors of the code.  All rights reserved.

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         forth in Section 4.c of the IETF Trust's Legal Provisions
         Relating to IETF Documents
         (http://trustee.ietf.org/license-info)."

    -- Revision history.

    REVISION
        "201502020000Z" -- February 2, 2015
    DESCRIPTION
         "This MIB modules defines the MIB objects for MPLS-TP
          identifiers"

    ::= { mplsStdMIB 18 }

    -- notifications
    mplsIdNotifications OBJECT IDENTIFIER ::= { mplsIdStdMIB 0 }
    -- tables, scalars
    mplsIdObjects       OBJECT IDENTIFIER ::= { mplsIdStdMIB 1 }
    -- conformance
    mplsIdConformance   OBJECT IDENTIFIER ::= { mplsIdStdMIB 2 }

    -- MPLS common objects

  mplsIdGlobalId OBJECT-TYPE
       SYNTAX      MplsGlobalId
       MAX-ACCESS  read-write
       STATUS      current
       DESCRIPTION
           "This object allows the operator or service provider to
            assign a unique operator identifier, also called the MPLS-TP
            Global_ID.
            If this value is used in mplsTunnelExtNodeConfigGlobalId
            for mapping Global_ID::Node_ID with the local identifier,
            then this object value MUST NOT be changed."
       ::= { mplsIdObjects 1 }
```

```
  mplsIdNodeId OBJECT-TYPE
       SYNTAX      MplsNodeId
       MAX-ACCESS  read-write
       STATUS      current
       DESCRIPTION
          "This object allows the operator or service provider to
           assign a unique MPLS-TP Node_ID.  The Node_ID is assigned
           within the scope of the Global_ID/ICC_Operator_ID.
           If this value is used in mplsTunnelExtNodeConfigNodeId
           for mapping Global_ID::Node_ID with the local identifier,
           then this object value SHOULD NOT be changed.
           If this value is used in mplsTunnelExtNodeConfigNodeId
           for mapping ICC_Operator_ID::Node_ID with the local
           identifier, then this object value MUST NOT be changed."
      ::= { mplsIdObjects 2 }

  mplsIdCc OBJECT-TYPE
       SYNTAX      MplsCcId
       MAX-ACCESS  read-write
       STATUS      current
       DESCRIPTION
          "This object allows the operator or service provider to
           assign a Country Code (CC) to the node.  Global
           uniqueness of ICC is assured by concatenating the ICC
           with a Country Code (CC).
           If this value is used in mplsTunnelExtNodeConfigCcId
           for mapping ICC_Operator_ID::Node_ID with the local
           identifier, then this object value MUST NOT be changed."
      REFERENCE
           "MPLS-TP Identifiers Following ITU-T Conventions,
            RFC 6923, Section 3"
          ::= { mplsIdObjects 3 }

  mplsIdIcc OBJECT-TYPE
       SYNTAX      MplsIccId
       MAX-ACCESS  read-write
       STATUS      current
       DESCRIPTION
          "This object allows the operator or service provider to
           assign a unique MPLS-TP ITU-T Carrier Code (ICC) to
           the node.  Together, the CC and the ICC form
           the ICC_Operator_ID as CC::ICC.
           If this value is used in mplsTunnelExtNodeConfigIccId
           for mapping ICC_Operator_ID::Node_ID with the local
           identifier, then this object value MUST NOT be changed."
      REFERENCE
           "MPLS-TP Identifiers Following ITU-T Conventions,
            RFC 6923, Section 3"
```

```
          ::= { mplsIdObjects 4 }

   -- Module compliance.

  mplsIdCompliances
     OBJECT IDENTIFIER ::= { mplsIdConformance 1 }

  mplsIdGroups
     OBJECT IDENTIFIER ::= { mplsIdConformance 2 }

  -- Compliance requirement for fully compliant implementations.

  mplsIdModuleFullCompliance MODULE-COMPLIANCE
     STATUS current
     DESCRIPTION
          "Compliance statement for agents that provide full
            support of the MPLS-ID-STD-MIB module."

     MODULE -- this module

        -- The mandatory group has to be implemented by all LSRs that
        -- originate, terminate, or act as transit for MPLS-TP Tunnels.

        GROUP mplsIdIpOperatorGroup
        DESCRIPTION
            "This group is mandatory for devices that support
             IP-based identifier configuration."

        GROUP mplsIdIccOperatorGroup
        DESCRIPTION
            "This group is mandatory for devices that support
             ICC-based identifier configuration."

         ::= { mplsIdCompliances 1 }

         -- Compliance requirement for read-only implementations.

        mplsIdModuleReadOnlyCompliance MODULE-COMPLIANCE
           STATUS current
           DESCRIPTION
                "Compliance statement for agents that only provide
                 read-only support for the MPLS-ID-STD-MIB module."

        MODULE -- this module
```

```
        GROUP mplsIdIpOperatorGroup
        DESCRIPTION
            "This group is mandatory for devices that support
             IP-based identifier configuration."

        GROUP mplsIdIccOperatorGroup
        DESCRIPTION
            "This group is mandatory for devices that support
             ICC-based identifier configuration."

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

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

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

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

        ::= { mplsIdCompliances 2 }

    -- Units of conformance.

        mplsIdIpOperatorGroup OBJECT-GROUP
              OBJECTS { mplsIdGlobalId,
                        mplsIdNodeId
              }
              STATUS  current
              DESCRIPTION
                  "The objects in this group are optional for an
                   ICC-based node."
              ::= { mplsIdGroups 1 }
```

```
        mplsIdIccOperatorGroup OBJECT-GROUP
              OBJECTS { mplsIdNodeId,
                        mplsIdCc,
                        mplsIdIcc
              }
              STATUS  current
              DESCRIPTION
                 "The objects in this group are optional for an
                  IP-based node."
              ::= { mplsIdGroups 2 }

   -- MPLS-ID-STD-MIB module ends
   END
```

12. MPLS LSR Extension MIB Definitions

```
   MPLS-LSR-EXT-STD-MIB DEFINITIONS ::= BEGIN

   IMPORTS
      MODULE-IDENTITY, OBJECT-TYPE
         FROM SNMPv2-SMI                                  -- RFC 2578
      MODULE-COMPLIANCE, OBJECT-GROUP
         FROM SNMPv2-CONF                                 -- RFC 2580
      mplsStdMIB
         FROM MPLS-TC-STD-MIB                             -- RFC 3811
      RowPointer
         FROM SNMPv2-TC                                   -- RFC 2579
      mplsXCIndex, mplsXCInSegmentIndex, mplsXCOutSegmentIndex,
      mplsInterfaceGroup, mplsInSegmentGroup, mplsOutSegmentGroup,
      mplsXCGroup, mplsLsrNotificationGroup
         FROM MPLS-LSR-STD-MIB;                           -- RFC 3813

   mplsLsrExtStdMIB MODULE-IDENTITY
      LAST-UPDATED
         "201502020000Z" -- February 2, 2015
      ORGANIZATION
         "Multiprotocol Label Switching (MPLS) Working Group"
      CONTACT-INFO
         "
                Venkatesan Mahalingam
                Dell Inc,
                5450 Great America Parkway,
                Santa Clara, CA 95054, USA
          Email: venkat.mahalingams@gmail.com
```

```
                Kannan KV Sampath
                Redeem,
                India
          Email: kannankvs@gmail.com

                Sam Aldrin
                Huawei Technologies
                2330 Central Express Way,
                Santa Clara, CA 95051, USA
          Email:  aldrin.ietf@gmail.com

                Thomas D. Nadeau
          Email: tnadeau@lucidvision.com
        "
      DESCRIPTION
        "This MIB module contains generic object definitions for
         MPLS LSRs in transport networks.

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         (http://trustee.ietf.org/license-info)."

      -- Revision history.

      REVISION
         "201502020000Z" -- February 2, 2015
      DESCRIPTION
           "MPLS LSR-specific MIB objects extension"

      ::= { mplsStdMIB 19 }

   -- notifications
   mplsLsrExtNotifications OBJECT IDENTIFIER ::= { mplsLsrExtStdMIB 0 }

   -- tables, scalars
   mplsLsrExtObjects       OBJECT IDENTIFIER
                            ::= { mplsLsrExtStdMIB 1 }
   -- conformance
   mplsLsrExtConformance   OBJECT IDENTIFIER
                            ::= { mplsLsrExtStdMIB 2 }

   -- MPLS LSR common objects
```

```
   mplsXCExtTable  OBJECT-TYPE
       SYNTAX        SEQUENCE OF MplsXCExtEntry
       MAX-ACCESS    not-accessible
       STATUS        current
       DESCRIPTION
          "This table sparse augments the mplsXCTable of
           MPLS-LSR-STD-MIB (RFC 3813) to provide MPLS-TP-specific
           information about associated tunnel information"
       REFERENCE
          "Multiprotocol Label Switching (MPLS) Label Switching
           Router (LSR) Management Information Base (MIB), RFC 3813."
   ::= { mplsLsrExtObjects 1 }

   mplsXCExtEntry  OBJECT-TYPE
       SYNTAX        MplsXCExtEntry
       MAX-ACCESS    not-accessible

       STATUS        current
       DESCRIPTION
          "An entry in this table sparsely extends the cross-connect
           information represented by an entry in
           the mplsXCTable in MPLS-LSR-STD-MIB (RFC 3813) through
           a sparse augmentation.  An entry can be created by
           a network operator via SNMP SET commands or in
           response to signaling protocol events."
       REFERENCE
          "Multiprotocol Label Switching (MPLS) Label Switching
           Router (LSR) Management Information Base (MIB), RFC 3813."

     INDEX { mplsXCIndex, mplsXCInSegmentIndex,
             mplsXCOutSegmentIndex }
    ::= { mplsXCExtTable 1 }

   MplsXCExtEntry ::= SEQUENCE {
      mplsXCExtTunnelPointer        RowPointer,
      mplsXCExtOppositeDirXCPtr     RowPointer
   }

   mplsXCExtTunnelPointer OBJECT-TYPE
       SYNTAX        RowPointer
       MAX-ACCESS    read-only
       STATUS        current
       DESCRIPTION
          "This read-only object indicates the back pointer to
           the tunnel entry segment.
           The only valid value for Tunnel Pointer is
           mplsTunnelTable entry."
```

```
       REFERENCE
          "Multiprotocol Label Switching (MPLS) Label Switching
           Router (LSR) Management Information Base (MIB), RFC 3813."
    ::= { mplsXCExtEntry 1 }

   mplsXCExtOppositeDirXCPtr OBJECT-TYPE
       SYNTAX        RowPointer
       MAX-ACCESS    read-create
       STATUS        current
       DESCRIPTION
          "This object indicates the pointer to the opposite-
           direction XC entry.  This object cannot be modified if
           mplsXCRowStatus for the corresponding entry in the
           mplsXCTable is active(1).  If this pointer is not set or
           removed, mplsXCOperStatus should be set to down(2)."
       REFERENCE
          "Multiprotocol Label Switching (MPLS) Label Switching
           Router (LSR) Management Information Base (MIB), RFC 3813."
    ::= { mplsXCExtEntry 2 }

    mplsLsrExtCompliances
       OBJECT IDENTIFIER ::= { mplsLsrExtConformance 1 }

    mplsLsrExtGroups
       OBJECT IDENTIFIER ::= { mplsLsrExtConformance 2 }

    -- Compliance requirement for fully compliant implementations.

    mplsLsrExtModuleFullCompliance MODULE-COMPLIANCE
        STATUS current
        DESCRIPTION
           "Compliance statement for agents that provide full support
            for MPLS-LSR-EXT-STD-MIB.
            The mandatory group has to be implemented by all LSRs
            that originate, terminate, or act as transit for
            TE-LSPs/tunnels.
            In addition, depending on the type of tunnels supported,
            other groups become mandatory as explained below."

     MODULE MPLS-LSR-STD-MIB -- The MPLS-LSR-STD-MIB, RFC 3813

     MANDATORY-GROUPS {
       mplsInSegmentGroup,
       mplsOutSegmentGroup,
       mplsXCGroup,
       mplsLsrNotificationGroup
     }
```

```
    MODULE -- this module

    MANDATORY-GROUPS    {
      mplsXCExtGroup
    }

    ::= { mplsLsrExtCompliances 1 }

   -- Compliance requirement for implementations that provide
   -- read-only access.

    mplsLsrExtModuleReadOnlyCompliance MODULE-COMPLIANCE
      STATUS current
      DESCRIPTION
         "Compliance requirement for implementations that only
          provide read-only support for MPLS-LSR-EXT-STD-MIB.
          Such devices can then be monitored but cannot be
          configured using this MIB module."

    MODULE MPLS-LSR-STD-MIB

    MANDATORY-GROUPS {
        mplsInterfaceGroup,
        mplsInSegmentGroup,
        mplsOutSegmentGroup
    }

    MODULE -- this module

    GROUP mplsXCExtReadOnlyObjectsGroup
    DESCRIPTION
          "This group is mandatory for devices that support
           opposite-direction XC configuration of tunnels."

    -- mplsXCExtTable
         OBJECT mplsXCExtOppositeDirXCPtr
         MIN-ACCESS   read-only
         DESCRIPTION
             "Write access is not required.
              This object indicates the pointer to the opposite-
              direction XC entry.  The only valid value for XC
              Pointer is mplsXCTable entry."
         ::= { mplsLsrExtCompliances 2 }

    -- Units of conformance.
```

```
    mplsXCExtGroup  OBJECT-GROUP
    OBJECTS {
        mplsXCExtTunnelPointer,
        mplsXCExtOppositeDirXCPtr
    }
    STATUS  current
    DESCRIPTION
        "This object should be supported in order to access
        the tunnel entry from the XC entry."
    ::= { mplsLsrExtGroups 1 }

    mplsXCExtReadOnlyObjectsGroup OBJECT-GROUP
    OBJECTS {
        mplsXCExtTunnelPointer,
        mplsXCExtOppositeDirXCPtr
    }
    STATUS  current
    DESCRIPTION
        "This Object is needed to associate the opposite-direction
        (forward/reverse) XC entry."
    ::= { mplsLsrExtGroups 2 }

   -- MPLS-LSR-EXT-STD-MIB module ends
   END
```

13. MPLS Tunnel Extension MIB Definitions

This MIB module imports from [RFC2578], [RFC2579], [RFC2580], [RFC3289], [RFC3811], and [RFC3812].

```
MPLS-TE-EXT-STD-MIB DEFINITIONS ::= BEGIN

IMPORTS
   MODULE-IDENTITY, OBJECT-TYPE
      FROM SNMPv2-SMI                                -- RFC 2578
   MODULE-COMPLIANCE, OBJECT-GROUP
      FROM SNMPv2-CONF                               -- RFC 2580
   TruthValue, RowStatus, RowPointer, StorageType
      FROM SNMPv2-TC                                 -- RFC 2579
   IndexIntegerNextFree
      FROM DIFFSERV-MIB                              -- RFC 3289
   MplsGlobalId, MplsNodeId, MplsCcId, MplsIccId
      FROM MPLS-TC-EXT-STD-MIB
   mplsStdMIB, MplsTunnelIndex, MplsTunnelInstanceIndex,
   MplsExtendedTunnelId
      FROM MPLS-TC-STD-MIB                           -- RFC 3811
   mplsTunnelIndex, mplsTunnelInstance, mplsTunnelIngressLSRId,
   mplsTunnelEgressLSRId
```

```
        FROM MPLS-TE-STD-MIB                          -- RFC 3812
    ;

  mplsTeExtStdMIB MODULE-IDENTITY
    LAST-UPDATED
      "201502020000Z" -- February 2, 2015
    ORGANIZATION
      "Multiprotocol Label Switching (MPLS) Working Group"
    CONTACT-INFO
      "
             Venkatesan Mahalingam
             Dell Inc,
             5450 Great America Parkway,
             Santa Clara, CA 95054, USA
       Email: venkat.mahalingams@gmail.com

             Kannan KV Sampath
             Redeem,
             India
       Email: kannankvs@gmail.com

             Sam Aldrin
             Huawei Technologies
             2330 Central Express Way,
             Santa Clara, CA 95051, USA
       Email:  aldrin.ietf@gmail.com

             Thomas D. Nadeau
       Email: tnadeau@lucidvision.com
      "
    DESCRIPTION
      "This MIB module contains generic object definitions for
       extending the MPLS Traffic Engineering tunnels in transport
       networks.

       Copyright (c) 2015 IETF Trust and the persons identified as
       authors of the code.  All rights reserved.

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       without modification, is permitted pursuant to, and subject to
       the license terms contained in, the Simplified BSD License set
       forth in Section 4.c of the IETF Trust's Legal Provisions
       Relating to IETF Documents
       (http://trustee.ietf.org/license-info)."
```

```
      -- Revision history.

      REVISION
       "201502020000Z" -- February 2, 2015

      DESCRIPTION
           "MPLS TE MIB objects extension"

      ::= { mplsStdMIB 20 }

   -- Top-level components of this MIB module.

   -- tables, scalars
   mplsTeExtObjects       OBJECT IDENTIFIER
                                  ::= { mplsTeExtStdMIB 0 }
   -- conformance
   mplsTeExtConformance   OBJECT IDENTIFIER
                                  ::= { mplsTeExtStdMIB 1 }

  -- Start of MPLS Transport Profile Node configuration table

  mplsTunnelExtNodeConfigLocalIdNext OBJECT-TYPE
   SYNTAX        IndexIntegerNextFree (0..16777215)
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
      "This object contains an unused value for
       mplsTunnelExtNodeConfigLocalId, or a zero to indicate
       that none exist.  Negative values are not allowed,
       as they do not correspond to valid values of
       mplsTunnelExtNodeConfigLocalId."
    ::= { mplsTeExtObjects 1 }

    mplsTunnelExtNodeConfigTable OBJECT-TYPE
     SYNTAX        SEQUENCE OF MplsTunnelExtNodeConfigEntry
     MAX-ACCESS    not-accessible
     STATUS        current
     DESCRIPTION
       "This table allows the operator to map a node or
        LSR identifier (IP-compatible [Global_ID::Node_ID] or
        ICC-based [ICC_Operator_ID::Node_ID]) with a local
        identifier.

        This table is created to reuse the existing
        mplsTunnelTable for MPLS-based transport network
        tunnels also.
```

```
        Since the MPLS tunnel's Ingress/Egress LSR identifiers'
        size (Unsigned32) value is not compatible for
        MPLS-TP Tunnel, i.e., Global_ID::Node_ID of size 8 bytes and
        ICC_Operator_ID::Node_ID of size 12 bytes, there exists a
        need to map the Global_ID::Node_ID or ICC_Operator_ID::Node_ID
        with the local identifier of size 4 bytes (Unsigned32) value
        in order to index (Ingress/Egress LSR identifier)
        the existing mplsTunnelTable."

     ::= { mplsTeExtObjects 2 }

    mplsTunnelExtNodeConfigEntry OBJECT-TYPE
     SYNTAX        MplsTunnelExtNodeConfigEntry
     MAX-ACCESS    not-accessible
     STATUS        current
     DESCRIPTION
        "An entry in this table represents a mapping
        identification for the operator or service provider
        to a node or an LSR.

        As per RFC 6370, IP-compatible mapping is represented
        as Global_ID::Node_ID.

        As per RFC 6923, the CC and the ICC form the ICC_Operator_ID
        as CC::ICC, and ICC-compatible mapping is represented
        as ICC_Operator_ID::Node_ID.

        Note: Each entry in this table should have a unique
        [Global_ID and Node_ID] or [CC::ICC and Node_ID] combination."
        INDEX { mplsTunnelExtNodeConfigLocalId }
        ::= { mplsTunnelExtNodeConfigTable 1 }

    MplsTunnelExtNodeConfigEntry ::= SEQUENCE {
          mplsTunnelExtNodeConfigLocalId     MplsExtendedTunnelId,
          mplsTunnelExtNodeConfigGlobalId    MplsGlobalId,
          mplsTunnelExtNodeConfigCcId        MplsCcId,
          mplsTunnelExtNodeConfigIccId       MplsIccId,
          mplsTunnelExtNodeConfigNodeId      MplsNodeId,
          mplsTunnelExtNodeConfigIccValid    TruthValue,
          mplsTunnelExtNodeConfigStorageType StorageType,
          mplsTunnelExtNodeConfigRowStatus   RowStatus

    }

    mplsTunnelExtNodeConfigLocalId  OBJECT-TYPE
       SYNTAX        MplsExtendedTunnelId
       MAX-ACCESS    not-accessible
       STATUS        current
```

```
      DESCRIPTION
        "This object is used in accommodating the bigger-
         size Global_ID::Node_ID and/or the ICC_Operator_ID::Node_ID
         with the smaller-size LSR identifier in order to index
         the mplsTunnelTable.

         The local identifier is configured between 0 and 16777215,
         as the valid IP address range starts from
         16777216(01.00.00.00).
         This range is chosen to determine whether the
         mplsTunnelTable's Ingress/Egress LSR ID is an IP address or
         local identifier.  If the configured range is not an
         IP address, the operator is expected to retrieve the
         complete information (Global_ID::Node_ID or
         ICC_Operator_ID::Node_ID) from mplsTunnelExtNodeConfigTable.
         This way, the existing mplsTunnelTable is reused for
         bidirectional tunnel extensions for MPLS-based transport
         networks.

         The local identifier allows the operator to assign
         a unique identifier to map Global_ID::Node_ID and/or
         ICC_Operator_ID::Node_ID.  As this local identifier is unique
         within the node and the same syntax of this object can be
         used for MPLS-TE tunnel also, it is up to the operator/local
         management entity to choose a non-conflicting value for
         indexing the MPLS and MPLS-TP tunnel entries."
      ::= { mplsTunnelExtNodeConfigEntry 1 }


   mplsTunnelExtNodeConfigGlobalId  OBJECT-TYPE
      SYNTAX        MplsGlobalId
      MAX-ACCESS    read-create
      STATUS        current
      DESCRIPTION
        "This object indicates the Global Operator Identifier.
         This object has no meaning when
         mplsTunnelExtNodeConfigIccValid is set true."
      REFERENCE
            "MPLS Transport Profile (MPLS-TP) Identifiers, RFC 6370,
             Section 3."
      ::= { mplsTunnelExtNodeConfigEntry 2 }

   mplsTunnelExtNodeConfigCcId OBJECT-TYPE
        SYNTAX      MplsCcId
        MAX-ACCESS  read-create
        STATUS      current
```

```
          DESCRIPTION
             "This object allows the operator or service provider to
              configure a unique MPLS-TP ITU-T Country Code (CC)
              either for Ingress ID or Egress ID.

              This object has no meaning when
              mplsTunnelExtNodeConfigIccValid is set to false."
             REFERENCE
                "MPLS-TP Identifiers Following ITU-T Conventions,
                RFC 6923, Section 3"
       ::= { mplsTunnelExtNodeConfigEntry 3 }

       mplsTunnelExtNodeConfigIccId OBJECT-TYPE
            SYNTAX      MplsIccId
            MAX-ACCESS  read-create
            STATUS      current
            DESCRIPTION
               "This object allows the operator or service provider to
                configure a unique MPLS-TP ITU-T Carrier Code (ICC)
                either for Ingress ID or Egress ID.

                This object has no meaning when
                mplsTunnelExtNodeConfigIccValid is set to false."
            REFERENCE
               "MPLS-TP Identifiers Following ITU-T Conventions,
                RFC 6923, Section 3"
       ::= { mplsTunnelExtNodeConfigEntry 4 }

       mplsTunnelExtNodeConfigNodeId  OBJECT-TYPE
          SYNTAX        MplsNodeId
          MAX-ACCESS    read-create
          STATUS        current
          DESCRIPTION
             "This object indicates the Node_ID within the scope
              of a Global_ID or ICC_Operator_ID."
          REFERENCE
              "MPLS Transport Profile (MPLS-TP) Identifiers, RFC 6370,
               Section 4."
          ::= { mplsTunnelExtNodeConfigEntry 5 }

       mplsTunnelExtNodeConfigIccValid  OBJECT-TYPE
          SYNTAX        TruthValue
          MAX-ACCESS    read-create
          STATUS        current
          DESCRIPTION
             "Denotes whether or not this entry uses
              mplsTunnelExtNodeConfigCcId,
              mplsTunnelExtNodeConfigIccId, and
```

```
              mplsTunnelExtNodeConfigNodeId for mapping
              the ICC-based identifiers with the local identifier.
              Note that if this variable is set to false, then the
              mplsTunnelExtNodeConfigGlobalId and
              mplsTunnelExtNodeConfigNodeId objects should have
              the valid information."
           DEFVAL { false }
             ::= { mplsTunnelExtNodeConfigEntry 6 }

       mplsTunnelExtNodeConfigStorageType OBJECT-TYPE
          SYNTAX        StorageType
          MAX-ACCESS    read-create
          STATUS        current
          DESCRIPTION
           "This variable indicates the storage type for this
            object.
            Conceptual rows having the value 'permanent'
            need not allow write-access to any columnar
            objects in the row."
          DEFVAL { volatile }
          ::= { mplsTunnelExtNodeConfigEntry 7 }

    mplsTunnelExtNodeConfigRowStatus OBJECT-TYPE
       SYNTAX        RowStatus
       MAX-ACCESS    read-create
       STATUS        current
       DESCRIPTION
          "This object allows the operator to create, modify,
           and/or delete a row in this table."
       ::= { mplsTunnelExtNodeConfigEntry 8 }


   -- End of MPLS Transport Profile Node configuration table

   -- Start of MPLS Transport Profile Node IP-compatible
   -- mapping table

  mplsTunnelExtNodeIpMapTable OBJECT-TYPE
     SYNTAX        SEQUENCE OF MplsTunnelExtNodeIpMapEntry

     MAX-ACCESS    not-accessible
     STATUS        current
     DESCRIPTION
         "This read-only table allows the operator to retrieve
          the local identifier for a given Global_ID::Node_ID in an
          IP-compatible operator environment.
          This table MAY be used in on-demand and/or proactive
          OAM operations to get the Ingress/Egress LSR identifier
```

```
          (local identifier) from Src-Global_Node_ID
          or Dst-Global_Node_ID.  The Ingress and Egress LSR
          identifiers are used to retrieve the tunnel entry.

          This table returns nothing when the associated entry
          is not defined in mplsTunnelExtNodeConfigTable."
      ::= { mplsTeExtObjects 3 }

    mplsTunnelExtNodeIpMapEntry OBJECT-TYPE
      SYNTAX        MplsTunnelExtNodeIpMapEntry
      MAX-ACCESS    not-accessible
      STATUS        current
      DESCRIPTION
            "An entry in this table represents a mapping of
             Global_ID::Node_ID with the local identifier.

             An entry in this table is created automatically when
             the local identifier is associated with Global_ID and
             Node_Id in the mplsTunnelExtNodeConfigTable.

             Note: Each entry in this table should have a unique
             Global_ID and Node_ID combination."
       INDEX { mplsTunnelExtNodeIpMapGlobalId,
               mplsTunnelExtNodeIpMapNodeId
             }
       ::= { mplsTunnelExtNodeIpMapTable 1 }

    MplsTunnelExtNodeIpMapEntry ::= SEQUENCE {
          mplsTunnelExtNodeIpMapGlobalId    MplsGlobalId,
          mplsTunnelExtNodeIpMapNodeId      MplsNodeId,
          mplsTunnelExtNodeIpMapLocalId     MplsExtendedTunnelId
    }

    mplsTunnelExtNodeIpMapGlobalId  OBJECT-TYPE
       SYNTAX        MplsGlobalId
       MAX-ACCESS    not-accessible
       STATUS        current
       DESCRIPTION
         "This object indicates the Global_ID."
       ::= { mplsTunnelExtNodeIpMapEntry 1 }

    mplsTunnelExtNodeIpMapNodeId  OBJECT-TYPE
       SYNTAX        MplsNodeId
       MAX-ACCESS    not-accessible
       STATUS        current
```

```
      DESCRIPTION
        "This object indicates the Node_ID within the
         operator."
      ::= { mplsTunnelExtNodeIpMapEntry 2 }

   mplsTunnelExtNodeIpMapLocalId  OBJECT-TYPE
      SYNTAX        MplsExtendedTunnelId
      MAX-ACCESS    read-only
      STATUS        current
      DESCRIPTION
        "This object contains an IP-compatible local identifier
         that is defined in mplsTunnelExtNodeConfigTable."
      ::= { mplsTunnelExtNodeIpMapEntry 3 }

   -- End MPLS Transport Profile Node IP compatible table

   -- Start of MPLS Transport Profile Node ICC based table

   mplsTunnelExtNodeIccMapTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF MplsTunnelExtNodeIccMapEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
       "This read-only table allows the operator to retrieve
        the local identifier for a given ICC_Operator_ID::Node_ID
        in an ICC operator environment.

        This table MAY be used in on-demand and/or proactive
        OAM operations to get the Ingress/Egress LSR
        identifier (local identifier) from Src-ICC
        or Dst-ICC.  The Ingress and Egress LSR
        identifiers are used to retrieve the tunnel entry.
        This table returns nothing when the associated entry
        is not defined in mplsTunnelExtNodeConfigTable."
    ::= { mplsTeExtObjects 4 }

   mplsTunnelExtNodeIccMapEntry OBJECT-TYPE
    SYNTAX        MplsTunnelExtNodeIccMapEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
          "An entry in this table represents a mapping of
           ICC_Operator_ID::Node_ID with the local identifier.

           An entry in this table is created automatically when
           the local identifier is associated with
           ICC_Operator_ID::Node_ID in
           the mplsTunnelExtNodeConfigTable."
```

```
      INDEX { mplsTunnelExtNodeIccMapCcId,
              mplsTunnelExtNodeIccMapIccId,
              mplsTunnelExtNodeIccMapNodeId }
      ::= { mplsTunnelExtNodeIccMapTable 1 }

    MplsTunnelExtNodeIccMapEntry ::= SEQUENCE {
          mplsTunnelExtNodeIccMapCcId       MplsCcId,
          mplsTunnelExtNodeIccMapIccId      MplsIccId,
          mplsTunnelExtNodeIccMapNodeId     MplsNodeId,
          mplsTunnelExtNodeIccMapLocalId    MplsExtendedTunnelId
    }

    mplsTunnelExtNodeIccMapCcId OBJECT-TYPE
         SYNTAX      MplsCcId
         MAX-ACCESS  not-accessible
         STATUS      current
         DESCRIPTION
            "This object allows the operator or service provider to
             configure a unique MPLS-TP ITU-T Country Code (CC)
             either for Ingress or Egress LSR ID.

             The CC is a string of two alphabetic characters
             represented with uppercase letters (i.e., A-Z)."
         ::= { mplsTunnelExtNodeIccMapEntry 1 }

         mplsTunnelExtNodeIccMapIccId OBJECT-TYPE
              SYNTAX      MplsIccId
              MAX-ACCESS  not-accessible
              STATUS      current
              DESCRIPTION
                 "This object allows the operator or service provider
                  to configure a unique MPLS-TP ITU-T Carrier
                  Code (ICC) either for Ingress or Egress LSR ID.

                  The ICC is a string of one to six characters, each
                  character being either alphabetic (i.e., A-Z) or
                  numeric (i.e., 0-9) characters.  Alphabetic characters
                  in the ICC should be represented with uppercase
                  letters."
         ::= { mplsTunnelExtNodeIccMapEntry 2 }

         mplsTunnelExtNodeIccMapNodeId  OBJECT-TYPE
            SYNTAX        MplsNodeId
            MAX-ACCESS    not-accessible
            STATUS        current
            DESCRIPTION
              "This object indicates the Node_ID within the
               ICC-based operator."
```

```
        ::= { mplsTunnelExtNodeIccMapEntry 3}

   mplsTunnelExtNodeIccMapLocalId  OBJECT-TYPE
      SYNTAX        MplsExtendedTunnelId
      MAX-ACCESS    read-only
      STATUS        current
      DESCRIPTION
        "This object contains an ICC-based local identifier
         that is defined in mplsTunnelExtNodeConfigTable."
   ::= { mplsTunnelExtNodeIccMapEntry 4 }

-- End MPLS Transport Profile Node ICC-based table

-- Start of MPLS Tunnel table extension

  mplsTunnelExtTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF MplsTunnelExtEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
      "This table represents extensions to mplsTunnelTable
       in order to support MPLS-TP Tunnels.

       As per MPLS-TP Identifiers (RFC 6370), LSP_ID for IP-based
       co-routed bidirectional tunnel:

       A1-{Global_ID::Node_ID::Tunnel_Num}::Z9-{Global_ID::
       Node_ID::Tunnel_Num}::LSP_Num

       LSP_ID for IP based associated bidirectional tunnel:
       A1-{Global_ID::Node_ID::Tunnel_Num::LSP_Num}::
       Z9-{Global_ID::Node_ID::Tunnel_Num::LSP_Num}

       mplsTunnelTable is reused for forming the LSP_ID
       as follows:

       Source Tunnel_Num is mapped with mplsTunnelIndex,
       Source Node_ID is mapped with
       mplsTunnelIngressLSRId, Destination Node_ID is
       mapped with mplsTunnelEgressLSRId, and LSP_Num is mapped with
       mplsTunnelInstance.

       Source Global_ID::Node_ID and/or ICC_Operator_ID::Node_ID and
       Destination Global_ID::Node_ID and/or ICC_Operator_ID::Node-ID
       are maintained in the mplsTunnelExtNodeConfigTable.
       mplsTunnelExtNodeConfigLocalId is used to create an entry
       in mplsTunnelTable."
```

```
     REFERENCE
           "MPLS Transport Profile (MPLS-TP) Identifiers, RFC 6370."
     ::= { mplsTeExtObjects 5 }

    mplsTunnelExtEntry OBJECT-TYPE
    SYNTAX        MplsTunnelExtEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
          "An entry in this table represents additional MPLS-TP-
           specific tunnel configurations."
    INDEX {
      mplsTunnelIndex,
      mplsTunnelInstance,
      mplsTunnelIngressLSRId,
      mplsTunnelEgressLSRId
     }
     ::= { mplsTunnelExtTable 1 }

    MplsTunnelExtEntry ::= SEQUENCE {
         mplsTunnelExtOppositeDirPtr          RowPointer,
         mplsTunnelExtOppositeDirTnlValid     TruthValue,
         mplsTunnelExtDestTnlIndex            MplsTunnelIndex,
         mplsTunnelExtDestTnlLspIndex         MplsTunnelInstanceIndex,
         mplsTunnelExtDestTnlValid            TruthValue,
         mplsTunnelExtIngressLSRLocalIdValid  TruthValue,
         mplsTunnelExtEgressLSRLocalIdValid   TruthValue
    }

    mplsTunnelExtOppositeDirPtr  OBJECT-TYPE
       SYNTAX        RowPointer
       MAX-ACCESS    read-create
       STATUS        current
       DESCRIPTION
          "This object points to the opposite-direction tunnel entry."
    ::= { mplsTunnelExtEntry 1 }

    mplsTunnelExtOppositeDirTnlValid  OBJECT-TYPE
       SYNTAX        TruthValue
       MAX-ACCESS    read-create
       STATUS        current
       DESCRIPTION
          "Denotes whether or not this tunnel uses
           mplsTunnelExtOppositeDirPtr for identifying the opposite-
           direction tunnel information.  Note that if this variable
           is set to true, then the mplsTunnelExtOppositeDirPtr should
           point to the first accessible row of the valid opposite-
           direction tunnel."
```

```
      DEFVAL { false }
        ::= { mplsTunnelExtEntry 2 }

   mplsTunnelExtDestTnlIndex  OBJECT-TYPE
      SYNTAX        MplsTunnelIndex
      MAX-ACCESS    read-create
      STATUS        current
      DESCRIPTION
         "This object is applicable only for the bidirectional
          tunnel that has the forward and reverse LSPs in the
          different tunnel entries.

          The values of this object and the
          mplsTunnelExtDestTnlLspIndex object together can be used
          to identify an opposite-direction LSP, i.e., if the
          mplsTunnelIndex and mplsTunnelInstance hold the value
          for forward LSP, this object and
          mplsTunnelExtDestTnlLspIndex can be used to retrieve
          the reverse-direction LSP and vice versa.

          This object and mplsTunnelExtDestTnlLspIndex values
          provide the first two indices of tunnel entry, and
          the remaining indices can be derived as follows:
          the Ingress and Egress Identifiers should be
          swapped in order to index the other direction tunnel."
         ::= { mplsTunnelExtEntry 3 }

   mplsTunnelExtDestTnlLspIndex  OBJECT-TYPE
      SYNTAX        MplsTunnelInstanceIndex
      MAX-ACCESS    read-create
      STATUS        current
      DESCRIPTION
         "This object is applicable only for the bidirectional
          tunnel that has the forward and reverse LSPs in the
          different tunnel entries.  This object holds
          the instance index of the opposite-direction tunnel."
         ::= { mplsTunnelExtEntry 4 }

   mplsTunnelExtDestTnlValid  OBJECT-TYPE
      SYNTAX        TruthValue
      MAX-ACCESS    read-create
      STATUS        current
      DESCRIPTION
         "Denotes whether or not this tunnel uses
          mplsTunnelExtDestTnlIndex and
          mplsTunnelExtDestTnlLspIndex for identifying
          the opposite-direction tunnel information.  Note that if
          this variable is set to true, then the
```

```
            mplsTunnelExtDestTnlIndex and
            mplsTunnelExtDestTnlLspIndex objects should have
            the valid opposite-direction tunnel indices."
        DEFVAL { false }
          ::= { mplsTunnelExtEntry 5 }

    mplsTunnelExtIngressLSRLocalIdValid OBJECT-TYPE
        SYNTAX        TruthValue
        MAX-ACCESS    read-create
        STATUS        current
        DESCRIPTION
         "This object denotes whether the mplsTunnelIngressLSRId
          contains the local value that is used to reference
          the complete Ingress Global_ID::Node_ID or ICC_Operator_ID
          from the mplsTunnelExtNodeConfigTable.

          If this object is set to FALSE, mplsTunnelExtNodeConfigTable
          will not contain an entry to reference the local identifier
          with Global_ID::Node_ID or ICC_Operator_ID::Node_ID value.

          This object is set to FALSE for legacy implementations like
          MPLS TE tunnels where mplsTunnelIngressId itself provides
          the complete Ingress LSR ID."
        REFERENCE
          "MPLS-TE-STD-MIB (RFC 3812), Section 11.
           mplsTunnelIngressLSRId object in mplsTunnelTable."
        DEFVAL { false }
          ::= { mplsTunnelExtEntry 6 }

    mplsTunnelExtEgressLSRLocalIdValid OBJECT-TYPE
        SYNTAX        TruthValue
        MAX-ACCESS    read-create
        STATUS        current
        DESCRIPTION
         "This object denotes whether the mplsTunnelEgressLSRId
          contains the local value, which is used to reference
          the complete Egress Global_ID::Node_ID or
          ICC_Operator_ID::Node_ID from
          the mplsTunnelExtNodeConfigTable.

          If this object is set to FALSE, mplsTunnelExtNodeConfigTable
          will not contain an entry to reference the local identifier
          with Global_ID::Node_ID or ICC_Operator_ID::Node_ID value.

          This object is set to FALSE for legacy implementations like
          MPLS TE tunnels where mplsTunnelEgressId itself provides
          the complete Egress LSR ID."
```

```
       REFERENCE
         "MPLS-TE-STD-MIB (RFC 3812), Section 11.
          mplsTunnelEgressLSRId object in mplsTunnelTable."
       DEFVAL { false }
         ::= { mplsTunnelExtEntry 7 }

    -- End of MPLS Tunnel table extension

   -- Module compliance.

   mplsTeExtCompliances
      OBJECT IDENTIFIER ::= { mplsTeExtConformance 1 }

   mplsTeExtGroups
      OBJECT IDENTIFIER ::= { mplsTeExtConformance 2 }

   -- Compliance requirement for fully compliant implementations.

   mplsTeExtModuleFullCompliance MODULE-COMPLIANCE
      STATUS current
      DESCRIPTION
           "Compliance statement for agents that provide full
            support the MPLS-TE-EXT-STD-MIB module."

      MODULE -- this module

         -- The mandatory group has to be implemented by all
         -- LSRs that originate/terminate MPLS-TP Tunnels.
         -- In addition, depending on the type of tunnels
         -- supported, other groups become mandatory as
         -- explained below.

         MANDATORY-GROUPS    {
            mplsTunnelExtGroup
         }

         GROUP mplsTunnelExtIpOperatorGroup
         DESCRIPTION
             "This group is mandatory for devices that support
              configuration of IP-based identifier tunnels."

         GROUP mplsTunnelExtIccOperatorGroup
         DESCRIPTION
             "This group is mandatory for devices that support
              configuration of ICC based tunnels."

          ::= { mplsTeExtCompliances 1 }
```

```
   -- Compliance requirement for read-only implementations.

   mplsTeExtModuleReadOnlyCompliance MODULE-COMPLIANCE
      STATUS current
      DESCRIPTION
          "Compliance statement for agents that only provide
           read-only support for the MPLS-TE-EXT-STD-MIB module."

      MODULE -- this module

   MANDATORY-GROUPS    {
      mplsTunnelExtGroup
   }

   GROUP mplsTunnelExtIpOperatorGroup
   DESCRIPTION
       "This group is mandatory for devices that support
        configuration of IP-based identifier tunnels."

   GROUP mplsTunnelExtIccOperatorGroup
   DESCRIPTION
       "This group is mandatory for devices that support
        configuration of ICC-based tunnels."

   -- mplsTunnelExtTable

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

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

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

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

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

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

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

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

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

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

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

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

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

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

        ::= { mplsTeExtCompliances 2 }

     -- Units of conformance.

     mplsTunnelExtGroup OBJECT-GROUP
        OBJECTS {
          mplsTunnelExtOppositeDirPtr,
          mplsTunnelExtOppositeDirTnlValid,
          mplsTunnelExtDestTnlIndex,
          mplsTunnelExtDestTnlLspIndex,
          mplsTunnelExtDestTnlValid,
          mplsTunnelExtIngressLSRLocalIdValid,
          mplsTunnelExtEgressLSRLocalIdValid
       }

       STATUS  current
       DESCRIPTION
            "Necessary, but not sufficient, set of objects to
             implement tunnels.  In addition, depending on the
             operating environment, the following groups are
             mandatory."
       ::= { mplsTeExtGroups 1 }

   mplsTunnelExtIpOperatorGroup  OBJECT-GROUP
      OBJECTS { mplsTunnelExtNodeConfigLocalIdNext,
                mplsTunnelExtNodeConfigGlobalId,
                mplsTunnelExtNodeConfigNodeId,
                mplsTunnelExtNodeIpMapLocalId,
                mplsTunnelExtNodeConfigStorageType,
                mplsTunnelExtNodeConfigRowStatus
      }
      STATUS  current
      DESCRIPTION
           "Object(s) needed to implement IP-compatible tunnels."
      ::= { mplsTeExtGroups 2 }

   mplsTunnelExtIccOperatorGroup  OBJECT-GROUP
      OBJECTS { mplsTunnelExtNodeConfigLocalIdNext,
                mplsTunnelExtNodeConfigCcId,
                mplsTunnelExtNodeConfigIccId,
                mplsTunnelExtNodeConfigNodeId,
                mplsTunnelExtNodeConfigIccValid,
                mplsTunnelExtNodeIccMapLocalId,
```

```
                mplsTunnelExtNodeConfigStorageType,
                mplsTunnelExtNodeConfigRowStatus
        }
        STATUS  current
        DESCRIPTION
             "Object(s) needed to implement ICC-based tunnels."
        ::= { mplsTeExtGroups 3 }

    -- MPLS-TE-EXT-STD-MIB module ends
    END
```

14. Security Considerations

This document follows the security considerations mentioned in Section 12 of [RFC3812]. These security considerations are also applicable to the MIB objects and tables defined in this document, which are identified as below.

- The common objects mplsIdGlobalId, mplsIdNodeId, mplsIdCc, and mplsIdIcc are used to define the identity of an MPLS-TP node for OAM purposes. If write-access is allowed to these objects it offers the possibility for incorrect values to be entered that will confuse the information returned by OAM functions and possibly prevent OAM from operating correctly. Furthermore, there is the possibility of inducing one node to impersonate another with confusing results.

- mplsTunnelExtNodeConfigTable, mplsTunnelExtTable and mplsXCExtTable collectively contain objects to provision MPLS-TP Tunnels, tunnel hops, and tunnel resources.

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:

- mplsTunnelExtNodeConfigTable, mplsTunnelExtTable, and mplsXCExtTable collectively show the characteristics of the MPLS-TP tunnel network topology. If an Administrator does not want to reveal this information, then these tables should be considered sensitive/vulnerable.

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example by using IPsec), 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.

Implementations SHOULD provide the security features described by the SNMPv3 framework (see [RFC3410]), and implementations claiming compliance to the SNMPv3 standard MUST include full support for authentication and privacy via the User-based Security Model (USM) [RFC3414] with the AES cipher algorithm [RFC3826]. Implementations MAY also provide support for the Transport Security Model (TSM) [RFC5591] in combination with a secure transport such as SSH [RFC5592] or TLS/DTLS [RFC6353].

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.

15. IANA Considerations

As described in [RFC4221] and [RFC6639], and as requested in the MPLS-TC-STD-MIB [RFC3811], MPLS-related Standards Track MIB modules should be rooted under the mplsStdMIB subtree. There are four MPLS MIB modules contained in this document; each of the following subsections lists a new assignment made by IANA under the mplsStdMIB subtree. New assignments can only be made via a Standards Action as specified in [RFC5226].

15.1. IANA Considerations for MPLS-TC-EXT-STD-MIB

IANA has assigned the OID { mplsStdMIB 17 } to the MPLS-TC-EXT-STD-MIB module specified in this document.

15.2. IANA Considerations for MPLS-ID-STD-MIB

IANA has assigned the OID { mplsStdMIB 18 } to the MPLS-ID-STD-MIB module specified in this document.

15.3. IANA Considerations for MPLS-LSR-EXT-STD-MIB

IANA has assigned the OID { mplsStdMIB 19 } to the MPLS-LSR-EXT-STD-MIB module specified in this document.

15.4. IANA Considerations for MPLS-TE-EXT-STD-MIB

IANA has assigned the OID { mplsStdMIB 20 } to the MPLS-TE-EXT-STD-MIB module specified in this document.

16. References

16.1. Normative References

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