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Multiprotocol Label Switching (MPLS) Forwarding Equivalence Class To Next Hop Label Forwarding Entry (FEC-To-NHLFE) Management Information Base (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 defining, configuring, and monitoring Forwarding Equivalence Class (FEC) to Next Hop Label Forwarding Entry (NHLFE) mappings and corresponding actions for use with Multiprotocol Label Switching (MPLS).

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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 specifying Forwarding Equivalence Class (FEC) to Next Hop Label Forwarding Entry (NHLFE) mappings and corresponding actions for Multiprotocol Label Switching (MPLS).

At the ingress of an MPLS network, packets entering the MPLS domain are assigned to an FEC. Those packets belonging to an FEC are associated with an NHLFE (i.e., MPLS label) via the FEC-to-NHLFE (FTN) mapping [RFC3031]. This relationship defines how ingress LSRs will impose MPLS labels onto incoming packets. It also defines how egress LSRs will decapsulate the MPLS shim header from MPLS packets.

Conceptually, some of the FTN table functionality could be implemented using the Forwarding Information Base (FIB) to map all packets destined for a prefix to an LSP. However, this mapping is coarse in nature.

Similar functionality is already being used in other contexts such as security filters, access filters, and RSVP flow identification. All of these require various combinations of matching based on IP header and upper-layer header information to identify packets for a particular treatment. When packets match a particular rule, a corresponding action is executed on those packets. For example, two popular actions to take when a successful match is identified are allowing the packet to be forwarded or to discard it. However, other

actions are possible, such as modifying the TOS byte, or redirecting a packet to a particular outgoing interface. In the context of MPLS, the possible actions performed by an NHLFE are to redirect packets to either an MPLS Label Switched Path (LSP) or an MPLS Traffic Engineered (TE) Tunnel.

This document attempts to consolidate the various matching requirements and associated action options needed for MPLS into a single specification.

2. Terminology

Although all of the terminology used in this document is either covered in the MPLS Architecture [RFC3031] or in the SNMP Architecture [RFC3411], it is informational to define some immediately pertinent acronyms/terminology here.

MPLS	Multiprotocol Label Switching
FEC	Forwarding Equivalence Class
NHLFE	Next-Hop Label Forwarding Entry
FTN	FEC-to-NHLFE
MIB	Management Information Base

3. Conventions Used In This Document

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 BCP 14, RFC 2119 [RFC2119].

4. 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].

5. Outline

This MIB module resides on any LSR which does the FEC-to-NHLFE mapping in order to map traffic into the MPLS domain. This MIB module consists of three tables:

- mplsFTNTable defines the rule base against which incoming packets are matched and defines the actions to be taken on matching packets;

- mplsFTNMapTable defines the application of these rules to specific interfaces;

- mplsFTNPerfTable provides performance counters for every entry in mplsFTNTable that is active on one or more interfaces, on a per-interface basis.

5.1. mplsFTNTable

This table allows FEC to NHLFE mappings to be specified. Each entry in this table (also referred to as an "FTN entry" in this document) defines a rule to be applied to incoming packets (on interfaces that the entry is activated on using mplsFTNMapTable as explained in Section 5.2) and an action to be taken on matching packets. mplsFTNTable allows 6-tuple matching rules based on one or more of source address range, destination address range, source port range, destination port range, IPv4 Protocol field [RFC791] or IPv6 next-header field [RFC2460], and the DiffServ Code Point (DSCP, [RFC2474]) to be specified. Packet redirection is based on an action pointer which points either at an mplsXCEntry in MPLS-LSR-STD-MIB [RFC3813] when the NHLFE is a non-TE LSP, or at an mplsTunnelEntry in MPLS-TE-STD-MIB [RFC3812] when the NHLFE is the origin of a TE tunnel.

5.1.1. Advantages of Address Ranges Over CIDR Prefixes

One possible way of specifying a set of addresses as part of an FTN rule is to use CIDR prefixes [RFC1519]. We have instead chosen to allow FTN rules to be expressed in terms of address ranges in mplsFTNTable because they have the following advantages.

- The number of CIDR prefixes needed to represent some address ranges is very large. For example, we need the following 6 CIDR prefixes to represent the range of addresses [192.0.2.0-192.0.2.62]: 192.0.2.0/27, 192.0.2.32/28, 192.0.2.48/29, 192.0.2.56/30, 192.0.2.60/31, and 192.0.2.62/32. A rule such as "redirect all packets with a source address in the range [192.0.2.0-192.0.2.62] and destination address in the range [192.0.2.128-192.0.2.190] to tunnel #2" would require the creation

of 36 conceptual rows in mplsFTNTable if the rules were expressed as CIDR prefixes, but only a single conceptual row would be required if we used address ranges instead.

- Every CIDR prefix can be expressed as a single equivalent address range.

- A particular implementation is free to translate the address ranges specified in mplsFTNTable internally to equivalent CIDR prefixes, if it so chooses. However, given that powerful range matching algorithms are available, many implementations may prefer to implement these directly.

5.2. mplsFTNMapTable

This table provides the capability to activate or map FTN entries defined in mplsFTNTable to specific interfaces in the system. Packets received on an interface are compared against FTN entries in the order in which entries are applied to the interface.

5.2.1. Indexing Requirements

The indexing structure of mplsFTNMapTable was designed to satisfy the following requirements.

- We must be able to insert a new entry into an existing list of entries on an interface with a single SET operation. Thus, we must be able to support an insertion operation that does not require manual reindexing of existing entries.

- A management application must be able to traverse entries that have been applied to a particular interface in the order of application. The number of (non-bulk) retrieval operations to obtain this information as dictated by the particular indexing scheme that we choose for mplsFTNMapTable must be no more than that dictated by any other indexing scheme. For example, the indexing scheme must not force the Network Management Application to retrieve all the entries in the table and sift through them offline to obtain this information.

5.2.2. How the Current Indexing Works

The natural data-structure for implementing constant time insertions between two existing entries and for supporting in-order traversals is a linked-list.

The chosen indexing structure of mplsFTNMapTable makes the entries in the table behave like items in a linked-list. Each conceptual row

has an object, mplsFTNMapPrevIndex, which is a pointer to the previous entry that is applied to a particular interface. This object is self-adjusting, i.e., its value is automatically adjusted by the agent, if necessary, after an insertion or deletion operation.

This indexing scheme provides a mechanism to 'insert' an FTN entry between two existing entries already applied on an interface. This is done by specifying the entry after which a new entry should be inserted in mplsFTNMapPrevIndex.

Using this linked-list structure, one can retrieve FTN entries in the order of application on a per-interface basis as follows:

- To determine the first FTN entry on an interface with index ifIndex, perform a GETNEXT retrieval operation on mplsFTNMapRowStatus.ifIndex.0.0; the returned object, if one exists, is (say) mplsFTNMapRowStatus.ifIndex.0.n (mplsFTNMapRowStatus is the first accessible columnar object in the conceptual row). Then, the index of the first FTN entry applied on this interface is n.

- To determine the FTN entry applied to an interface after the one indexed by n, perform a GETNEXT retrieval operation on mplsFTNMapRowStatus.ifIndex.n.0. If such an entry exists, the returned object would be of the form mplsFTNMapRowStatus.ifIndex.n.m. Then, the index of the next FTN entry applied on this interface is m.

- If the FTN entry indexed by n is the last entry applied to the interface with index ifIndex, then the object returned would either be:

  1. mplsFTNMapRowStatus.ifIndexNext.0.k, where ifIndexNext is the index of the next interface in ifTable to which an FTN entry has been applied, in which case k is the index of the first FTN entry applied to the interface with index ifIndexNext;

  or:

  2. mplsFTNMapStorageType.firstIfIndex.0.p, if there are no more entries in mplsFTNMapTable, where firstIfIndex is the first entry in ifTable to which an FTN entry has been mapped.

The above steps can be used to retrieve all the applied entries on a per-interface basis in application order. Note that the number of retrieval operations is equal to the number of applied FTN entries (i.e., the minimum number of GETNEXT operations needed using any indexing scheme).

Also note that we could not have created this linked-list structure using a 'next' pointer object instead of the 'previous' pointer object that we chose because this would not allow us to determine the first FTN entry that has been mapped to a specific interface using a single SNMP (non-bulk) retrieval operation.

The use of this indexing structure is further illustrated using an example in Section 7.

5.3. mplsFTNPerfTable

If an FTN entry has been applied to one or more interfaces, this table provides high-capacity performance counters to monitor each such FTN entry on a per-interface basis.

6. Avoiding Retrieval-Modification Interactions

The problem of an ongoing traversal or retrieval operation on an SNMP table being affected by a concurrent modification operation on that table is not unique to this MIB module. However, it is useful to note that a cautious application can keep track of the state of the modifiable tables in this MIB module using the objects mplsFTNTableLastChanged and mplsFTNMapTableLastChanged.

For instance, before performing a traversal of mplsFTNMapTable, the application should retrieve the value of mplsFTNMapTableLastChanged. Each subsequent GETNEXT operation on the table should include this object as well. For example, GETNEXT(mplsFTNMapTableLastChanged.0, mplsFTNMapRowStatus.ifIndex.n.0) can be used to:

- Determine the FTN entry after the one indexed by n (in linked-list order) mapped to the interface with index ifIndex, as explained in Section 5.2.2;

- Verify that the value of mplsFTNMapTable has not been modified during the retrieval process by comparing the value of mplsFTNMapTableLastChanged retrieved by this operation with the value retrieved before the traversal was begun.

Using this technique, an application can ensure the validity of the retrieved information with minimal overhead. This is particularly important while retrieving information from frequently modified tables.

7. Example Illustrating MIB Module Components

In this section, we use an example to illustrate how the objects defined in MPLS-FTN-STD-MIB work together to perform FEC to NHLFE mapping.

Note that for the various table entries involved in this example, we only show the objects that help illustrate each case.

7.1. Sample FTN Rules

Suppose that we wish to activate the following two FTN rules.

Rule #1: On interface ifIndex = 1, redirect packets with source IPv4 address matching 192.0.2.63 to an LSP with outgoing ifIndex = 50 and outgoing label = 150 where the specified LSP is represented by the following entries in mplsXCTable and mplsOutSegmentTable.

In mplsXCTable:

```
{
   mplsXCIndex = 0x02,
   mplsXCInSegmentIndex = 0x00,
   mplsXCOutSegmentIndex = 0x03,
   mplsXCLabelStackIndex = 0
}
```

The value 0x00 for mplsXCInSegmentIndex represents an originating LSP [RFC3813].

In mplsOutSegmentTable:

```
{
   mplsOutSegmentIndex = 0x03,
   mplsOutSegmentIfIndex = 50,
   mplsOutSegmentPushTopLabel = true,
   mplsOutSegmentTopLabel = 150
}
```

Rule #2: On interface ifIndex = 1, redirect packets with destination IPv4 addresses in the range [192.0.2.32, 192.0.2.96] to tunnel #4, where the specified tunnel is represented by the following entry in mplsTunnelTable:

```
   {
      mplsTunnelIndex = 4,
      -- primary tunnel
      mplsTunnelInstance = 0,
      mplsTunnelIngressLSRID = 192.0.2.1,
      mplsTunnelEgressLSRID = 192.0.2.2
   }
```

7.2. Creating FTN Entries and Applying them to Interfaces

The action "redirect packets with source IPv4 address matching 192.0.2.63 to an LSP with outgoing ifIndex = 50 and outgoing label = 150" in Rule #1 can be implemented by the following entry in mplsFTNTable:

```
   {
      mplsFTNIndex = 1,
      mplsFTNDescr = "Rule #1",
      -- source address only
      mplsFTNMask = 0x80,
      mplsFTNAddrType = ipv4,
      mplsFTNSourceAddrMin = 192.0.2.63,
      mplsFTNSourceAddrMax = 192.0.2.63,
      mplsFTNActionType = redirectLsp(1),
      mplsFTNActionPointer = mplsXCLspId.1.2.1.0.1.3
   }
```

This indicates to which LSP the LSR should redirect packets by setting mplsFTNActionPointer to the first accessible columnar object instance in mplsXCEntry that corresponds of the LSP to use, in this case mplsXCLspId.1.2.1.0.1.3.

This action is then activated on "interface ifIndex = 1" by the following entry in mplsFTNMapTable to complete the implementation of Rule #1:

```
   {
      -- apply rule to interface ifIndex = 1
      mplsFTNMapIndex = 1,
      -- first FTN entry on this interface
      mplsFTNPrevIndex = 0,
      -- index of current entry in mplsFTNTable, i.e., Rule #1
      mplsFTNMapCurrIndex = 1
   }
```

The action "redirect packets with destination IPv4 addresses in the range [192.0.2.32, 192.0.2.96] to tunnel #4" in Rule #2 can be implemented by the following entry in mplsFTNTable:

```
   {
      mplsFTNIndex = 2,
      mplsFTNDescr = "Rule #2",
      -- destination address only
      mplsFTNMask = 0x40,
      mplsFTNAddrType = ipv4,
      mplsFTNDestAddrMin = 192.0.2.32,
      mplsFTNDestAddrMax = 192.0.2.96,
      mplsFTNActionType = redirectTunnel(2),
      mplsFTNActionPointer = mplsTunnelName.4.0.3221225985.3221225986
   }
```

where 3221225985 and 3221225986 are representations of the addresses 192.0.2.1 and 192.0.2.2, respectively, as Unsigned32 (the underlying data type) entities.

This rule needs to be activated on "interface ifIndex = 1" after Rule #1 which was previously activated on this interface. This is done by the following entry in mplsFTNMapTable to complete the implementation of Rule #2:

```
   {
      -- apply rule to interface ifIndex = 1
      mplsFTNMapIndex = 1,
      -- insert after Rule #1 (mplsFTNIndex = 1)
      mplsFTNPrevIndex = 1,
      -- index of current entry in mplsFTNTable, i.e., Rule #2
      mplsFTNMapCurrIndex = 2
   }
```

7.3. Mapping an FTN Entry to Multiple Interfaces

Suppose we now wish to activate the following rule:

> Rule #2b: On interface ifIndex = 2, redirect packets with destination IPv4 addresses in the range [192.0.2.32, 192.0.2.96] to tunnel #4.

Notice that the FEC and corresponding action associated with this rule (i.e., "redirect packets with destination IPv4 addresses in the range [192.0.2.32, 192.0.2.96] to tunnel #4") are the same as that associated with Rule #2. Hence, we can reuse the existing entry with mplsFTNIndex = 2 from mplsFTNTable.

However, we have to create the following new entry in mplsFTNMapTable to activate this FTN entry as the first one on the interface with ifIndex = 2.

```
{
   -- apply rule to interface ifIndex = 2
   mplsFTNMapIndex = 2,
   -- first FTN entry on this interface
   mplsFTNPrevIndex = 0,
   -- index of current entry in mplsFTNTable
   mplsFTNMapCurrIndex = 2
}
```

7.4. Inserting an Entry Into Existing List

At a later point, suppose that we wish to introduce the following Rule between Rules #1 and #2.

> Rule #3: On interface ifIndex = 1, redirect all packets with destination IPv4 address matching the prefix 192.0.2.32/28 to tunnel #3, where the tunnel we wish to redirect traffic to is represented by the following entry in mplsTunnelTable:
>
> ```
> {
>    mplsTunnelIndex = 3,
>    -- primary tunnel
>    mplsTunnelInstance = 0,
>    mplsTunnelIngressLSRID = 192.0.2.3,
>    mplsTunnelEgressLSRID = 192.0.2.4
> }
> ```

Note that the ordering of the rules on a particular interface is critical since the range of addresses specified in Rule #3 is a subset of the ones specified in Rule #2.

Without the linked-list style insertion feature supported by mplsFTNMapTable, we would possibly have had to reindex existing entries (or plan for such changes by leaving sufficient gaps between indexes, something that only postpones the problem). With the existing tables, we solve this problem by creating the following entries.

We implement the phrase "redirect all packets with destination IPv4 address matching the prefix 1.4.0.0/16 to tunnel #3" in Rule #3 by creating the following entry in mplsFTNTable:

```
   {
      mplsFTNIndex = 3,
      mplsFTNDescr = "Rule #3",
      -- destination address only
      mplsFTNMask = 0x40,
      mplsFTNAddrType = ipv4,
      -- address range equivalent to CIDR prefix 192.0.2.32/28
      mplsFTNDestAddrMin = 192.0.2.32,
      mplsFTNDestAddrMax = 192.0.2.47,
      mplsFTNActionType = redirectTunnel,
      mplsFTNActionPointer = mplsTunnelName.3.0.3221225987.3221225988
   }
```

where 3221225987 and 3221225988 are representations of the addresses 192.0.2.3 and 192.0.2.4, respectively, as Unsigned32 (the underlying data type) entities.

We next insert this rule in mplsFTNMapTable just after Rule #1 as follows:

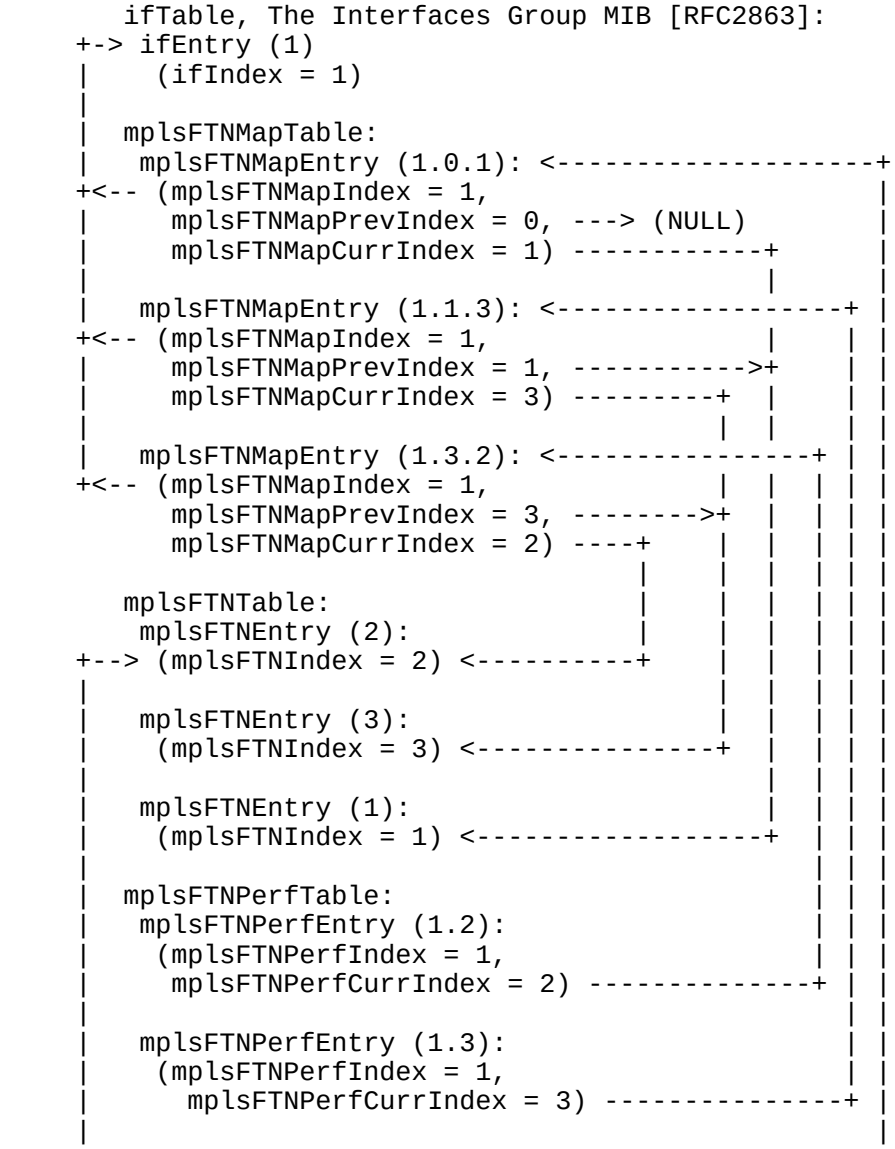
```
   {
      -- apply rule to interface ifIndex = 1
      mplsFTNMapIndex = 1,
      -- insert after Rule #1 (mplsFTNIndex = 1)
      mplsFTNPrevIndex = 1,
      -- index of current entry in mplsFTNTable i.e., Rule #3
      mplsFTNMapCurrIndex = 3
   }
```

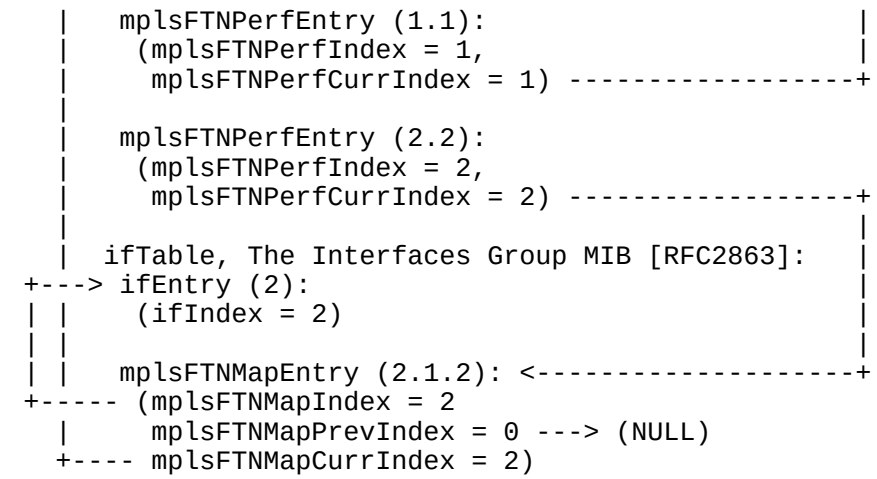
After the insertion of Rule #3 in mplsFTNMapTable, the 'previous' pointer object mplsFTNMapPrevIndex of the next entry (corresponding to Rule #2) adjusts automatically to point to this entry.

Note that, of the existing entries in the table, the only one that is impacted by an insertion operation is the entry on that particular interface immediately after the newly inserted one, if one exists. None of the other entries in mplsFTNMapTable are impacted. For instance, in this particular example, when the entry for Rule #3 was inserted between those for Rules #1 and #2, the entries for Rules #1 and #2b were not impacted.

7.5. Pictorial Tabular Relationship

At this point, the relationship between different table entries can be represented pictorially as follows. For each conceptual row instance, we show the table that it belongs to, along with its indices in parentheses. (Note that various conceptual rows are depicted in a way that is convenient for showing the interrelationships and are not necessarily in lexicographical order.)



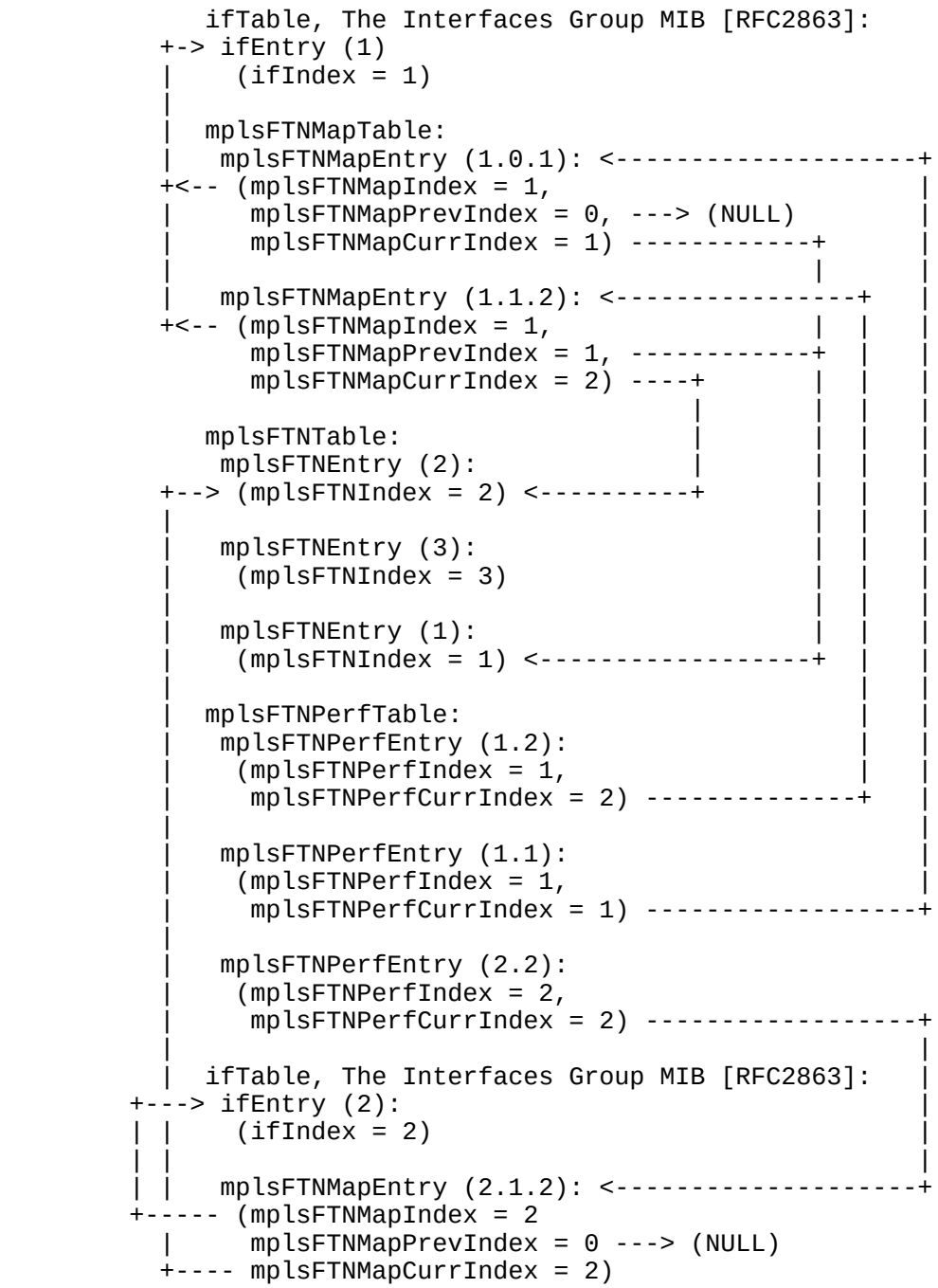


7.6. Deleting an Entry

Let us next look at how we can remove the recently applied Rule #3 and how the existing conceptual rows behave in this situation.

The conceptual row corresponding to the application of Rule #3 to interface ifIndex = 1 has the following index values: mplsFTNMapIndex = 1, mplsFTNMapPrevIndex = 1, and mplsFTNMapCurrIndex = 3. To delete this conceptual row, the Network Management Application performs a SET operation setting the object instance mplsFTNMapRowStatus.1.1.3 to the value destroy(6). The agent then destroys this conceptual row. It also automatically adjusts the object instance of mplsFTNMapPrevIndex corresponding to Rule #2 from the value 3 (i.e., pointing to the recently destroyed Rule #3) to the value 1 (i.e., to Rule #1).

At this point, the rules applied to interface ifIndex = 1 are Rule #1 and Rule #2, in that order. The relationship between different table entries can be represented pictorially as follows.


ifTable, The Interfaces Group MIB [RFC2863]:
ifEntry (1)
(ifIndex = 1)
mplsFTNMapTable:
mplsFTNMapEntry (1.0.1):
(mplsFTNMapIndex = 1,
mplsFTNMapPrevIndex = 0, ---> (NULL)
mplsFTNMapCurrIndex = 1)
mplsFTNMapEntry (1.1.2):
(mplsFTNMapIndex = 1,
mplsFTNMapPrevIndex = 1,
mplsFTNMapCurrIndex = 2)
mplsFTNTable:
mplsFTNEntry (2):
(mplsFTNIndex = 2)
mplsFTNEntry (3):
(mplsFTNIndex = 3)
mplsFTNEntry (1):
(mplsFTNIndex = 1)
mplsFTNPerfTable:
mplsFTNPerfEntry (1.2):
(mplsFTNPerfIndex = 1,
mplsFTNPerfCurrIndex = 2)
mplsFTNPerfEntry (1.1):
(mplsFTNPerfIndex = 1,
mplsFTNPerfCurrIndex = 1)
mplsFTNPerfEntry (2.2):
(mplsFTNPerfIndex = 2,
mplsFTNPerfCurrIndex = 2)
ifTable, The Interfaces Group MIB [RFC2863]:
ifEntry (2):
(ifIndex = 2)
mplsFTNMapEntry (2.1.2):
(mplsFTNMapIndex = 2
mplsFTNMapPrevIndex = 0 ---> (NULL)
mplsFTNMapCurrIndex = 2)

Note that the FTN entry for Rule #3 still exists in mplsFTNTable at this point but is not referenced by any conceptual row in mplsFTNMapTable or mplsFTNPerfTable.

Also note that the deletion of an entry from mplsFTNMapTable only impacts the entry on that particular interface immediately after the deleted entry, if one exists. None of the other conceptual rows in mplsFTNMapTable are impacted. For instance, in this particular example, when the entry for Rule #3 was deleted, the entries for Rules #1 and #2b were not impacted.

8. The Use of RowPointer

RowPointer is a textual convention used to identify a conceptual row in a conceptual table in a MIB by pointing to the first accessible object. In this MIB module, in mplsFTNTable, the RowPointer object mplsFTNActionPointer indicates the LSP or TE Tunnel to redirect packets matching an FTN entry to. This object MUST point to the first instance of the first accessible columnar object in the appropriate conceptual row in order to allow the manager to find the appropriate corresponding entry in either MPLS-LSR-STD-MIB [RFC3813] or MPLS-TE-STD-MIB [RFC3812]. If this object returns zeroDotZerok, it implies that there is no currently defined action that is associated with that particular FTN entry.

9. MPLS-FTN-STD-MIB Definitions

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

IMPORTS
   MODULE-IDENTITY, OBJECT-TYPE, Unsigned32, Counter64, Integer32
       FROM SNMPv2-SMI                                    -- [RFC2578]
   RowStatus, StorageType, RowPointer,
   TEXTUAL-CONVENTION, TimeStamp
       FROM SNMPv2-TC                                     -- [RFC2579]
   MODULE-COMPLIANCE, OBJECT-GROUP
       FROM SNMPv2-CONF                                   -- [RFC2580]
   InterfaceIndexOrZero,
   ifGeneralInformationGroup, ifCounterDiscontinuityGroup
       FROM IF-MIB                                        -- [RFC2863]
   SnmpAdminString
       FROM SNMP-FRAMEWORK-MIB                            -- [RFC3411]
   Dscp
       FROM DIFFSERV-DSCP-TC                              -- [RFC3289]
   InetAddressType, InetAddress, InetPortNumber
       FROM INET-ADDRESS-MIB                              -- [RFC3291]
   mplsStdMIB
       FROM MPLS-TC-STD-MIB                               -- [RFC3811]
```

```
      ;

   mplsFTNStdMIB MODULE-IDENTITY
      LAST-UPDATED "200406030000Z"  -- June 6, 2004
      ORGANIZATION "Multiprotocol Label Switching (MPLS) Working Group"
      CONTACT-INFO
          "
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           IETF MPLS Working Group email: mpls@uu.net"

      DESCRIPTION
           "Copyright (C) The Internet Society (2004). The
           initial version of this MIB module was published
           in RFC 3814. For full legal notices see the RFC
           itself or see:
           http://www.ietf.org/copyrights/ianamib.html

           This MIB module contains managed object definitions for
           specifying FEC to NHLFE (FTN) mappings and corresponding
           performance for MPLS."

      -- Revision history.

      REVISION
          "200406030000Z"  -- June 3, 2004

      DESCRIPTION
          "Initial version issued as part of RFC 3814."
```

```
       ::= { mplsStdMIB 8 }

   -- TEXTUAL-CONVENTIONs used in this MIB.
   MplsFTNEntryIndex ::= TEXTUAL-CONVENTION
      STATUS              current
      DESCRIPTION
          "Index for an entry in mplsFTNTable."
      SYNTAX              Unsigned32 (1..4294967295)

   MplsFTNEntryIndexOrZero ::= TEXTUAL-CONVENTION
      STATUS              current
      DESCRIPTION
          "Index for an entry in mplsFTNTable or the special value
           zero. The value zero is object-specific and must
           therefore be defined as part of the description of any
           object which uses this syntax.  Examples of the usage
           of zero might include situations when none or all
           entries in mplsFTNTable need to be referenced."
      SYNTAX              Unsigned32 (0..4294967295)

   -- Top-Level Components of this MIB.

   mplsFTNNotifications OBJECT IDENTIFIER ::= { mplsFTNStdMIB 0 }
   mplsFTNObjects       OBJECT IDENTIFIER ::= { mplsFTNStdMIB 1 }
   mplsFTNConformance   OBJECT IDENTIFIER ::= { mplsFTNStdMIB 2 }

   -- Next free index in mplsFTNTable.
   mplsFTNIndexNext OBJECT-TYPE
      SYNTAX              MplsFTNEntryIndexOrZero
      MAX-ACCESS          read-only
      STATUS              current
      DESCRIPTION
          "This object contains the next available valid value to
           be used for mplsFTNIndex when creating entries in the
           mplsFTNTable.

           When creating a new conceptual row (configuration
           entry) in mplsFTNTable with an SNMP SET operation the
           command generator (Network Management Application) must
           first issue a management protocol retrieval operation
           to obtain the current value of this object.

           If the command responder (agent) does not wish to allow
           creation of more entries in mplsFTNTable, possibly
           because of resource exhaustion, this object MUST return
           a value of 0.

           If a non-zero value is returned the Network Management
```

```
            Application must determine whether the value is indeed
            still unused since two Network Management Applications
            may attempt to create a row simultaneously and use the
            same value.

            If it is currently unused and the SET succeeds, the
            agent MUST change the value of this object to a
            currently unused non-zero value (according to an
            implementation specific algorithm) or zero (if no
            further row creation will be permitted).

            If the value is in use, however, the SET fails and the
            Network Management Application must then reread this
            object to obtain a new usable value."
        ::= { mplsFTNObjects 1 }

    -- Last time an object in mplsFTNTable changed.
    mplsFTNTableLastChanged OBJECT-TYPE
        SYNTAX              TimeStamp
        MAX-ACCESS          read-only
        STATUS              current
        DESCRIPTION
            "Indicates the last time an entry was added, deleted or
             modified in mplsFTNTable.  Management stations should
             consult this object to determine if mplsFTNTable
             requires their attention.  This object is particularly
             useful for applications performing a retrieval on
             mplsFTNTable to ensure that the table is not modified
             during the retrieval operation."
        ::=  { mplsFTNObjects 2 }

    -- Table of FTN entries.
    mplsFTNTable  OBJECT-TYPE
        SYNTAX          SEQUENCE OF MplsFTNEntry
        MAX-ACCESS      not-accessible
        STATUS          current
        DESCRIPTION
            "This table contains the currently defined FTN entries.
             This table allows FEC to NHLFE mappings to be
             specified.  Each entry in this table defines a rule to
             be applied to incoming packets (on interfaces that the
             FTN entry is activated on using mplsFTNMapTable) and an
             action to be taken on matching packets
             (mplsFTNActionPointer).

             This table supports 6-tuple matching rules based on one
             or more of source address range, destination address
             range, source port range, destination port range, IPv4
```

```
            Protocol field or IPv6 next-header field and the
            DiffServ Code Point (DSCP) to be specified.

            The action pointer points either to instance of
            mplsXCEntry in MPLS-LSR-STD-MIB when the NHLFE is a non-
            TE LSP, or to an instance of mplsTunnelEntry in the
            MPLS-TE-STD-MIB when the NHLFE is an originating TE
            tunnel."
        REFERENCE
            "J. Postel, Internet Protocol, RFC 791, STD 5, September
            1981

            Deering, S., and R. Hinden, Internet Protocol, Version
            6 (IPv6) Specification, RFC 2460, December 1998

            Nichols, K, Blake, S., Baker, F. and D. Black,
            Definition of the Differentiated Services Field (DS
            Field) in the IPv4 and IPv6 Headers, RFC 2474, December
            1998

            Srinivasan, C., A. Viswanathan, and T. Nadeau, MPLS
            Label Switch Router Management Information Base,
            RFC 3813

            Srinivasan, C., A. Viswanathan, and T. Nadeau, MPLS
            Traffic Engineering Management Information Base,
            RFC 3812"
        ::=  { mplsFTNObjects 3 }

    mplsFTNEntry  OBJECT-TYPE
        SYNTAX          MplsFTNEntry
        MAX-ACCESS      not-accessible
        STATUS          current
        DESCRIPTION
            "Each entry represents one FTN entry which defines a
             rule to compare incoming packets with and an action to
             be taken on matching packets."
        INDEX { mplsFTNIndex }
        ::=  { mplsFTNTable 1 }

    MplsFTNEntry  ::=  SEQUENCE {
          mplsFTNIndex               MplsFTNEntryIndex,
          mplsFTNRowStatus           RowStatus,
          mplsFTNDescr               SnmpAdminString,
          mplsFTNMask                BITS,
          mplsFTNAddrType            InetAddressType,
          mplsFTNSourceAddrMin       InetAddress,
          mplsFTNSourceAddrMax       InetAddress,
```

```
        mplsFTNDestAddrMin         InetAddress,
        mplsFTNDestAddrMax         InetAddress,
        mplsFTNSourcePortMin       InetPortNumber,
        mplsFTNSourcePortMax       InetPortNumber,
        mplsFTNDestPortMin         InetPortNumber,
        mplsFTNDestPortMax         InetPortNumber,
        mplsFTNProtocol            Integer32,
        mplsFTNDscp                Dscp,
        mplsFTNActionType          INTEGER,
        mplsFTNActionPointer       RowPointer,
        mplsFTNStorageType         StorageType
     }

   mplsFTNIndex   OBJECT-TYPE
      SYNTAX             MplsFTNEntryIndex
      MAX-ACCESS         not-accessible
      STATUS             current
      DESCRIPTION
          "This is the unique index for a conceptual row in
           mplsFTNTable.

           To create a new conceptual row in mplsFTNTable a
           Network Management Application SHOULD retrieve the
           current value of mplsFTNIndexNext to determine the next
           valid available value of mplsFTNIndex."
      ::= { mplsFTNEntry 1 }

   mplsFTNRowStatus OBJECT-TYPE
      SYNTAX             RowStatus
      MAX-ACCESS         read-create
      STATUS             current
      DESCRIPTION
          "Used for controlling the creation and deletion of this
           row. All writeable objects in this row may be modified
           at any time. If a Network Management Application
           attempts to delete a conceptual row by setting this
           object to 'destroy' and there are one or more entries
           in mplsFTNMapTable pointing to the row (i.e., when
           mplsFTNIndex of the conceptual row being deleted is
           equal to mplsFTNMapCurrIndex for one or more entries in
           mplsFTNMapTable), the agent MUST also destroy the
           corresponding entries in mplsFTNMapTable."
      ::= { mplsFTNEntry 2 }

   mplsFTNDescr   OBJECT-TYPE
      SYNTAX             SnmpAdminString
      MAX-ACCESS         read-create
      STATUS             current
```

```
      DESCRIPTION
          "The description of this FTN entry. Since the index for
           this table has no particular significance or meaning,
           this object should contain some meaningful text that an
           operator could use to further distinguish entries in
           this table."
      ::= { mplsFTNEntry 3 }

   mplsFTNMask OBJECT-TYPE
      SYNTAX             BITS {
                          sourceAddr(0),
                          destAddr(1),
                          sourcePort(2),
                          destPort(3),
                          protocol(4),
                          dscp(5)
                         }
      MAX-ACCESS          read-create
      STATUS              current
      DESCRIPTION
          "This bit map indicates which of the fields described
           next, namely source address range, destination address
           range, source port range, destination port range, IPv4
           Protocol field or IPv6 next-header field and
           Differentiated Services Code Point (DSCP) is active for
           this FTN entry. If a particular bit is set to zero then
           the corresponding field in the packet MUST be ignored
           for comparison purposes."
      ::= { mplsFTNEntry 4 }

   mplsFTNAddrType OBJECT-TYPE
      SYNTAX             InetAddressType
      MAX-ACCESS         read-create
      STATUS             current
      DESCRIPTION
          "This object determines the type of address contained in
           the source and destination address objects
           (mplsFTNSourceAddrMin, mplsFTNSourceAddrMax,
           mplsFTNDestAddrMin and mplsFTNDestAddrMax) of a
           conceptual row.

           This object MUST NOT be set to unknown(0) when
           mplsFTNMask has bit positions sourceAddr(0) or
           destAddr(1) set to one.

           When both these bit positions of mplsFTNMask are set to
           zero the value of mplsFTNAddrType SHOULD be set to
           unknown(0) and the corresponding source and destination
```

```
            address objects SHOULD be set to zero-length strings."
        ::= { mplsFTNEntry 5 }

    mplsFTNSourceAddrMin OBJECT-TYPE
        SYNTAX              InetAddress
        MAX-ACCESS          read-create
        STATUS              current
        DESCRIPTION
            "The lower end of the source address range. The type of
             this object is determined by the corresponding
             mplsFTNAddrType object."
        ::= { mplsFTNEntry 6 }

    mplsFTNSourceAddrMax OBJECT-TYPE
        SYNTAX              InetAddress
        MAX-ACCESS          read-create
        STATUS              current
        DESCRIPTION
            "The upper end of the source address range. The type of
             this object is determined by the corresponding
             mplsFTNAddrType object."
        ::= { mplsFTNEntry 7 }

    mplsFTNDestAddrMin OBJECT-TYPE
        SYNTAX              InetAddress
        MAX-ACCESS          read-create
        STATUS              current
        DESCRIPTION
            "The lower end of the destination address range. The
             type of this object is determined by the corresponding
             mplsFTNAddrType object."
        ::= { mplsFTNEntry 8 }

    mplsFTNDestAddrMax OBJECT-TYPE
        SYNTAX              InetAddress
        MAX-ACCESS          read-create
        STATUS              current
        DESCRIPTION
            "The higher end of the destination address range. The
             type of this object is determined by the corresponding
             mplsFTNAddrType object."
        ::= { mplsFTNEntry 9 }

    mplsFTNSourcePortMin OBJECT-TYPE
        SYNTAX              InetPortNumber
        MAX-ACCESS          read-create
        STATUS              current
        DESCRIPTION
```

```
            "The lower end of the source port range."
        DEFVAL { 0 }
        ::= { mplsFTNEntry 10 }

    mplsFTNSourcePortMax OBJECT-TYPE
        SYNTAX             InetPortNumber
        MAX-ACCESS         read-create
        STATUS             current
        DESCRIPTION
            "The higher end of the source port range "
        DEFVAL { 65535 }
        ::= { mplsFTNEntry 11 }

    mplsFTNDestPortMin OBJECT-TYPE
        SYNTAX             InetPortNumber
        MAX-ACCESS         read-create
        STATUS             current
        DESCRIPTION
            "The lower end of the destination port range."
        DEFVAL { 0 }
        ::= { mplsFTNEntry 12 }

    mplsFTNDestPortMax OBJECT-TYPE
        SYNTAX             InetPortNumber
        MAX-ACCESS         read-create
        STATUS             current
        DESCRIPTION
            "The higher end of the destination port range."
        DEFVAL { 65535 }
        ::= { mplsFTNEntry 13 }

    mplsFTNProtocol OBJECT-TYPE
        SYNTAX             Integer32 (0..255)
        MAX-ACCESS         read-create
        STATUS             current
        DESCRIPTION
            "The IP protocol to match against the IPv4 protocol
             number or IPv6 Next-Header number in the packet. A
             value of 255 means match all.  Note that the protocol
             number of 255 is reserved by IANA, and Next-Header
             number of 0 is used in IPv6."
        DEFVAL { 255 }
        ::= { mplsFTNEntry 14 }

    mplsFTNDscp OBJECT-TYPE
        SYNTAX             Dscp
        MAX-ACCESS         read-create
        STATUS             current
```

```
      DESCRIPTION
          "The contents of the DSCP field."
      REFERENCE
          "Nichols, K., Blake, S., Baker, F. and D. Black,
           Definition of the Differentiated Services Field (DS
           Field) in the IPv4 and IPv6 Headers, RFC 2474, December
           1998."
      ::= { mplsFTNEntry 15 }

   mplsFTNActionType OBJECT-TYPE
      SYNTAX    INTEGER {
                   redirectLsp(1),   -- redirect into LSP
                   redirectTunnel(2) -- redirect into tunnel
                }
      MAX-ACCESS         read-create
      STATUS             current
      DESCRIPTION
          "The type of action to be taken on packets matching this
           FTN entry."
      ::= { mplsFTNEntry 16 }

   mplsFTNActionPointer OBJECT-TYPE
      SYNTAX             RowPointer
      MAX-ACCESS         read-create
      STATUS             current
      DESCRIPTION
          "If mplsFTNActionType is redirectLsp(1), then this
           object MUST contain zeroDotZero or point to a instance
           of mplsXCEntry indicating the LSP to redirect matching
           packets to.

           If mplsFTNActionType is redirectTunnel(2), then this
           object MUST contain zeroDotZero or point to a instance
           of mplsTunnelEntry indicating the MPLS TE tunnel to
           redirect matching packets to.

           If this object points to a conceptual row instance in a
           table consistent with mplsFTNActionType but this
           instance does not currently exist then no action will
           be taken on packets matching such an FTN entry till
           this instance comes into existence.

           If this object contains zeroDotZero then no action will
           be taken on packets matching such an FTN entry till it
           is populated with a valid pointer consistent with the
           value of mplsFTNActionType as explained above."
      ::= { mplsFTNEntry 17 }
```

```
   mplsFTNStorageType OBJECT-TYPE
      SYNTAX             StorageType
      MAX-ACCESS         read-create
      STATUS             current
      DESCRIPTION
          "The storage type for this FTN entry. Conceptual rows
           having the value 'permanent' need not allow write-
           access to any columnar objects in the row."
      DEFVAL { nonVolatile }
      ::= { mplsFTNEntry 18 }

   -- End of mplsFTNTable.

   -- Last time an object in mplsFTNMapTable changed.

   mplsFTNMapTableLastChanged OBJECT-TYPE
      SYNTAX              TimeStamp
      MAX-ACCESS          read-only
      STATUS              current
      DESCRIPTION
          "Indicates the last time an entry was added, deleted or
           modified in mplsFTNMapTable. Management stations should
           consult this object to determine if the table requires
           their attention.  This object is particularly useful
           for applications performing a retrieval on
           mplsFTNMapTable to ensure that the table is not
           modified during the retrieval operation."
      ::=  { mplsFTNObjects 4 }

   -- FTN to interface mapping table.

   mplsFTNMapTable OBJECT-TYPE
      SYNTAX              SEQUENCE OF MplsFTNMapEntry
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "This table contains objects which provide the
           capability to apply or map FTN rules as defined by
           entries in mplsFTNTable to specific interfaces in the
           system.  FTN rules are compared with incoming packets
           in the order in which they are applied on an interface.

           The indexing structure of mplsFTNMapTable is as
           follows.

           - mplsFTNMapIndex indicates the interface to which the
             rule is being applied.  A value of 0 represents the
             application of the rule to all interfaces.
```

- mplsFTNMapPrevIndex specifies the rule on the interface prior to the one being applied. A value of 0 specifies that the rule is being inserted at the head of the list of rules currently applied to the interface.

- mplsFTNMapCurrIndex is the index in mplsFTNTable corresponding to the rule being applied.

This indexing structure makes the entries in the table behave like items in a linked-list. The object mplsFTNMapPrevIndex in each conceptual row is a pointer to the previous entry that is applied to a particular interface. This allows a new entry to be 'inserted' at an arbitrary position in a list of entries currently applied to an interface. This object is self-adjusting, i.e., its value is automatically adjusted by the agent, if necessary, after an insertion or deletion operation.

Using this linked-list structure, one can retrieve FTN entries in the order of application on a per-interface basis as follows:

- To determine the first FTN entry on an interface with index ifIndex perform a GETNEXT retrieval operation on mplsFTNMapRowStatus.ifIndex.0.0; the returned object, if one exists, is (say) mplsFTNMapRowStatus.ifIndex.0.n (mplsFTNMapRowStatus is the first accessible columnar object in the conceptual row). Then the index of the first FTN entry applied on this interface is n.

- To determine the FTN entry applied to an interface after the one indexed by n perform a GETNEXT retrieval operation on mplsFTNMapRowStatus.ifIndex.n.0. If such an entry exists the returned object would be of the form mplsFTNMapRowStatus.ifIndex.n.m. Then the index of the next FTN entry applied on this interface is m.

- If the FTN entry indexed by n is the last entry applied to the interface with index ifIndex then the object returned would either be:

  1.mplsFTNMapRowStatus.ifIndexNext.0.k, where ifIndexNext is the index of the next interface in

```
              ifTable to which an FTN entry has been applied, in
              which case k is the index of the first FTN entry
              applied to the interface with index ifIndexNext;

            or:

            2.mplsFTNMapStorageType.firstIfIndex.0.p, if there
              are no more entries in mplsFTNMapTable, where
              firstIfIndex is the first entry in ifTable to
              which an FTN entry has been mapped.

          Use the above steps to retrieve all the applied FTN
          entries on a per-interface basis in application order.
          Note that the number of retrieval operations is the
          same as the number of applied FTN entries (i.e., the
          minimum number of GETNEXT operations needed using any
          indexing scheme).

          Agents MUST NOT allow the same FTN entry as specified
          by mplsFTNMapCurrIndex to be applied multiple times to
          the same interface.

          Agents MUST NOT allow the creation of rows in this
          table until the corresponding rows are created in the
          mplsFTNTable.

          If a row in mplsFTNTable is destroyed, the agent MUST
          destroy the corresponding entries (i.e., ones with a
          matching value of mplsFTNCurrIndex) in this table as
          well."
      ::=  { mplsFTNObjects 5 }

   mplsFTNMapEntry OBJECT-TYPE
      SYNTAX              MplsFTNMapEntry
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "Each conceptual row represents the application of an
           FTN rule at a specific position in the list of FTN
           rules applied on an interface. "
      INDEX {
            mplsFTNMapIndex,
            mplsFTNMapPrevIndex,
            mplsFTNMapCurrIndex
      }
      ::=  { mplsFTNMapTable 1 }

   MplsFTNMapEntry  ::=  SEQUENCE {
```

```
        mplsFTNMapIndex       InterfaceIndexOrZero,
        mplsFTNMapPrevIndex    MplsFTNEntryIndexOrZero,
        mplsFTNMapCurrIndex    MplsFTNEntryIndex,
        mplsFTNMapRowStatus    RowStatus,
        mplsFTNMapStorageType  StorageType
     }

   mplsFTNMapIndex OBJECT-TYPE
      SYNTAX              InterfaceIndexOrZero
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "The interface index that this FTN entry is being
           applied to. A value of zero indicates an entry that is
           applied all interfaces.

           Entries mapped to an interface by specifying its (non-
           zero) interface index in mplsFTNMapIndex are applied
           ahead of entries with mplsFTNMapIndex equal to zero."
      ::= { mplsFTNMapEntry 1 }

   mplsFTNMapPrevIndex OBJECT-TYPE
      SYNTAX              MplsFTNEntryIndexOrZero
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "The index of the previous FTN entry that was applied to
           this interface. The special value zero indicates that
           this should be the first FTN entry in the list."
      ::=  { mplsFTNMapEntry 2 }

   mplsFTNMapCurrIndex OBJECT-TYPE
      SYNTAX              MplsFTNEntryIndex
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "Index of the current FTN entry that is being applied to
           this interface."
      ::=  { mplsFTNMapEntry 3 }

   mplsFTNMapRowStatus OBJECT-TYPE
      SYNTAX              RowStatus {
                                active(1),
                                createAndGo(4),
                                destroy(6)
                             }
      MAX-ACCESS          read-create
      STATUS              current
```

```
      DESCRIPTION
          "Used for controlling the creation and deletion of this
           row.

           All writable objects in this row may be modified at any
           time.

           If a conceptual row in mplsFTNMapTable points to a
           conceptual row in mplsFTNTable which is subsequently
           deleted, the corresponding conceptual row in
           mplsFTNMapTable MUST also be deleted by the agent."
      ::=  { mplsFTNMapEntry 4 }

   mplsFTNMapStorageType OBJECT-TYPE
      SYNTAX              StorageType
      MAX-ACCESS          read-create
      STATUS              current
      DESCRIPTION
          "The storage type for this entry.  Conceptual rows
           having the value 'permanent' need not allow write-
           access to any columnar objects in this row."
      DEFVAL { nonVolatile }
      ::= { mplsFTNMapEntry 5 }

   -- End of mplsFTNMapTable

   -- FTN entry performance table

   mplsFTNPerfTable OBJECT-TYPE
      SYNTAX              SEQUENCE OF MplsFTNPerfEntry
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "This table contains performance statistics on FTN
           entries on a per-interface basis."
      ::= { mplsFTNObjects 6 }

   mplsFTNPerfEntry OBJECT-TYPE
      SYNTAX              MplsFTNPerfEntry
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "Each entry contains performance information for the
           specified interface and an FTN entry mapped to this
           interface."
      INDEX  { mplsFTNPerfIndex, mplsFTNPerfCurrIndex }
      ::=  { mplsFTNPerfTable 1 }
```

```
   MplsFTNPerfEntry  ::=  SEQUENCE {
         mplsFTNPerfIndex                    InterfaceIndexOrZero,
         mplsFTNPerfCurrIndex                MplsFTNEntryIndex,
         mplsFTNPerfMatchedPackets           Counter64,
         mplsFTNPerfMatchedOctets            Counter64,
         mplsFTNPerfDiscontinuityTime        TimeStamp
      }

   mplsFTNPerfIndex OBJECT-TYPE
      SYNTAX              InterfaceIndexOrZero
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "The interface index of an interface that an FTN entry
           has been applied/mapped to.  Each instance of this
           object corresponds to an instance of mplsFTNMapIndex."
      ::= { mplsFTNPerfEntry 1 }

   mplsFTNPerfCurrIndex OBJECT-TYPE
      SYNTAX              MplsFTNEntryIndex
      MAX-ACCESS          not-accessible
      STATUS              current
      DESCRIPTION
          "Index of an FTN entry that has been applied/mapped to
           the specified interface.  Each instance of this object
           corresponds to an instance of mplsFTNMapCurrIndex."
      ::=  { mplsFTNPerfEntry 2 }

   mplsFTNPerfMatchedPackets OBJECT-TYPE
      SYNTAX              Counter64
      MAX-ACCESS          read-only
      STATUS              current
      DESCRIPTION
          "Number of packets that matched the specified FTN entry
           if it is applied/mapped to the specified interface.
           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
           mplsFTNDiscontinuityTime."
      ::= { mplsFTNPerfEntry 3 }

   mplsFTNPerfMatchedOctets OBJECT-TYPE
      SYNTAX              Counter64
      MAX-ACCESS          read-only
      STATUS              current
      DESCRIPTION
          "Number of octets that matched the specified FTN entry
           if it is applied/mapped to the specified interface.
```

```
            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
            mplsFTNDiscontinuityTime."
        ::= { mplsFTNPerfEntry 4 }

    mplsFTNPerfDiscontinuityTime 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 entry's counters suffered
             a discontinuity.  If no such discontinuities have
             occurred since the last re-initialization of the local
             management subsystem, then this object contains a zero
             value."
        ::= { mplsFTNPerfEntry 5 }

    -- End of mplsFTNPerfTable

    -- Module compliance.

    -- Top level object IDs.

    mplsFTNGroups
        OBJECT IDENTIFIER ::= { mplsFTNConformance 1 }
    mplsFTNCompliances
        OBJECT IDENTIFIER ::= { mplsFTNConformance 2 }

    -- Compliance requirement for fully compliant implementations.
    mplsFTNModuleFullCompliance MODULE-COMPLIANCE
        STATUS current
        DESCRIPTION
            "Compliance statement for agents that provide full
             support for MPLS-FTN-STD-MIB."

        MODULE IF-MIB -- The Interfaces Group MIB, RFC 2863.
        MANDATORY-GROUPS {
            ifGeneralInformationGroup,
            ifCounterDiscontinuityGroup
        }

        MODULE -- This module.
        MANDATORY-GROUPS {
            mplsFTNRuleGroup,
            mplsFTNMapGroup,
            mplsFTNPerfGroup
```

```
      }

      OBJECT mplsFTNAddrType
      SYNTAX InetAddressType { ipv4(1), ipv6(2) }
      DESCRIPTION
          "An implementation is only required to support IPv4
           and/or IPv6 addresses.  An implementation is only
           required to support the address types that are actually
           supported on the LSR."

      OBJECT mplsFTNSourceAddrMin
      SYNTAX       InetAddress (SIZE (4 | 20))
      DESCRIPTION
          "An implementation is only required to support IPv4
           and/or IPv6 addresses.  An implementation is only
           required to support the address types that are actually
           supported on the LSR."

      OBJECT mplsFTNSourceAddrMax
      SYNTAX       InetAddress (SIZE (4 | 20))
      DESCRIPTION
          "An implementation is only required to support IPv4
           and/or IPv6 addresses.  An implementation is only
           required to support the address types that are actually
           supported on the LSR."

      OBJECT mplsFTNDestAddrMin
      SYNTAX       InetAddress (SIZE (4 | 20))
      DESCRIPTION
          "An implementation is only required to support IPv4
           and/or IPv6 addresses.  An implementation is only
           required to support the address types that are actually
           supported on the LSR."

      OBJECT mplsFTNDestAddrMax
      SYNTAX       InetAddress (SIZE (4 | 20))
      DESCRIPTION
          "An implementation is only required to support IPv4
           and/or IPv6 addresses.  An implementation is only
           required to support the address types that are actually
           supported on the LSR."
      ::= { mplsFTNCompliances 1 }

   -- Compliance requirement for read-only implementations.
   mplsFTNModuleReadOnlyCompliance MODULE-COMPLIANCE
      STATUS current
      DESCRIPTION
          "Compliance requirement for implementations that only
```

```
            provide read-only support for MPLS-FTN-STD-MIB. Such
            devices can then be monitored but cannot be configured
            using this MIB module."

        MODULE IF-MIB -- The interfaces Group MIB, RFC 2863
        MANDATORY-GROUPS {
           ifGeneralInformationGroup,
           ifCounterDiscontinuityGroup
        }

        MODULE -- This module
        MANDATORY-GROUPS {
           mplsFTNRuleGroup,
           mplsFTNMapGroup,
           mplsFTNPerfGroup
        }

        OBJECT mplsFTNIndexNext
        MIN-ACCESS   not-accessible
        DESCRIPTION
            "This object is not needed when mplsFTNTable is
             implemented as read-only."

        OBJECT mplsFTNRowStatus
        SYNTAX       RowStatus { active(1) }
        MIN-ACCESS   read-only
        DESCRIPTION
            "Write access is not required, and active is the only
             status that needs to be supported."

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

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

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

        OBJECT mplsFTNSourceAddrMin
```

```
      SYNTAX       InetAddress (SIZE (4 | 20))
      MIN-ACCESS   read-only
      DESCRIPTION
          "Write access is not required. An implementation is only
           required to support IPv4 and IPv6 addresses."

      OBJECT mplsFTNSourceAddrMax
      SYNTAX       InetAddress (SIZE (4 | 20))
      MIN-ACCESS   read-only
      DESCRIPTION
          "Write access is not required. An implementation is only
           required to support IPv4 and IPv6 addresses."

      OBJECT mplsFTNDestAddrMin
      SYNTAX       InetAddress (SIZE (4 | 20))
      MIN-ACCESS   read-only
      DESCRIPTION
          "Write access is not required. An implementation is only
           required to support IPv4 and IPv6 addresses."

      OBJECT mplsFTNDestAddrMax
      SYNTAX       InetAddress (SIZE (4 | 20))
      MIN-ACCESS   read-only
      DESCRIPTION
          "Write access is not required. An implementation is only
           required to support IPv4 and IPv6 addresses."

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

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

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

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

      OBJECT mplsFTNProtocol
```

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

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

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

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

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

      OBJECT mplsFTNMapRowStatus
      SYNTAX       RowStatus { active(1) }
      MIN-ACCESS   read-only
      DESCRIPTION
          "Write access is not required, and active(1) is the only
           status that needs to be supported."

      OBJECT mplsFTNMapStorageType
      MIN-ACCESS   read-only
      DESCRIPTION
          "Write access is not required."
      ::= { mplsFTNCompliances 2 }

   -- Units of conformance.
   mplsFTNRuleGroup OBJECT-GROUP
      OBJECTS {
            mplsFTNIndexNext,
            mplsFTNTableLastChanged,
            mplsFTNRowStatus,
            mplsFTNDescr,
            mplsFTNMask,
            mplsFTNAddrType,
            mplsFTNSourceAddrMin,
            mplsFTNSourceAddrMax,
```

```
            mplsFTNDestAddrMin,
            mplsFTNDestAddrMax,
            mplsFTNSourcePortMin,
            mplsFTNSourcePortMax,
            mplsFTNDestPortMin,
            mplsFTNDestPortMax,
            mplsFTNProtocol,
            mplsFTNActionType,
            mplsFTNActionPointer,
            mplsFTNDscp,
            mplsFTNStorageType
      }
      STATUS current
      DESCRIPTION
          "Collection of objects that implement MPLS FTN rules."
      ::= { mplsFTNGroups 1 }

   mplsFTNMapGroup OBJECT-GROUP
      OBJECTS {
            mplsFTNMapTableLastChanged,
            mplsFTNMapRowStatus,
            mplsFTNMapStorageType
      }
      STATUS current
      DESCRIPTION
          "Collection of objects that implement activation of MPLS
           FTN entries on interfaces."
      ::= { mplsFTNGroups 2 }

   mplsFTNPerfGroup OBJECT-GROUP
      OBJECTS {
            mplsFTNPerfMatchedPackets,
            mplsFTNPerfMatchedOctets,
            mplsFTNPerfDiscontinuityTime
      }
      STATUS current
      DESCRIPTION
          "Collection of objects providing MPLS FTN performance
           information."
      ::= { mplsFTNGroups 3 }

   END
```

10. Security Considerations

This MIB module can be used to configure LSRs to redirect non-MPLS traffic into an MPLS cloud. As such, improper manipulation of the objects represented in this MIB module may result in traffic being redirected to unintended destinations, potentially resulting in denial of service to end-users.

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:

- mplsFTNTable and mplsFTNMapTable can be used to create packet matching rules for classifying IPv4 or IPv6 traffic and redirecting matched packets into the MPLS cloud. Modifying objects in these tables can result in the misdirection of traffic and potential denial of service to end-users. It may also result in traffic which was intended to be redirected into the MPLS cloud being routed through the IP network instead, potentially resulting in degradation of service quality or outright denial of service.

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:

- mplsFTNPerfTable provides counters for monitoring the performance of packet classification rules defined in mplsFTNTable and mplsFTNMapTable. Unauthorized read access to objects in these tables may be used to gain traffic flow information.

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 [RFC3410], 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 that SNMPv3 be deployed and cryptographic security be enabled. 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 to only those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

11. IANA Considerations

As described in [MPLSMGMT] and as requested in [RFC3811], MPLS related standards-track MIB modules should be rooted under the mplsStdMIB subtree. New assignments can only be made by a standards action as specified in [RFC2434].

11.1. IANA Considerations for MPLS-FTN-STD-MIB

The IANA has assigned mplsStdMIB 8 to the MPLS-FTN-STD-MIB module specified in this document.

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