

Network Working Group
Request for Comments: 4625
Category: Standards Track

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September 2006

Fibre Channel Routing Information MIB

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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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 information related to routing within a Fibre Channel fabric, which is independent of the usage of a particular routing protocol.

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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 information related to the Fibre Channel network's Routing Table for routing within a Fabric. Managed objects specific to particular routing protocols, such as the Fabric Shortest Path First (FSPF) protocol [FC-SW-4], are not specified in this MIB module.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

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. Short Overview of Fibre Channel

3.1. Introduction

The Fibre Channel (FC) is logically a bidirectional point-to-point serial data channel, structured for high performance. Fibre Channel provides a general transport vehicle for higher-level protocols, such as Small Computer System Interface (SCSI) command sets, the High-Performance Parallel Interface (HIPPI) data framing, IP (Internet Protocol), IEEE 802.2, and others.

Physically, Fibre Channel is an interconnection of multiple communication points, called N_Ports, interconnected either by a switching network, called a Fabric, or by a point-to-point link. A Fibre Channel "node" consists of one or more N_Ports. A Fabric may consist of multiple Interconnect Elements, some of which are switches. An N_Port connects to the Fabric via a port on a switch called an F_Port. When multiple FC nodes are connected to a single port on a switch via an "Arbitrated Loop" topology, the switch port

is called an FL_Port, and the nodes' ports are called NL_Ports. The term Nx_Port is used to refer to either an N_Port or an NL_Port. The term Fx_Port is used to refer to either an F_Port or an FL_Port. A switch port, which is interconnected to another switch port via an Inter-Switch Link (ISL), is called an E_Port. A B_Port connects a bridge device with an E_Port on a switch; a B_Port provides a subset of E_Port functionality.

Many Fibre Channel components, including the fabric, each node, and most ports, have globally-unique names. These globally-unique names are typically formatted as World Wide Names (WWNs). More information on WWNs can be found in [FC-FS]. WWNs are expected to be persistent across agent and unit resets.

Fibre Channel frames contain 24-bit address identifiers that identify the frame's source and destination ports. Each FC port has both an address identifier and a WWN. When a fabric is in use, the FC address identifiers are dynamic and are assigned by a switch. Each octet of a 24-bit address represents a level in an address hierarchy, a Domain_ID being the highest level of the hierarchy.

3.2. Routing Protocols

The routing of frames within the Fabric is normally based on the standard routing protocol, called the Fabric Shortest Path First (FSPF) protocol. The operation of FSPF (or of any other routing protocol) allows a switch to generate and maintain its own routing table of how to forward frames it receives; i.e., a table in which to look up the destination address of a received frame in order to determine the best link by which to forward that frame towards its destination.

3.3. Virtual Fabrics

The latest standard for an interconnecting Fabric containing multiple Fabric Switch elements is [FC-SW-4] (which replaces the previous revision, [FC-SW-3]). [FC-SW-4] carries forward the existing specification for the operation of a single Fabric in a physical infrastructure, augmenting it with the definition of Virtual Fabrics and with the specification of how multiple Virtual Fabrics can operate within one (or more) physical infrastructures. The use of Virtual Fabrics provides for each frame to be tagged in its header to indicate which one of several Virtual Fabrics that frame is being transmitted on. All frames entering a particular "Core Switch" [FC-SW-4] (i.e., a physical switch) on the same Virtual Fabric are processed by the same "Virtual Switch" within that Core switch.

4. Relationship to Other MIBs

The first standardized MIB for Fibre Channel [RFC2837] was focussed on Fibre Channel switches. It is being replaced by the more generic Fibre Channel Management MIB [FC-MGMT], which defines basic information for Fibre Channel hosts and switches, including extensions to the standard IF-MIB [RFC2863] for Fibre Channel interfaces.

This MIB extends beyond [FC-MGMT] to cover the routing of traffic within a Fabric of a Fibre Channel network. The standard routing protocol for Fibre Channel is FSPF [FC-SW-4]. Another MIB [RFC4626] specifies management information specific to FSPF. This MIB contains routing information that is independent of FSPF (i.e., it would still apply even if a routing protocol other than FSPF were in use in the network).

This MIB imports some common Textual Conventions from T11-TC-MIB, defined in [RFC4439].

5. MIB Overview

This MIB module provides the means for monitoring the operation of, and configuring some parameters of, one or more instances of the FSPF protocol. (Note that there are no definitions in this MIB module of "managed actions" that can be invoked via SNMP.)

5.1. Fibre Channel Management Instance

A Fibre Channel management instance is defined in [FC-MGMT] as a separable managed instance of Fibre Channel functionality. Fibre Channel functionality may be grouped into Fibre Channel management instances in whatever way is most convenient for the implementation(s). For example, one such grouping accommodates a single SNMP agent with multiple AgentX [RFC2741] sub-agents, each sub-agent implementing a different Fibre Channel management instance.

The object, `fcmInstanceIndex`, is IMPORTed from the FC-MGMT-MIB [FC-MGMT] as the index value that uniquely identifies each Fibre Channel management instance within the same SNMP context ([RFC3411], Section 3.3.1).

5.2. Switch Index

The FC-MGMT-MIB [FC-MGMT] defines the `fcmSwitchTable` as a table of information about Fibre Channel switches that are managed by Fibre Channel management instances. Each Fibre Channel management instance can manage one or more Fibre Channel switches. The Switch Index, `fcmSwitchIndex`, is IMPORTed from the FC-MGMT-MIB as the index value that uniquely identifies a Fibre Channel switch among those (one or more) managed by the same Fibre Channel management instance.

5.3. Fabric Index

Whether operating on a physical Fabric (i.e., without Virtual Fabrics) or within a Virtual Fabric, the operation of FSPF within a Fabric is identical. Therefore, this MIB defines all Fabric-related information in tables that are INDEX-ed by an arbitrary integer, named a "Fabric Index", the syntax of which is IMPORTed from the T11-TC-MIB. When a device is connected to a single physical Fabric, without use of any virtual Fabrics, the value of this Fabric Index will always be 1. In an environment of multiple virtual and/or physical Fabrics, this index provides a means to distinguish one Fabric from another.

It is quite possible, and may even be likely, that a Fibre Channel switch will have ports connected to multiple virtual and/or physical Fabrics. Thus, in order to simplify a management protocol query concerning all the Fabrics to which a single switch is connected, `fcmSwitchIndex` will be listed before `t11FcRouteFabricIndex` when they both appear in the same INDEX clause.

5.4. The `t11FcRouteGroup` Group

This MIB contains one object group, the `t11FcRouteGroup`, which contains objects to allow the displaying and the configuring of routes in the Fibre Channel Routing tables for the locally managed switches.

5.5. The `t11FcRouteTable`'s INDEX

It is normally valuable for a MIB table that contains routes to be ordered such that a management application is able to query the table based on some attribute, without having to read every row in the MIB table. This requires that the rows in the table be ordered according to such attributes, and thus that those attributes be represented by objects included in the table's INDEX clause. Examples of this can be seen in the `ipCidrRouteTable` [RFC2096] and, more recently, the `inetCidrRouteTable` in [RFC4292].

While this useful feature results in an unusually large number (ten) of objects in the `t11FcRouteTable`'s INDEX clause, all ten are either integers or strings of 3 (or zero) octet length, so the resulting OIDs are not unusually large. (Specifically, the aggregate number of sub-identifiers to be appended to an OBJECT-TYPE's OID, when naming an instance of an object in the `t11FcRouteTable`, is at most 22 sub-identifiers; i.e., less than the *minimum* number to be appended for the `inetCidrRouteTable` table.)

6. The T11-FC-ROUTE-MIB Module

T11-FC-ROUTE-MIB DEFINITIONS ::= BEGIN

IMPORTS

```

MODULE-IDENTITY, OBJECT-TYPE,
    Unsigned32, mib-2                FROM SNMPv2-SMI    -- [RFC2578]
MODULE-COMPLIANCE, OBJECT-GROUP    FROM SNMPv2-CONF  -- [RFC2580]
RowStatus, TimeStamp,
StorageType                        FROM SNMPv2-TC      -- [RFC2579]
InterfaceIndex, InterfaceIndexOrZero FROM IF-MIB      -- [RFC2863]
fcmInstanceId, fcmSwitchIndex,
FcAddressIdOrZero, FcDomainIdOrZero FROM FC-MGMT-MIB  -- [FC-MGMT]
T11FabricIndex                     FROM T11-TC-MIB;    -- [RFC4439]

```

t11FcRouteMIB MODULE-IDENTITY

```

LAST-UPDATED "200608140000Z"
ORGANIZATION "T11"
CONTACT-INFO

```

```

    "
        Claudio DeSanti
        Cisco Systems, Inc.
        170 West Tasman Drive
        San Jose, CA 95134 USA
        EMail: cds@cisco.com

```

```

        Keith McCloghrie
        Cisco Systems, Inc.
        170 West Tasman Drive
        San Jose, CA USA 95134
        Email: kzm@cisco.com"

```

DESCRIPTION

"The MIB module for configuring and displaying Fibre Channel Route Information.

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```

REVISION      "200608140000Z"

```

DESCRIPTION

"Initial version of this MIB module, published as RFC4625."

::= { mib-2 144 }

t11FcRouteNotifications OBJECT IDENTIFIER ::= { t11FcRouteMIB 0 }
 t11FcRouteObjects OBJECT IDENTIFIER ::= { t11FcRouteMIB 1 }
 t11FcRouteConformance OBJECT IDENTIFIER ::= { t11FcRouteMIB 2 }

--

-- Per-Fabric routing information

--

t11FcRouteFabricTable OBJECT-TYPE
 SYNTAX SEQUENCE OF T11FcRouteFabricEntry
 MAX-ACCESS not-accessible
 STATUS current
 DESCRIPTION
 "The table containing Fibre Channel Routing information
 that is specific to a Fabric."
 ::= { t11FcRouteObjects 1 }

t11FcRouteFabricEntry OBJECT-TYPE
 SYNTAX T11FcRouteFabricEntry
 MAX-ACCESS not-accessible
 STATUS current
 DESCRIPTION
 "Each entry contains routing information specific to a
 particular Fabric on a particular switch (identified by
 values of fcmInstanceIndex and fcmSwitchIndex)."
 INDEX { fcmInstanceIndex, fcmSwitchIndex,
 t11FcRouteFabricIndex }
 ::= { t11FcRouteFabricTable 1 }

T11FcRouteFabricEntry ::=

```

SEQUENCE {
    t11FcRouteFabricIndex      T11FabricIndex,
    t11FcRouteFabricLastChange TimeStamp
}

```

t11FcRouteFabricIndex OBJECT-TYPE
 SYNTAX T11FabricIndex
 MAX-ACCESS not-accessible
 STATUS current
 DESCRIPTION
 "A unique index value that uniquely identifies a
 particular Fabric.

In a Fabric conformant to FC-SW-3, only a single Fabric

can operate within a physical infrastructure, and thus the value of this Fabric Index will always be 1.

In a Fabric conformant to FC-SW-4, multiple Virtual Fabrics can operate within one (or more) physical infrastructures. In such a case, index value is used to uniquely identify a particular Fabric within a physical infrastructure."

```
::= { t11FcRouteFabricEntry 1 }
```

t11FcRouteFabricLastChange OBJECT-TYPE

SYNTAX TimeStamp

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The value of sysUpTime at the most recent time when any corresponding row in the t11FcRouteTable was created, modified, or deleted. A corresponding row in the t11FcRouteTable is for the same management instance, the same switch, and same Fabric as the row in this table.

If no change has occurred since the last restart of the management system, then the value of this object is 0."

```
::= { t11FcRouteFabricEntry 2 }
```

```
--
```

```
-- Fibre Channel Routing table
```

```
--
```

t11FcRouteTable OBJECT-TYPE

SYNTAX SEQUENCE OF T11FcRouteEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The Fibre Channel Routing tables for the locally managed switches. This table lists all the routes that are configured in and/or computed by any local switch for any Fabric.

Such routes are used by a switch to forward frames (of user data) on a Fabric. The conceptual process is based on extracting the Destination Fibre Channel Address Identifier (D_ID) out of a received frame (of user data) and comparing it to each entry of this table that is applicable to the given switch and Fabric. Such comparison consists of first performing a logical-AND of the extracted D_ID with a mask (the value of t11FcRouteDestMask) and second comparing the result of that 'AND' operation to the value of t11FcRouteDestAddrId. A similar comparison is made of the Source Fibre Channel Address Identifier (S_ID) of a frame

against the t11FcRouteSrcAddrId and t11FcRouteSrcMask values of an entry. If an entry's value of t11FcRouteInInterface is non-zero, then a further comparison determines if the frame was received on the appropriate interface. If all of these comparisons for a particular entry are successful, then that entry represents a potential route for forwarding the received frame.

For entries configured by a user, t11FcRouteProto has the value 'netmgmt'; only entries of this type can be deleted by the user."

```
::= { t11FcRouteObjects 2 }
```

t11FcRouteEntry OBJECT-TYPE

SYNTAX T11FcRouteEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"Each entry contains a route to a particular destination, possibly from a particular subset of source addresses, on a particular Fabric via a particular output interface and learned in a particular manner."

```
INDEX      { fcmInstanceIndex, fcmSwitchIndex,
              t11FcRouteFabricIndex,
              t11FcRouteDestAddrId, t11FcRouteDestMask,
              t11FcRouteSrcAddrId, t11FcRouteSrcMask,
              t11FcRouteInInterface, t11FcRouteProto,
              t11FcRouteOutInterface }
```

```
::= { t11FcRouteTable 1 }
```

T11FcRouteEntry ::=

```
SEQUENCE {
    t11FcRouteDestAddrId    FcAddressIdOrZero,
    t11FcRouteDestMask      FcAddressIdOrZero,
    t11FcRouteSrcAddrId     FcAddressIdOrZero,
    t11FcRouteSrcMask       FcAddressIdOrZero,
    t11FcRouteInInterface   InterfaceIndexOrZero,
    t11FcRouteProto         INTEGER,
    t11FcRouteOutInterface  InterfaceIndex,
    t11FcRouteDomainId      FcDomainIdOrZero,
    t11FcRouteMetric        Unsigned32,
    t11FcRouteType          INTEGER,
    t11FcRouteIfDown        INTEGER,
    t11FcRouteStorageType   StorageType,
    t11FcRouteRowStatus     RowStatus
}
```

t11FcRouteDestAddrId OBJECT-TYPE

SYNTAX FcAddressIdOrZero (SIZE (3))

MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"The destination Fibre Channel Address Identifier of this route. A zero-length string for this field is not allowed."

::= { t11FcRouteEntry 1 }

t11FcRouteDestMask OBJECT-TYPE

SYNTAX FcAddressIdOrZero
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"The mask to be logical-ANDed with a destination Fibre Channel Address Identifier before it is compared to the value in the t11FcRouteDestAddrId field. Allowed values are 255.255.255, 255.255.0, or 255.0.0. FSPF's definition generates routes to a Domain_ID, so the mask for all FSPF-generated routes is 255.0.0. The zero-length value has the same meaning as 0.0.0."

::= { t11FcRouteEntry 2 }

t11FcRouteSrcAddrId OBJECT-TYPE

SYNTAX FcAddressIdOrZero
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"The source Fibre Channel Address Identifier of this route. Note that if this object and the corresponding instance of t11FcRouteSrcMask both have a value of 0.0.0, then this route matches all source addresses. The zero-length value has the same meaning as 0.0.0."

::= { t11FcRouteEntry 3 }

t11FcRouteSrcMask OBJECT-TYPE

SYNTAX FcAddressIdOrZero
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"The mask to be logical-ANDed with a source Fibre Channel Address Identifier before it is compared to the value in the t11FcRouteSrcAddrId field. Allowed values are 255.255.255, 255.255.0, 255.0.0, or 0.0.0. The zero-length value has the same meaning as 0.0.0."

::= { t11FcRouteEntry 4 }

t11FcRouteInInterface OBJECT-TYPE

SYNTAX InterfaceIndexOrZero

MAX-ACCESS not-accessible
 STATUS current
 DESCRIPTION

"If the value of this object is non-zero, it is the value of ifIndex that identifies the local Fibre Channel interface through which a frame must have been received in order to match with this entry. If the value of this object is zero, the matching does not require that the frame be received on any specific interface."

::= { t11FcRouteEntry 5 }

t11FcRouteProto OBJECT-TYPE

SYNTAX INTEGER {
 other(1),
 local(2),
 netmgmt(3),
 fspf(4)
 }

MAX-ACCESS not-accessible
 STATUS current
 DESCRIPTION

"The mechanism via which this route was learned:
 other(1) - not specified
 local(2) - local interface
 netmgmt(3) - static route
 fspf(4) - Fibre Shortest Path First
 "

::= { t11FcRouteEntry 6 }

t11FcRouteOutInterface OBJECT-TYPE

SYNTAX InterfaceIndex
 MAX-ACCESS not-accessible
 STATUS current
 DESCRIPTION

"The value of ifIndex that identifies the local Fibre Channel interface through which the next hop of this route is to be reached."

::= { t11FcRouteEntry 7 }

t11FcRouteDomainId OBJECT-TYPE

SYNTAX FcDomainIdOrZero
 MAX-ACCESS read-create
 STATUS current
 DESCRIPTION

"The domain_ID of next hop switch.

This object can have a value of zero if the value

of t11FcRouteProto is 'local'."
 ::= { t11FcRouteEntry 8 }

t11FcRouteMetric OBJECT-TYPE

SYNTAX Unsigned32 (0..65536)

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The routing metric for this route.

The use of this object is dependent on t11FcRouteProto."
 ::= { t11FcRouteEntry 9 }

t11FcRouteType OBJECT-TYPE

SYNTAX INTEGER {
 local(1),
 remote(2)
 }

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The type of route.

local(1) - a route for which the next Fibre Channel
 port is the final destination;

remote(2) - a route for which the next Fibre Channel
 port is not the final destination."

DEFVAL {local}

::= { t11FcRouteEntry 10 }

t11FcRouteIfDown OBJECT-TYPE

SYNTAX INTEGER {
 remove(1),
 retain(2)
 }

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The value of this object indicates what happens to
 this route when the output interface (given by the
 corresponding value of t11FcRouteOutInterface) is
 operationally 'down'. If this object's value is 'retain',
 the route is to be retained in this table. If this
 object's value is 'remove', the route is to be removed
 from this table."

DEFVAL { retain }

::= { t11FcRouteEntry 11 }

```

t11FcRouteStorageType OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The storage type for this conceptual row.
        Conceptual rows having the value 'permanent' need not
        allow write-access to any columnar objects in the row."
    DEFVAL { nonVolatile }
    ::= { t11FcRouteEntry 12 }

t11FcRouteRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The status of this conceptual row.
        The only rows that can be deleted by setting this object to
        'destroy' are those for which t11FcRouteProto has the value
        'netmgmt'."
    ::= { t11FcRouteEntry 13 }

--
-- Conformance
--
t11FcRouteCompliances OBJECT IDENTIFIER
    ::= { t11FcRouteConformance 1 }
t11FcRouteGroups      OBJECT IDENTIFIER
    ::= { t11FcRouteConformance 2 }

t11FcRouteCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for entities that
        implement the T11-FC-ROUTE-MIB.
--
-- Note: The next four OBJECT clauses are for auxiliary objects, and the
-- SMIV2 does not permit inclusion of objects that are not accessible
-- in an OBJECT clause (see Sections 3.1 & 5.4.3 in STD 58, RFC 2580).
-- Thus, these four clauses cannot be included below in the normal
-- location for OBJECT clauses.
--
--      OBJECT      t11FcRouteSrcAddrId
--      SYNTAX      FcAddressIdOrZero (SIZE (0))
--      DESCRIPTION
--          'Support is not required for routes that
--          match only a subset of possible source

```

```

--          addresses.'
--
-- OBJECT      t11FcRouteSrcMask
-- SYNTAX      FcAddressIdOrZero (SIZE (0))
-- DESCRIPTION
--          'Support is not required for routes that
--          match only a subset of possible source
--          addresses.'
--
-- OBJECT      t11FcRouteDestMask
-- DESCRIPTION
--          'Support is mandatory only for FSPF-generated
--          routes.  Since FSPF's definition generates
--          routes to a Domain_ID, the mask for all
--          FSPF-generated routes is 255.0.0.  Thus,
--          support is only required for 255.0.0.'
--
-- OBJECT      t11FcRouteInInterface
-- SYNTAX      InterfaceIndexOrZero (0)
-- DESCRIPTION
--          'Support for routes specific to particular
--          source interfaces is not required.'
--
--
MODULE -- this module
    MANDATORY-GROUPS { t11FcRouteGroup }

    OBJECT      t11FcRouteIfDown
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT      t11FcRouteDomainId
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT      t11FcRouteMetric
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT      t11FcRouteType
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT      t11FcRouteStorageType

```

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

```
OBJECT      t11FcRouteRowStatus
SYNTAX      INTEGER { active(1) }
MIN-ACCESS read-only
DESCRIPTION
    "Write access is not required."
```

```
 ::= { t11FcRouteCompliances 1 }
t11FcRouteGroup OBJECT-GROUP
OBJECTS { t11FcRouteFabricLastChange,
          t11FcRouteDomainId,
          t11FcRouteMetric,
          t11FcRouteType,
          t11FcRouteIfDown,
          t11FcRouteStorageType,
          t11FcRouteRowStatus
        }
STATUS      current
DESCRIPTION
    "A collection of objects for displaying and configuring
    routes."
 ::= { t11FcRouteGroups 1 }
```

END

7. Acknowledgements

This document was originally developed and approved by the INCITS Task Group T11.5 (<http://www.t11.org>) as the SM-RTM project. We wish to acknowledge the contributions and comments from the INCITS Technical Committee T11, including the following:

T11 Chair: Robert Snively, Brocade
T11 Vice Chair: Claudio DeSanti, Cisco Systems
T11.5 Chair: Roger Cummings, Symantec
T11.5 members, especially:
 Ken Hirata, Emulex
 Scott Kipp, McData
 Elizabeth G. Rodriguez, Dot Hill

The document was subsequently approved by the IETF's IMSS Working Group, chaired by David Black (EMC Corporation). We also wish to acknowledge Bert Wijnen (Lucent Technologies), the IETF Area Director, for his review of the document.

8. IANA Considerations

The IANA has assigned a MIB OID for the T11-FC-ROUTE-MIB module under the appropriate subtree.

9. Security Considerations

There are several 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 objects and their sensitivity/vulnerability are:

```
t11FcRouteDomainId, t11FcRouteMetric, t11FcRouteType,  
t11FcRouteIfDown, t11FcRouteRowStatus  
-- configure new routes and/or modify existing routes.
```

Such objects may be considered sensitive or vulnerable in some network environments. For example, the ability to change network topology or network speed may afford an attacker the ability to obtain better performance at the expense of other network users. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations.

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. The objects and their sensitivity/vulnerability are: the write-able objects listed above plus one other:

```
t11FcRouteLastChangeTime
-- the time of the last routing table change.
```

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 implementors 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 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.

10. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
- [RFC2578] McCloghrie, K., Perkins, D., Schoenwaelder, J., Case, J., Rose, M., and S. Waldbusser, "Structure of Management Information Version 2 (SMIv2)", STD 58, RFC 2578, April 1999.
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Acknowledgement

Funding for the RFC Editor function is provided by the IETF Administrative Support Activity (IASA).

