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Definition of Managed Objects for the LLN On-demand Ad hoc Distance-
vector Routing Protocol - Next Generation (LOADng)
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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 objects for configuring parameters of the LLN On-demand Ad hoc Distance-vector Routing Protocol - Next Generation (LOADng) process on a router. The MIB module defined in this memo, denoted LOADng-MIB, also reports state. While LOADng is layer agnostic and can be run with different address families (e.g., on L2 using MAC addresses, or on L3 using IP addresses), this MIB module assumes that LOADng is used on L3, and uses only IPv4/IPv6 addresses.

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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 objects for configuring parameters of the LLN On-demand Ad hoc Distance-vector Routing Protocol - Next Generation (LOADng) [[LOADng](#)] process on a router. The MIB module defined in this memo, denoted LOADng-MIB, also reports state. While LOADng is layer agnostic and can be run with different address families (e.g., on L2 using MAC addresses, or on L3 using IP addresses), this MIB module assumes that LOADng is used on L3, and uses only IPv4/IPv6 addresses.

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 \[RFC3410\]](#).

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 module 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 [[RFC2578](#)], [[RFC2579](#)] and [[RFC2580](#)].

3. Conventions

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

4. Overview

The LLN On-demand Ad hoc Distance-vector Routing Protocol - Next Generation (LOADng) [[LOADng](#)] is a routing protocol, derived from AODV [[RFC3561](#)] and extended for use in Low power and Lossy Networks (LLNs). As a reactive protocol, the basic operations of LOADng include generation of Route Requests (RREQs) by a router (originator) for when discovering a route to a destination, forwarding of such RREQs until they reach the destination router, generation of Route Replies (RREPs) upon receipt of an RREQ by the indicated destination, and unicast hop-by-hop forwarding of these RREPs towards the originator. If a route is detected broken, i.e., if forwarding of a data packet to the recorded next hop on the route to the destination is detected to fail, a Route Error (RERR) message is returned in

unicast to the originator of that data packet.

This MIB module describes objects for configuring parameters of a LOADng process on a router, as well as for the relevant state of a LOADng process on a router, in order to monitor and manage parameters and information bases of LOADng.

[4.1.](#) Terms

The following definitions apply throughout this document:

- o Configuration Objects - switches, tables, objects which are initialized to default settings or set through the management interface defined by this MIB module.
- o State Objects - automatically generated values which define the current operating state of the LOADng protocol process in the router.

[5.](#) Structure of the MIB Module

This section presents the structure of the LOADng-MIB module. The MIB module is arranged into the following structure:

- o LOADngObjects - defining objects within this MIB module. The objects are arranged into the following groups:
 - * Configuration Group - defining objects related to the configuration of the LOADng instance on the router.

- * State Group - defining objects which reflect the current state of the LOADng instance running on the router.
- o LOADngConformance - defining the minimal and maximal conformance requirements for implementations of this MIB module.

[5.1.](#) The Configuration Group

The LOADng router is configured with a set of controls. The authoritative list of configuration controls within the LOADng-MIB module are found within the MIB module itself. Generally, an attempt was made in developing the LOADng-MIB module to support all configuration objects defined in [[LOADng](#)]. For all of the configuration parameters, the same default values of these parameters as defined in [[LOADng](#)] are followed.

[5.2.](#) The State Group

The State Group reports current state information of a router running [[LOADng](#)]. The LOADng-MIB State Group tables were designed to contain the complete set of state information defined within the information bases specified in Section 6 of [[LOADng](#)].

[5.3.](#) Tables and Indexing

The LOADng-MIB module contains a number of tables which record data related to:

- o the local LOADng router,
- o a local LOADng interface on the LOADng router,
- o other LOADng routers in the routing domain.

The LOADng-MIB module's tables and their indexing are:

- o loadngInterfaceTable - describes the configuration of the interfaces of this LOADng router. This table has 'INDEX {

loadngIfIndex }'.

- o loadngLibLocalIfSetTable - records all network addresses which are defined as local interface network addresses on this LOADng router. This table has 'INDEX { loadngLibLocalIfSetIfAddrIndex, loadngLibLocalIfSetIfIndex }'.
- o loadngLibDestAddressSetTable - records addresses, for which a LOADng Router will generate RREPs in response to received RREQs, in addition to its own interface addresses (as listed in the Local Interface Set). This table has 'INDEX { loadngLibDestAddressSetIndex }'.
- o loadngBlacklistedNeighborSetTable - records the neighbor interface addresses of a LOADng Router, with which connectivity has been detected to be unidirectional. This table has 'INDEX { loadngBlacklistedNeighborSetIndex }'.
- o loadngRoutingSetTable - records the next hop on the route to each known destination. This table has 'INDEX { loadngRoutingSetIndex }'.
- o loadngPendingAckSetTable - records information about RREPs which have been transmitted with the ackrequired flag set, and for which an RREP_ACK has not yet been received. This table has 'INDEX { loadngPendingAckSetIndex }'.

[6.](#) Relationship to Other MIB Modules

This section specifies the relationship of the MIB module contained in this document to other standards, particularly to standards containing other MIB modules. Definitions imported from other MIB modules and other MIB modules that SHOULD be implemented in conjunction with the MIB module contained within this document are identified in this section.

[6.1.](#) Relationship to the SNMPv2-MIB

The 'system' group in the SNMPv2-MIB module [[RFC3418](#)] is defined as being mandatory for all systems, and the objects apply to the entity as a whole. The 'system' group provides identification of the management entity and certain other system-wide data. The LOADng-MIB

module does not duplicate those objects.

6.2. MIB Modules Required for IMPORTS

The following LOADng-MIB module IMPORTS objects from SNMPv2-SMI [[RFC2578](#)], SNMPv2-TC [[RFC2579](#)], SNMPv2-CONF [[RFC2580](#)], IF-MIB [[RFC2863](#)], and INET-ADDRESS-MIB [[RFC4001](#)].

7. Definitions

This section contains the MIB module defined by the specification.

```
LOADNG-MIB DEFINITIONS ::= BEGIN
```

```
-- This MIB module defines objects for the management of
-- LLN On-demand Ad hoc Distance-vector Routing Protocol - Next
-- Generation (LOADng), T. Clausen, A. Colin de Verdiere,
-- J. Yi, A. Niktash, Y. Igarashi, H. Satoh, U. Herberg,
-- C. Lavenue, T. Lys, April 2012.
```

```
IMPORTS
```

```
    MODULE-IDENTITY, OBJECT-TYPE,
    Counter32, Counter64, Integer32, Unsigned32, mib-2,
        TimeTicks
    FROM SNMPv2-SMI -- RFC2578
```

```
    TEXTUAL-CONVENTION, TruthValue, TimeStamp,
        RowStatus
    FROM SNMPv2-TC -- RFC2579
```

```
    MODULE-COMPLIANCE, OBJECT-GROUP
    FROM SNMPv2-CONF -- STD58
```

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```
    InetAddressType, InetAddress,
    InetAddressPrefixLength
    FROM INET-ADDRESS-MIB -- RFC4001
```

```
    InterfaceIndex
    FROM IF-MIB -- RFC2863
```

```
;
```

loadngMIB MODULE-IDENTITY

LAST-UPDATED "201206111000Z" -- June 11, 2012

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DESCRIPTION

"This loadng-MIB module is applicable to routers
implementing the LLN On-demand Ad hoc Distance-vector

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of this MIB module is part of RFCXXXX; see the RFC
itself for full legal notices."

```
-- revision
REVISION "201206111000Z" -- June 11, 2012
DESCRIPTION
    "The first version of this MIB module,
      published as RFCXXXX.
    "
-- RFC-Editor assigns XXXX
::= { mib-2 XXXX } -- to be assigned by IANA
```

```
--
-- Top-Level Components of this MIB Module
--
loadngObjects      OBJECT IDENTIFIER ::= { loadngMIB 1 }
loadngConformance OBJECT IDENTIFIER ::= { loadngMIB 2 }
```

```
--
-- loadngObjects
--
```

```
--    1) Configuration Objects Group
--    2) State Objects Group
```

```
--
-- loadngConfigurationObjGrp
--
```

```
-- Contains the LOADng objects which configure specific options
-- which determine the overall performance and operation of the
-- LOADng protocol.
```

```
loadngConfigurationObjGrp OBJECT IDENTIFIER ::= { loadngObjects 1 }
```

```
loadngInterfaceTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LoadngInterfaceEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "loadngInterfaceTable describes the
```

configuration of the interfaces of this LOADng router. The ifIndex is from the interfaces group defined in the Interfaces Group MIB. If the corresponding entry with ifIndex value is deleted from the Interface Table, then the entry in this table is automatically deleted.

The objects in this table are persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"[RFC2863](#) - The Interfaces Group MIB, McCloghrie, K., and F. Kastenholz, June 2000."

::= { loadngConfigurationObjGrp 1 }

loadngInterfaceEntry OBJECT-TYPE

SYNTAX LoadngInterfaceEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"loadngInterfaceEntry describes one LOADng local interface configuration as indexed by its ifIndex as defined in the Standard MIB II Interface Table ([RFC2863](#))."

INDEX { loadngIfIndex }

::= { loadngInterfaceTable 1 }

LoadngInterfaceEntry ::=

SEQUENCE {

loadngIfIndex

InterfaceIndex,

loadngIfRowStatus

RowStatus

}

loadngIfIndex OBJECT-TYPE

SYNTAX InterfaceIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The ifIndex for this interface."

::= { loadngInterfaceEntry 1 }

loadngIfRowStatus OBJECT-TYPE

SYNTAX RowStatus
MAX-ACCESS read-create

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STATUS current

DESCRIPTION

"This object permits management of the table by facilitating actions such as row creation, construction, and destruction. The value of this object has no effect on whether other objects in this conceptual row can be modified.

An entry may not exist in the active state unless all objects in the entry have an appropriate value."

REFERENCE

"LOADng."

::= { loadngInterfaceEntry 2 }

--

-- Router Parameters

--

loadngNetTraversalTime OBJECT-TYPE

SYNTAX Unsigned32

UNITS "milliseconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"loadngNetTraversalTime corresponds to NET_TRAVERSAL_TIME of LOADng. It represents the maximum time that a packet is expected to take when traversing from one end of the network to the other.

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.

[Section 5](#) on Protocol Parameters."

DEFVAL { 500 }

```
::= { loadngConfigurationObjGrp 2 }
```

```
loadngRREQRetries OBJECT-TYPE
    SYNTAX      Unsigned32 (0..255)
    MAX-ACCESS   read-write
    STATUS       current
    DESCRIPTION
        "loadngRREQRetries corresponds to
```

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RREQ_RETRIES of LOADng. It represents the maximum number of subsequent RREQs that a particular router may generate in order to discover a route to a destination, before declaring that destination unreachable.

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.
[Section 5](#) on Protocol Parameters."

DEFVAL { 3 }

```
::= { loadngConfigurationObjGrp 3 }
```

```
loadngRREQRateLimit OBJECT-TYPE
    SYNTAX      Unsigned32 (1..255)
    MAX-ACCESS   read-write
    STATUS       current
    DESCRIPTION
        "loadngRREQRateLimit corresponds to
        RREQ_RATELIMIT of LOADng. It represents
        the maximum number of RREQs that a particular
        router is allowed to send per second.
```

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.

[Section 5](#) on Protocol Parameters."
DEFVAL { 3 }
 ::= { loadngConfigurationObjGrp 4 }

loadngRHoldTime OBJECT-TYPE
SYNTAX Unsigned32
UNITS "milliseconds"
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"loadngRHoldTime corresponds to
R_HOLD_TIME of LOADng. It represents
the minimum time a Routing Tuple should
be kept in the Routing Set after it was
last refreshed. This may be a network-wide

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constant, but may also be a variable whose
value is defined by an auxiliary mechanism,
e.g., by an extension to this protocol.

This object is persistent and when written
the entity SHOULD save the change to
non-volatile storage."

REFERENCE

"LOADng.

[Section 5](#) on Protocol Parameters."

DEFVAL { 10000 }

::= { loadngConfigurationObjGrp 5 }

loadngMaxRouteCost OBJECT-TYPE
SYNTAX Unsigned32 (0..255)
MAX-ACCESS read-write
STATUS current

DESCRIPTION

"loadngMaxRouteCost corresponds to
maximum distance in "hop count" of
MAX_DIST of LOADng. It represents
the value representing the
maximum possible distance in hop count.

This object is persistent and when written

the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.
[Section 5](#) on Protocol Parameters."

DEFVAL { 255 }

::= { loadngConfigurationObjGrp 6 }

loadngMaxWeakLinks OBJECT-TYPE

SYNTAX Unsigned32 (0..15)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"loadngMaxWeakLinks corresponds to the maximum distance in "weak links" of MAX_DIST of LOADng. It represents the value representing the maximum possible distance in weak links.

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.
[Section 5](#) on Protocol Parameters."

DEFVAL { 15 }

::= { loadngConfigurationObjGrp 7 }

loadngRREPAckRequired OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"loadngRREPAckRequired corresponds to RREP_ACK_REQUIRED of LOADng. It represents a boolean flag, which indicates (if set) that the router is configured to expect that each RREP it sends be confirmed by an RREP_ACK or (if cleared) that no RREP_ACK is expected.

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.

[Section 5](#) on Protocol Parameters."

DEFVAL { false }

::= { loadngConfigurationObjGrp 8 }

loadngRREPAckTimeout OBJECT-TYPE

SYNTAX Unsigned32

UNITS "milliseconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"loadngRHoldTime corresponds to RREP_ACK_TIMEOUT of LOADng. It represents the minimum time after transmission of an RREP, that a LOADng Router should wait for an RREP_ACK from a neighbor LOADng Router, before considering that the link to this neighbor is unidirectional.

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.

[Section 5](#) on Protocol Parameters."

DEFVAL { 500 }

::= { loadngConfigurationObjGrp 9 }

loadngBHoldTime OBJECT-TYPE

SYNTAX Unsigned32

UNITS "milliseconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"loadngRHoldTime corresponds to B_HOLD_TIME of LOADng. It represents the time during which the link between the neighbor LOADng Router and this LOADng Router must be considered as non-bidirectional, and that therefore RREQs received from that neighbor LOADng Router must be ignored after being added. loadngBHoldTime should be greater than $2 \times \text{loadngNetTraversalTime} \times \text{loadngRREQRetries}$, to ensure that subsequent RREQs will reach the destination via a route, excluding this link.

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE

"LOADng.
[Section 5](#) on Protocol Parameters."

DEFVAL { 3000 }

::= { loadngConfigurationObjGrp 10 }

loadngUseBidirectionalLinkOnly OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"loadngUseBidirectionalLinkOnly corresponds to USE_BIDIRECTIONAL_LINK_ONLY of LOADng. It represents a boolean flag, which indicates if the LOADng Router only uses verified bi-directional links for data packet forwarding. It is set by default. If cleared, then the LOADng Router can use links which have not been verified to be bi-directional.

This object is persistent and when written the entity SHOULD save the change to non-volatile storage."

REFERENCE


```

        "LOADng.
        Section 5 on Protocol Parameters."
    DEFVAL { true }
    ::= { loadngConfigurationObjGrp 11 }

--
-- Local Interface Set Table
--

loadngLibLocalIfSetTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LoadngLibLocalIfSetEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "A router's Local Interface Set records its
        local interfaces. The local interface
        is defined by the loadngIfIndex.

        The Local Interface Set consists of Local Interface
        Tuples per network interface."
    REFERENCE
        "LOADng."
    ::= { loadngConfigurationObjGrp 12 }

loadngLibLocalIfSetEntry OBJECT-TYPE
    SYNTAX      LoadngLibLocalIfSetEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "A router's Local Interface Set consists
        of Local Interface Tuples for each network
        interface.

        (I_local_iface_addr_list)

        Each tuple contains a list of one
        or more addresses of this interface.
        "
    REFERENCE
        "LOADng."
    INDEX { loadngLibLocalIfSetIndex, loadngLibLocalIfSetIfIndex }
    ::= { loadngLibLocalIfSetTable 1 }

```

```
LoadngLibLocalIfSetEntry ::=
    SEQUENCE {
        loadngLibLocalIfSetIndex
            Integer32,
        loadngLibLocalIfSetIfIndex
            InterfaceIndex,
        loadngLibLocalIfSetIpAddrType
            InetAddressType,
        loadngLibLocalIfSetIpAddr
            InetAddress,
        loadngLibLocalIfSetRowStatus
            RowStatus
    }
```

```
loadngLibLocalIfSetIndex OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The index for this table. Necessary
        because multiple addresses may be associated
        with a given loadngIfIndex."
    REFERENCE
        "LOADng."
    ::= { loadngLibLocalIfSetEntry 1 }
```

```
loadngLibLocalIfSetIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Specifies the local loadngIfIndex for which this
        IP address was added."
    REFERENCE
        "LOADng."
    ::= { loadngLibLocalIfSetEntry 2 }
```

```
loadngLibLocalIfSetIpAddrType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The type of the loadngLibLocalIfSetIpAddr
        in the InetAddress MIB (RFC4001).

        Only the values ipv4(1) and
        ipv6(2) are supported."
```

```
        "LOADng."
 ::= { loadngLibLocalIfSetEntry 3 }

loadngLibLocalIfSetIpAddress OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "loadngLibLocalIfSetIpAddress is an
         address of an interface of
         this router.

         This object is interpreted according to
         the setting of loadngLibLocalIfSetIpAddressType."
    REFERENCE
        "LOADng."
 ::= { loadngLibLocalIfSetEntry 4 }

loadngLibLocalIfSetRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object permits management of the table
         by facilitating actions such as row creation,
         construction, and destruction. The value of
         this object has no effect on whether other
         objects in this conceptual row can be
         modified.

         An entry may not exist in the active state unless all
         objects in the entry have an appropriate value."
    REFERENCE
        "LOADng."
 ::= { loadngLibLocalIfSetEntry 5 }
```

-- Destination Address Set Table

```
-- Entry (foreach local interface): (D_address)

loadngLibDestAddressSetTable OBJECT-TYPE
    SYNTAX          SEQUENCE OF LoadngLibDestAddressSetEntry
    MAX-ACCESS      not-accessible
    STATUS           current
    DESCRIPTION
        "The Destination Address Set records
```

addresses, for which a LOADng Router will generate RREPs in response to received RREQs, in addition to its own interface addresses (as listed in the Local Interface Set). The Destination Address Set thus represents those destinations (i.e., hosts), for which this LOADng Router is providing connectivity. It consists of destination address tuples: "

REFERENCE

"LOADng."

```
::= { loadngConfigurationObjGrp 13 }
```

```
loadngLibDestAddressSetEntry OBJECT-TYPE
    SYNTAX          LoadngLibDestAddressSetEntry
    MAX-ACCESS      not-accessible
    STATUS           current
    DESCRIPTION
        "The Destination Address Set consists
        of Destination Address Tuples:
```

```
        (D_address)
```

```
        "
```

REFERENCE

"LOADng."

```
INDEX { loadngLibDestAddressSetIndex }
```

```
::= { loadngLibDestAddressSetTable 1 }
```

```
LoadngLibDestAddressSetEntry ::=
```

```
    SEQUENCE {
```

```
        loadngLibDestAddressSetIndex
```

```
        Integer32,
```

```
        loadngLibDestAddressSetIpAddrType
```

```
        InetAddressType,
```

```

        loadngLibDestAddressSetIpAddr
            InetAddress
    }

loadngLibDestAddressSetIndex OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The index for this table. Necessary
        because multiple addresses may be associated
        with a given loadngIfIndex."
    REFERENCE
        "LOADng."
 ::= { loadngLibDestAddressSetEntry 1 }

```

```

loadngLibDestAddressSetIpAddrType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The type of the loadngLibDestAddressSetIpAddr
        in the InetAddress MIB (RFC4001)."

        Only the values ipv4(1) and
        ipv6(2) are supported."
    REFERENCE
        "LOADng."
 ::= { loadngLibDestAddressSetEntry 2 }

loadngLibDestAddressSetIpAddr OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "loadngLibDestAddressSetIpAddr is an
        address of an interface of
        a router."

        This object is interpreted according to
        the setting of loadngLibDestAddressSetIpAddrType."
    REFERENCE

```

```

        "LOADng."
 ::= { loadingLibDestAddressSetEntry 3 }

--
-- loadingStateObjGrp
--

-- Contains information describing the current state of the LOADng
-- process on this router.

loadingStateObjGrp    OBJECT IDENTIFIER ::= { loadingObjects 2 }

loadingUpTime OBJECT-TYPE
    SYNTAX TimeStamp
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The value of sysUpTime at the time current LOADng

```

```

        process was initialized.
        "
 ::= { loadingStateObjGrp 1 }

--
-- Blacklisted Neighbor Set Table
--

loadingBlacklistedNeighborSetTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LoadingBlacklistedNeighborSetEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Blacklisted Neighbor Set records the neighbor
        interface addresses of a LOADng Router, with which
        connectivity has been detected to be unidirectional.
        Specifically, the Blacklisted Neighbor Set records
        neighbors from which an RREQ has been received (i.e.,

```

through which a Forward Route would possible) but to which it has been determined that it is not possible to communicate (i.e., forwarding Route Replies via this neighbor fails, rendering installing the Forward Route impossible). It consists of Blacklisted Neighbor Tuples."

REFERENCE

"LOADng."

::= { loadngStateObjGrp 2 }

loadngBlacklistedNeighborSetEntry OBJECT-TYPE

SYNTAX LoadngBlacklistedNeighborSetEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"A router's Blacklisted Neighbor Set consists of Blacklisted Neighbor Tuples, one per network address:loadngBlacklistedNeighborSet

(B_neighbor_address, B_valid_time)

The association between these addrs and the router's Interface is found in the Standard MIB II's IP address table ([RFC1213](#))."

REFERENCE

"LOADng."

INDEX { loadngBlacklistedNeighborSetIndex }

::= { loadngBlacklistedNeighborSetTable 1 }

```
LoadngBlacklistedNeighborSetEntry ::=
  SEQUENCE {
    loadngBlacklistedNeighborSetIndex
      Integer32,
    loadngBlacklistedNeighborSetIpAddrType
      InetAddressType,
    loadngBlacklistedNeighborSetIpAddr
      InetAddress,
    loadngBlacklistedNeighborSetBTime
      TimeStamp
  }
```

```

loadngBlacklistedNeighborSetIndex OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The index for this table."
    REFERENCE
        "LOADng."
 ::= { loadngBlacklistedNeighborSetEntry 1 }

loadngBlacklistedNeighborSetIpAddressType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The type of the loadngBlacklistedNeighborSetIpAddress
         in the InetAddress MIB (RFC4001).

        Only the values ipv4(1) and
        ipv6(2) are supported."
    REFERENCE
        "LOADng."
 ::= { loadngBlacklistedNeighborSetEntry 2 }

loadngBlacklistedNeighborSetIpAddress OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "loadngBlacklistedNeighborSetIpAddress is the
         address of the blacklisted neighbor interface."
    REFERENCE
        "LOADng."
 ::= { loadngBlacklistedNeighborSetEntry 3 }

```

```

loadngBlacklistedNeighborSetBTime OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION

```



```

        "loadngBlacklistedNeighborSetBTime specifies the
        sysUptime when to expire this entry and remove
        it from the 'loadngBlacklistedNeighborSetTable'"
REFERENCE
    "LOADng."
 ::= { loadngBlacklistedNeighborSetEntry 4 }

--
-- Routing Set
--

loadngRoutingSetTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LoadngRoutingSetEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "The Routing Set records the next hop
        on the route to each known destination,
        when such a route is known. It consists of
        Routing Tuples."
    REFERENCE
        "LOADng."
 ::= { loadngStateObjGrp 3 }

loadngRoutingSetEntry OBJECT-TYPE
    SYNTAX      LoadngRoutingSetEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "A router's Routing Set consists
        of Routing Tuples:

        (R_dest_addr, R_next_addr, R_dist,
         R_metric, R_seq_num, R_valid_time,
         R_bidirectional, R_local_iface_addr)
        "
    REFERENCE
        "LOADng."
    INDEX { loadngRoutingSetIndex }
 ::= { loadngRoutingSetTable 1 }

```

```

LoadngRoutingSetEntry ::=
    SEQUENCE {
        loadngRoutingSetIndex
            Integer32,
        loadngRoutingSetDestIpAddressType
            InetAddressType,
        loadngRoutingSetDestIpAddress
            InetAddress,
        loadngRoutingSetNextIpAddressType
            InetAddressType,
        loadngRoutingSetNextIpAddress
            InetAddress,
        loadngRoutingSetRouteCost
            Unsigned32,
        loadngRoutingSetWeakLinks
            Unsigned32,
        loadngRoutingSetMetric
            Integer32,
        loadngRoutingSetSeqnum
            Integer32,
        loadngRoutingSetValidTime
            TimeStamp,
        loadngRoutingSetBidirectional
            TruthValue,
        loadngRoutingSetLocalIfaceIpAddressType
            InetAddressType,
        loadngRoutingSetLocalIfaceIpAddress
            InetAddress
    }

```

```

loadngRoutingSetIndex OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The index for this table."
    REFERENCE
        "LOADng."
 ::= { loadngRoutingSetEntry 1 }

```

```

loadngRoutingSetDestIpAddressType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The type of the loadngRoutingSetDestIpAddress
        in the InetAddress MIB (RFC4001)."

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```

        Only the values ipv4(1) and
        ipv6(2) are supported."
REFERENCE
    "LOADng."
 ::= { loadngRoutingSetEntry 2 }

loadngRoutingSetDestIpAddress OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "loadngRoutingSetDestIpAddressType is the address
        of the destination, either the address of an
        interface of a destination LOADng Router, or
        the address of an interface reachable via the
        destination LOADng Router, but which is outside
        the LLN."
    REFERENCE
        "LOADng."
 ::= { loadngRoutingSetEntry 3 }

loadngRoutingSetNextIpAddressType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The type of the loadngRoutingSetNextIpAddress
        in the InetAddress MIB (RFC4001)."

        Only the values ipv4(1) and
        ipv6(2) are supported."
    REFERENCE
        "LOADng."
 ::= { loadngRoutingSetEntry 4 }

loadngRoutingSetNextIpAddress OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "loadngRoutingSetNextIpAddress is the
        address of the next hop on the selected
```

```

        route to the destination."
REFERENCE
    "LOADng."
 ::= { loadngRoutingSetEntry 5 }

loadngRoutingSetRouteCost  OBJECT-TYPE

```

```

SYNTAX      Unsigned32
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "loadngRoutingSetRouteCost is the distance
    (in number of hops) associated
    with the selected route to the destination
    with address R_dest_addr."
REFERENCE
    "LOADng."
 ::= { loadngRoutingSetEntry 6 }

loadngRoutingSetWeakLinks  OBJECT-TYPE
SYNTAX      Unsigned32
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "loadngRoutingSetWeakLinks is the distance
    (in number of weak links) associated
    with the selected route to the destination
    with address R_dest_addr."
REFERENCE
    "LOADng."
 ::= { loadngRoutingSetEntry 7 }

loadngRoutingSetMetric  OBJECT-TYPE
SYNTAX      Integer32
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "loadngRoutingSetMetric specifies how R_dist
    is defined and calculated, as well as the
    comparison operator <= for determining which
    of two route costs is lower."
REFERENCE

```

```

        "LOADng."
 ::= { loadngRoutingSetEntry 8 }

loadngRoutingSetSeqnum OBJECT-TYPE
    SYNTAX      Integer32 (-1..65535)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "loadngRoutingSetSeqnum is the value of the
        <seq-num> field of the RREQ or RREP which installed
        or last updated this tuple. For the routing
        tuples installed by previous hop information of
        RREQ or RREP, loadngRoutingSetSeqnum must be

```

```

        set to -1."
REFERENCE
    "LOADng."
 ::= { loadngRoutingSetEntry 9 }

loadngRoutingSetValidTime OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "loadngRoutingSetValidTime specifies the sysUptime
        when to expire this entry and remove it from the
        'loadngRoutingSetTable'"
REFERENCE
    "LOADng."
 ::= { loadngRoutingSetEntry 10 }

```

```

loadngRoutingSetBidirectional OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "loadngRoutingSetBidirectional is a boolean
        flag, which specifies if the routing tuple
        is verified as representing a bi-directional
        route. Data traffic should only be routed
        through a routing tuple with R_bidirectional

```

```

        flag equals TRUE, unless the router is
        configured as accepting routes without
        bi-directionality verification explicitly by
        setting the USE_BIDIRECTIONAL_LINK_ONLY to FALSE."
REFERENCE
    "LOADng."
 ::= { loadngRoutingSetEntry 11 }

```

```

loadngRoutingSetLocalIfaceIpAddressType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The type of the loadngRoutingSetLocalIfaceIpAddress
        in the InetAddress MIB (RFC4001).

        Only the values ipv4(1) and
        ipv6(2) are supported."
REFERENCE

```

```

    "LOADng."
 ::= { loadngRoutingSetEntry 12 }

loadngRoutingSetLocalIfaceIpAddress OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "loadngRoutingSetLocalIfaceIpAddress is the address
        of the local interface, through which the
        destination can be reached."
    REFERENCE
        "LOADng."
 ::= { loadngRoutingSetEntry 13 }

```

```

--
-- Pending Acknowledgment Set
--

```

```

loadngPendingAckSetTable OBJECT-TYPE

```

```

SYNTAX      SEQUENCE OF LoadngPendingAckSetEntry
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
    "The Pending Acknowledgment Set contains
    information about RREPs which have been
    transmitted with the ackrequired flag set,
    and for which an RREP_ACK has not yet been
    received. It consists of Pending Acknowledgment
    Tuples."
REFERENCE
    "LOADng."
 ::= { loadngStateObjGrp 4 }

loadngPendingAckSetEntry  OBJECT-TYPE
    SYNTAX      LoadngPendingAckSetEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A router's Pending Acknowledgment Set
        consists of Pending Acknowledgment Tuples:

        (P_next_hop, P_originator, P_seq_num,
        P_ack_timeout)
        "
    REFERENCE
        "LOADng."

```

```

INDEX { loadngPendingAckSetIndex }
 ::= { loadngPendingAckSetTable 1 }

LoadngPendingAckSetEntry ::=
    SEQUENCE {
        loadngPendingAckSetIndex
            Integer32,
        loadngPendingAckSetNextIpAddrType
            InetAddressType,
        loadngPendingAckSetNextIpAddr
            InetAddress,
        loadngPendingAckSetOrigIpAddrType
            InetAddressType,
        loadngPendingAckSetOrigIpAddr

```

```

        InetAddress,
        loadngPendingAckSetSeqnum
        Integer32,
        loadngPendingAckSetValidTime
        TimeStamp
    }

loadngPendingAckSetIndex OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The index for this table."
    REFERENCE
        "LOADng."
 ::= { loadngPendingAckSetEntry 1 }

loadngPendingAckSetNextIpAddrType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The type of the loadngPendingAckSetNextIpAddr
         in the InetAddress MIB (RFC4001).

        Only the values ipv4(1) and
        ipv6(2) are supported."
    REFERENCE
        "LOADng."
 ::= { loadngPendingAckSetEntry 2 }

loadngPendingAckSetNextIpAddr OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS  read-only

```

```

    STATUS      current
    DESCRIPTION
        "loadngPendingAckSetNextIpAddr is the address
         of the neighbor interface to which the RREP
         was sent. "
    REFERENCE
        "LOADng."

```



```

 ::= { loadngPendingAckSetEntry 3 }

loadngPendingAckSetOrigIpAddressType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The type of the loadngPendingAckSetOrigIpAddress
         in the InetAddress MIB (RFC4001).

         Only the values ipv4(1) and
         ipv6(2) are supported."
    REFERENCE
        "LOADng."
 ::= { loadngPendingAckSetEntry 4 }

loadngPendingAckSetOrigIpAddress OBJECT-TYPE
    SYNTAX      InetAddress (SIZE(4|16))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "loadngPendingAckSetOrigIpAddress is the address
         of the originator of the RREP."
    REFERENCE
        "LOADng."
 ::= { loadngPendingAckSetEntry 5 }

loadngPendingAckSetSeqnum OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "loadngPendingAckSetSeqnum corresponds to the
         <seq-num> field of the sent RREP."
    REFERENCE
        "LOADng."
 ::= { loadngPendingAckSetEntry 6 }

loadngPendingAckSetValidTime OBJECT-TYPE
    SYNTAX      TimeStamp

```

```

        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION
            "loadngPendingAckSetValidTime specifies the sysUptime
            when to expire this entry and remove it from the
            'loadngPendingAckSetTable'"
        REFERENCE
            "LOADng."
    ::= { loadngPendingAckSetEntry 7 }

--
-- loadngConformance information
--

loadngCompliances          OBJECT IDENTIFIER ::= { loadngConformance 1 }
loadngMIBGroups            OBJECT IDENTIFIER ::= { loadngConformance 2 }

-- Compliance Statements
loadngBasicCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The basic implementation requirements for
        managed network entities that implement
        LOADng."
    MODULE -- this module

    MANDATORY-GROUPS { loadngConfigurationGroup }

    ::= { loadngCompliances 1 }

loadngFullCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The full implementation requirements for
        managed network entities that implement
        LOADng."
    MODULE -- this module

    MANDATORY-GROUPS { loadngConfigurationGroup,
                        loadngStateGroup }

    ::= { loadngCompliances 2 }

--

```

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```
-- Units of Conformance
```

```
--
```

```
loadngConfigurationGroup OBJECT-GROUP
```

```
  OBJECTS {
```

```
    loadngNetTraversalTime,
    loadngRREQRetries,
    loadngRREQRateLimit,
    loadngRHoldTime,
    loadngMaxRouteCost,
    loadngMaxWeakLinks,
    loadngRREPAckRequired,
    loadngRREPAckTimeout,
    loadngBHoldTime,
    loadngUseBidirectionalLinkOnly,
    loadngIfRowStatus,
    loadngLibLocalIfSetIfIndex,
    loadngLibLocalIfSetIpAddressType,
    loadngLibLocalIfSetRowStatus
```

```
  }
```

```
  STATUS current
```

```
  DESCRIPTION
```

```
    "Set of LOADng configuration objects implemented
    in this module."
```

```
 ::= { loadngMIBGroups 2 }
```

```
loadngStateGroup OBJECT-GROUP
```

```
  OBJECTS {
```

```
    loadngUpTime,
    loadngIfStateUpTime,
    loadngBlacklistedNeighborSetIpAddressType,
    loadngBlacklistedNeighborSetIpAddress,
    loadngBlacklistedNeighborSetBTime,
    loadngRoutingSetDestIpAddressType,
    loadngRoutingSetDestIpAddress,
    loadngRoutingSetNextIpAddressType,
    loadngRoutingSetNextIpAddress,
    loadngRoutingSetRouteCost,
    loadngRoutingSetWeakLinks,
    loadngRoutingSetMetric,
    loadngRoutingSetSeqnum,
    loadngRoutingSetValidTime,
    loadngRoutingSetBidirectional,
```

```
loadngRoutingSetLocalIfaceIpAddrType,  
loadngRoutingSetLocalIfaceIpAddr,  
loadngPendingAckSetNextIpAddrType,  
loadngPendingAckSetNextIpAddr,  
loadngPendingAckSetOrigIpAddrType,
```

```
loadngPendingAckSetOrigIpAddr,  
loadngPendingAckSetSeqnum,  
loadngPendingAckSetValidTime  
}  
STATUS current  
DESCRIPTION  
    "Set of LOADng state objects implemented  
    in this module."  
 ::= { loadngMIBGroups 3 }
```

END

8. Security Considerations

This MIB module defines objects for the configuration and monitoring of LOADng [[LOADng](#)].

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:

- o loadngNetTraversalTime - this writable object controls the maximum time that a packet is expected to take when traversing from one end of the network to the other. If set too low, a router will not wait long enough until receiving an RREP as response to an RREQ. Therefore, all route requests may fail and render LOADng useless.
- o loadngRREQRetries - this writable object controls how many RREQs may be sent until an RREP must have been received or the route discovery is considered failed. If set too low in very lossy

networks, route discovery may fail for destinations (which otherwise would have succeeded, had the value been higher). If set too high, a router may send unnecessary many RREQs, draining energy from the router and consuming bandwidth.

- o `loadngRREQRateLimit` - this writable object controls how many RREQs may be sent per second. If set too high, a malicious node (host or router) may request routes for many destinations, resulting in many RREQs, which drain energy from the router and consume bandwidth.

- o `loadngRHoldTime` - this writable object controls how long a Routing Tuple is hold in the Routing Set. If set too low, a router may not keep routes long enough, and may therefore frequently rediscover the same routes to a destination, resulting in bandwidth consumption and energy drain.
- o `loadngRREPackTimeout` - this writable object controls how long a router waits before expecting an RREP_ACK. If set too low, and if RREP_ACKs are required, the router may list the neighbor as unidirectional and may therefore not use it for routing.
- o `loadngBHoldTime` - this writable object controls how long a Blacklisted Neighbor Tuples is hold in the Blacklisted Neighbor Set. If set too high, a neighbor router may be blocked for a long time, even though it may have become reachable bidirectionally in the meantime.
- o `loadngRREPackRequired` - this writable object controls whether RREP_ACKs are required for verification of bidirectionality. If disabled in a lossy environment, and if bidirectionality is not verified by other means, unidirectional routes may be discovered to destinations.
- o `loadngMaxRouteCost`, `loadngMaxWeakLinks` - these writable objects control the maximum distance of a router in the LLN. If set too low, destinations may be ignored to which otherwise a path could be established by LOADng.

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:

- o loadngRoutingSetTable - The table contains information on destinations in the LLN, specifically their IP address in the loadngRoutingSetDestIpAddr object. This information provides an adversary broad information on the members of the LLN, located within this single table. This information can be use to expedite attacks on the other members of the LLN without having to go through a laborious discovery process on their own. This object is the index into the table, and has a MAX-ACCESS of 'not-accessible'. However, this information can be exposed using SNMP operations.

LLN technology is often deployed to support communications of

emergency services or military tactical applications. In these applications, it is imperative to maintain the proper operation of the communications network and to protect sensitive information related to its operation. Therefore, it is RECOMMENDED to provide support for the Transport Security Model (TSM) [[RFC5591](#)] in combination with TLS/DTLS [[RFC6353](#)].

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

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

Further, deployment of SNMP versions prior to SNMPv3 is NOT

RECOMMENDED. Instead, it is RECOMMENDED to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of this MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

9. IANA Considerations

Editor's Note (to be removed prior to publication): IANA is requested to assign a value for "XXXX" under the 'mib-2' subtree and to record the assignment in the SMI Numbers registry. When the assignment has been made, the RFC Editor is asked to replace "XXXX" (here and in the MIB module) with the assigned value and to remove this note. Note well: prior to official assignment by the IANA, a draft document MUST use placeholders (such as "XXXX" above) rather than actual numbers. See [RFC4181 Section 4.5](#) for an example of how this is done in a draft MIB module.

10. Acknowledgements

This MIB document uses the template authored by D. Harrington which is based on contributions from the MIB Doctors, especially Juergen Schoenwaelder, Dave Perkins, C.M.Heard and Randy Presuhn.

11. References

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Appendix A.

```
*****
* Note to the RFC Editor (to be removed prior to publication) *
*                                                                 *
* The reference to RFCXXXX within the DESCRIPTION clauses      *
* of the MIB module point to this draft and are to be          *
* assigned by the RFC Editor.                                    *
*                                                                 *
*****
```

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