        Definition of Managed Objects for IPv6 over Low-Power Wireless Personal
                         Area Networks (6LoWPANs)
                       draft-ietf-6lo-lowpan-mib-04

   Abstract

      This document defines a portion of the Management Information Base
      (MIB) for use with network management protocols in the Internet
      community. In particular, it defines objects for managing IPv6 over
      Low-Power Wireless Personal Area Networks (6LoWPANs).

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1. Introduction

   This document defines a portion of the Management Information Base (MIB) for use with network management protocols. In particular it defines objects for managing IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs) [RFC4944].

   While a MIB module provides a direct binding for accessing data via the Simple Network Management Protocol (SNMP) [RFC3410], supporting SNMP may not always be affordable on constrained devices. Other protocols to access data modeled in MIB modules are possible and proposals have been made recently to provide bindings to the Constrained Application Protocol (CoAP) [RFC7252].

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 document 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. 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 RFC
   2119 [RFC2119].

4. Overview

   The left part of Figure 1 provides an overview of the IETF protocols
   designed for constrained devices. The right part lists the MIB
   modules providing monitoring and troubleshooting support ([RFC4113],
   [RFC4292], [RFC4293], [RFC2863]). The LOWPAN-MIB defined in this
   document fills a hole by providing monitoring and troubleshooting
   support for the 6LoWPAN layer.

```
        Protocol Layer                     MIB Modules
    +-------------------+
    |  CoAP    [RFC7252]|
    +-------------------+          +-------------------------+
    |   UDP    [RFC0768]|          | UDP-MIB        [RFC4113]|
    +-------------------+          +-------------------------+
    |   IPv6   [RFC2460]|          | IP-MIB         [RFC4293]|
    |   ICMPv6 [RFC4443]|          | IP-FORWARD-MIB [RFC4292]|
    +-------------------+          +-------------------------+
    | 6LoWPAN [RFC4944] |          | LOWPAN-MIB     [RFCXXXX]|
    +-------------------+          +-------------------------+
                                   | IF-MIB         [RFC2863]|
    +-------------------+          +-------------------------+
    | IEEE 802.15.4, ...|
    +-------------------+
```

   /* RFC Ed.: replace XXXX above with RFC number
            and remove this note */

              Figure 1: Protocol Layers and MIB Modules

   The LOWPAN-MIB module is primarily a collection of counters that
   reflect how 6LoWPAN datagrams are processed by the 6LoWPAN layer.
   The objects are defined twice, once to report the global statistics
   as seen by the 6LoWPAN layer and once to report per interface 6LoWPAN
   layer statistics. The per interface statistics are optional to
   implement. The object identifier registration tree has the following
   structure:

      /* RFC Ed.: replace XXXX below with IANA assigned OID number
               and remove this note */

```
---- lowpanMIB(1.3.6.1.2.1.XXXX)
  +---- lowpanNotifications(0)
  +---- lowpanObjects(1)
  |   +---- lowpanStats(1)
  |   |   +--r- lowpanReasmTimeout(1)            Unsigned32
  |   |   +--r- lowpanInReceives(2)              Counter32
  |   |   +--r- lowpanInHdrErrors(3)             Counter32
  |   |   +--r- lowpanInMeshReceives(4)          Counter32
  |   |   +--r- lowpanInMeshForwds(5)            Counter32
  |   |   +--r- lowpanInMeshDelivers(6)          Counter32
  |   |   +--r- lowpanInReasmReqds(7)            Counter32
  |   |   +--r- lowpanInReasmFails(8)            Counter32
  |   |   +--r- lowpanInReasmOKs(9)              Counter32
  |   |   +--r- lowpanInCompReqds(10)            Counter32
  |   |   +--r- lowpanInCompFails(11)            Counter32
  |   |   +--r- lowpanInCompOKs(12)              Counter32
  |   |   +--r- lowpanInDiscards(13)             Counter32
  |   |   +--r- lowpanInDelivers(14)             Counter32
  |   |   +--r- lowpanOutRequests(15)            Counter32
  |   |   +--r- lowpanOutCompReqds(16)           Counter32
  |   |   +--r- lowpanOutCompFails(17)           Counter32
  |   |   +--r- lowpanOutCompOKs(18)             Counter32
  |   |   +--r- lowpanOutFragReqds(19)           Counter32
  |   |   +--r- lowpanOutFragFails(20)           Counter32
  |   |   +--r- lowpanOutFragOKs(21)             Counter32
  |   |   +--r- lowpanOutFragCreates(22)         Counter32
  |   |   +--r- lowpanOutMeshHopLimitExceeds(23) Counter32
  |   |   +--r- lowpanOutMeshNoRoutes(24)        Counter32
  |   |   +--r- lowpanOutMeshRequests(25)        Counter32
  |   |   +--r- lowpanOutMeshForwds(26)          Counter32
  |   |   +--r- lowpanOutMeshTransmits(27)       Counter32
  |   |   +--r- lowpanOutDiscards(28)            Counter32
  |   |   +--r- lowpanOutTransmits(29)           Counter32
  |   +---- lowpanIfStatsTable(2)
  |       +---- lowpanIfStatsEntry(1) [ifIndex]
  |           +--r- lowpanIfReasmTimeout(1)       Unsigned32
  |           +--r- lowpanIfInReceives(2)         Counter32
  |           +--r- lowpanIfInHdrErrors(3)        Counter32
  |           +--r- lowpanIfInMeshReceives(4)     Counter32
  |           +--r- lowpanIfInMeshForwds(5)       Counter32
  |           +--r- lowpanIfInMeshDelivers(6)     Counter32
  |           +--r- lowpanIfInReasmReqds(7)       Counter32
  |           +--r- lowpanIfInReasmFails(8)       Counter32
  |           +--r- lowpanIfInReasmOKs(9)         Counter32
  |           +--r- lowpanIfInCompReqds(10)       Counter32
  |           +--r- lowpanIfInCompFails(11)       Counter32
  |           +--r- lowpanIfInCompOKs(12)         Counter32
  |           +--r- lowpanIfInDiscards(13)        Counter32
```

```
         |         +--r- lowpanIfInDelivers(14)              Counter32
         |         +--r- lowpanIfOutRequests(15)             Counter32
         |         +--r- lowpanIfOutCompReqds(16)            Counter32
         |         +--r- lowpanIfOutCompFails(17)            Counter32
         |         +--r- lowpanIfOutCompOKs(18)              Counter32
         |         +--r- lowpanIfOutFragReqds(19)            Counter32
         |         +--r- lowpanIfOutFragFails(20)            Counter32
         |         +--r- lowpanIfOutFragOKs(21)              Counter32
         |         +--r- lowpanIfOutFragCreates(22)          Counter32
         |         +--r- lowpanIfOutMeshHopLimitExceeds(23)  Counter32
         |         +--r- lowpanIfOutMeshNoRoutes(24)         Counter32
         |         +--r- lowpanIfOutMeshRequests(25)         Counter32
         |         +--r- lowpanIfOutMeshForwds(26)           Counter32
         |         +--r- lowpanIfOutMeshTransmits(27)        Counter32
         |         +--r- lowpanIfOutDiscards(28)             Counter32
         |         +--r- lowpanIfOutTransmits(29)            Counter32
     +---- lowpanConformance(2)
        +---- lowpanGroups(1)
        |  +---- lowpanStatsGroup(1)
        |  +---- lowpanStatsMeshGroup(2)
        |  +---- lowpanIfStatsGroup(3)
        |  +---- lowpanIfStatsMeshGroup(4)
        +---- lowpanCompliances(2)
           +---- lowpanCompliance(1)
```

The counters defined in the LOWPAN-MIB module provide information
about the 6LoWPAN datagrams received and transmitted and how they are
processed in the 6LoWPAN layer. For link-layers that use the 6LoWPAN
dispatch byte as defined in [RFC4944] (e.g., IEEE 802.15.4), a
6LoWPAN datagram is a datagram with a dispatch byte matching the bit
patterns 01xxxxxx, 10xxxxxx, or 11xxxxxx. Datagrams with a dispatch
byte matching the bit pattern 00xxxxxx (NALP - not a LoWPAN frame)
are not considered to be 6LoWPAN datagram by this specification.
Other radio technologies may use different mechanisms to identify
6LoWPAN datagrams (e.g., the BLUETOOTH Low Energy Logical Link
Control and Adaptation Protocol uses Channel Identifiers
[I-D.ietf-6lo-btle]).

The Case Diagram [CASE] in Figure 2 illustrates the conceptual
relationships between the counters. Implementations may choose to
implement the processing of 6LoWPAN datagrams in a different order.

The generic InDiscards and OutDiscards counters can be incremented
anytime when 6LoWPAN datagrams are discarded due to reasons not
covered by the other more specific counters. For example, an
implementation discarding 6LoWPAN datagrams while all buffers are
used for ongoing packet reassemblies will increment the relevant
InDiscards counters for each discarded 6LoWPAN datagram.

```
                            IPv6 layer
                       ^              v
   InDelivers         -+-            -+-           OutRequests
                       |              |
   InDiscards        <--+             |
                       |              |
   InCompOKs         .-->|            |-->.        OutCompReqds
   InCompFails     <--|  |            |   +--> OutCompFails
   InCompReqds       '<--+           +<--'        OutCompOKs
                       |              |
                       |             +-->.        OutFragReqds
   InReasmOKs        .-->|            |   +--> OutFragFails
   InReasmFails    <--|  |            |  -+-       OutFragOKs
   InReasmReqds      '<--+           +<--'        OutFragCreates
                       |              |
                       |              |
   InMeshDelivers     |<--.           |
   InMeshForwds       |   |-->.       |
   InMeshReceives     +-->'   |       |
                       |     +-->      |          OutMeshHopLimitExceeds
                       |     +-->      |          OutMeshNoRoutes
                       |      |        |
                       |      |   .<--+           OutMeshRequests
                       |      '-->|   |           OutMeshForwds
                       |         '-->|            OutMeshTransmits
                       |              |
   InHdrErrors       <--+           +-->          OutDiscards
                       |              |
   InReceives         -+-            -+-          OutTransmits
                       ^              v
                        interface layer
```
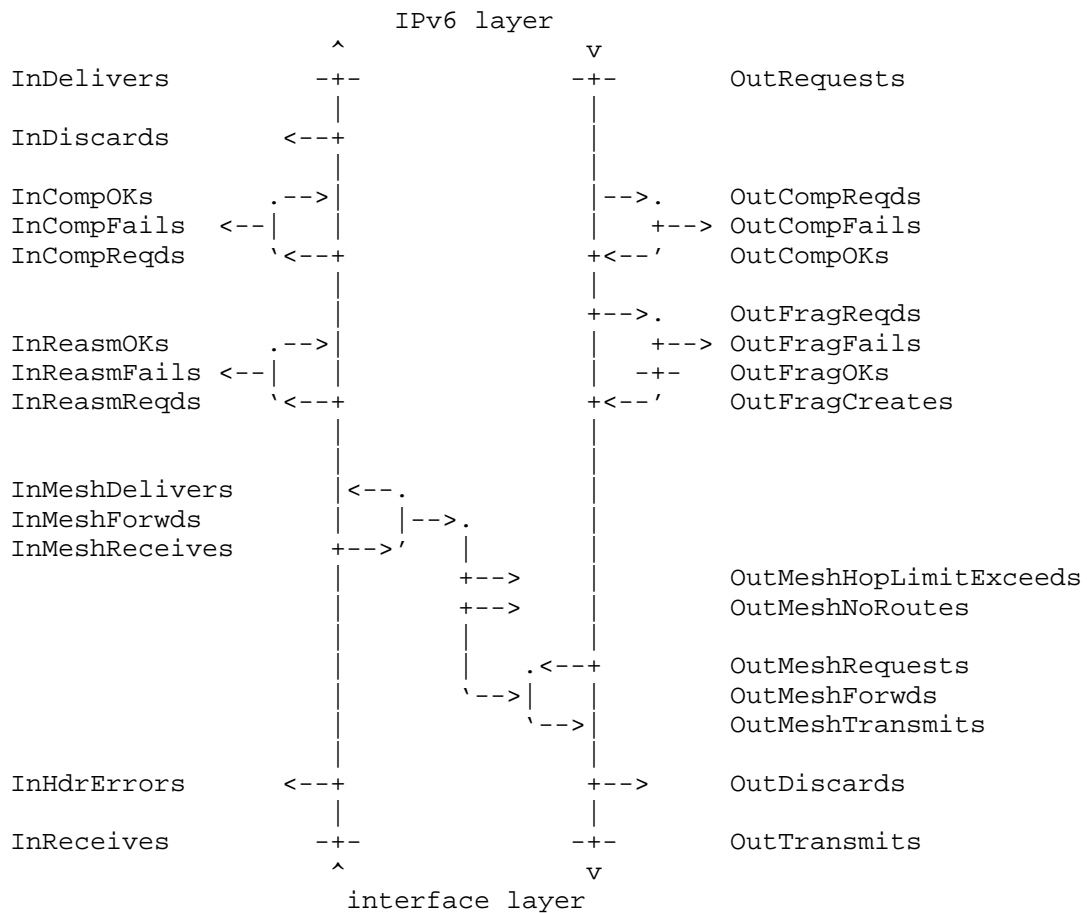
      Figure 2: Conceptual Relationship between LOWPAN-MIB Counters

   The fragmentation related counters have been modeled after the
   fragmentation related counters of the IP-MIB [RFC4293]. The discard
   counters have been placed at the end of the input and output chains
   but they can be bumped any time if a datagram is discarded for a
   reason not covered by the other counters.

   The compression related counters provide insights into compression
   requests and in particular also compression related failures. Note
   that the diagram is conceptual in the sense that compression happens
   after reassembly for incoming 6LoWPAN datagrams and compression
   happens before fragmentation for outgoing 6LoWPAN datagrams.
   Implementations may choose to implement things slightly differently.
   For example, implementations may decompress FRAG1 fragments as soon
   as they are received, not waiting for reassembly to complete.

The mesh header processing related counters do not have an explicit
discard counter. Implementations that do not support mesh forwarding
MUST count the number of received 6LoWPAN datagrams with a MESH
header (lowpanInMeshReceives) but they MUST NOT increment the
lowpanInMeshReceives and lowpanInMeshDelivers counters if these
6LoWPAN datagrams are dropped.

5. Relationship to Other MIB Modules

The MIB module imports definitions from SNMPv2-SMI [RFC2578],
SNMPv2-CONF [RFC2580], and IF-MIB [RFC2863].

6. Definitions

```
LOWPAN-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, Unsigned32, Counter32, mib-2
        FROM SNMPv2-SMI                             -- RFC 2578
    OBJECT-GROUP, MODULE-COMPLIANCE
        FROM SNMPv2-CONF                            -- RFC 2580
    ifIndex FROM IF-MIB;                            -- RFC 2863

lowpanMIB    MODULE-IDENTITY
    LAST-UPDATED    "201409050000Z"
    ORGANIZATION
        "IETF IPv6 over Networks of Resource-constrained Nodes
         Working Group"
    CONTACT-INFO
        "WG Email: 6lo@ietf.org
         WG Web:   http://tools.ietf.org/wg/6lo/

         Juergen Schoenwaelder
         Jacobs University Bremen
         Email: j.schoenwaelder@jacobs-university.de

         Anuj Sehgal
         Jacobs University Bremen
         Email: s.anuj@jacobs-university.de

         Tina Tsou
         Huawei Technologies
         Email: tina.tsou.zouting@huawei.com

         Cathy Zhou
         Huawei Technologies
         Email: cathyzhou@huawei.com"
```

        DESCRIPTION
            "The MIB module for monitoring nodes implementing the IPv6
             over Low-Power Wireless Personal Area Networks (6LoWPAN)
             protocol.

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             authors of the code. All rights reserved.

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

        REVISION "201409050000Z"
        DESCRIPTION
            "Initial version, published as RFC XXXX."
        -- RFC Ed.: replace XXXX with RFC number and remove this note

        ::= { mib-2 YYYY }
        -- RFC Ed.: replace YYYY with IANA assigned number

    -- object definitions

    lowpanNotifications   OBJECT IDENTIFIER ::= { lowpanMIB 0 }
    lowpanObjects   OBJECT IDENTIFIER ::= { lowpanMIB 1 }
    lowpanConformance   OBJECT IDENTIFIER ::= { lowpanMIB 2 }

    lowpanStats   OBJECT IDENTIFIER ::= { lowpanObjects 1 }

    lowpanReasmTimeout OBJECT-TYPE
        SYNTAX   Unsigned32
        UNITS   "seconds"
        MAX-ACCESS read-only
        STATUS   current
        DESCRIPTION
            "The maximum number of seconds that received fragments are
             held while they are awaiting reassembly at this entity."
        ::= { lowpanStats 1 }

    lowpanInReceives OBJECT-TYPE
        SYNTAX   Counter32
        MAX-ACCESS read-only
        STATUS   current
        DESCRIPTION
            "The total number of 6LoWPAN datagrams received, including
             those received in error."

```
        ::= { lowpanStats 2 }

    lowpanInHdrErrors OBJECT-TYPE
        SYNTAX       Counter32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "The number of received 6LoWPAN datagrams discarded due to
             errors in their headers, including unknown dispatch values."
        ::= { lowpanStats 3 }

    lowpanInMeshReceives OBJECT-TYPE
        SYNTAX       Counter32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "The number of received 6LoWPAN datagrams with a MESH
             header."
        ::= { lowpanStats 4 }

    lowpanInMeshForwds OBJECT-TYPE
        SYNTAX       Counter32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "The number of received 6LoWPAN datagrams requiring MESH
             forwarding."
        ::= { lowpanStats 5 }

    lowpanInMeshDelivers OBJECT-TYPE
        SYNTAX       Counter32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "The number of received 6LoWPAN datagrams with a MESH header
             delivered to the local system."
        ::= { lowpanStats 6 }

    lowpanInReasmReqds OBJECT-TYPE
        SYNTAX       Counter32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "The number of received 6LoWPAN fragments that needed to
             be reassembled. This includes both FRAG1 and FRAGN 6LoWPAN
             datagrams."
        ::= { lowpanStats 7 }
```

```
lowpanInReasmFails OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of failures detected by the re-assembly
         algorithm (e.g., timeouts). Note that this is not
         necessarily a count of discarded 6LoWPAN fragments
         since implementations can lose track of the number
         of fragments by combining them as received."
    ::= { lowpanStats 8 }

lowpanInReasmOKs OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of IPv6 packets successfully reassembled."
    ::= { lowpanStats 9 }

lowpanInCompReqds OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of 6LoWPAN datagrams requiring header
         decompression."
    ::= { lowpanStats 10 }

lowpanInCompFails OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of 6LoWPAN datagrams where header decompression
         failed (e.g., because the necessary context information was
         not available)."
    ::= { lowpanStats 11 }

lowpanInCompOKs OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of 6LoWPAN datagrams where header decompression
         was successful."
    ::= { lowpanStats 12 }
```

```
    lowpanInDiscards OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of received 6LoWPAN datagrams for which no
             problems were encountered to prevent their continued
             processing, but were discarded (e.g., for lack of buffer
             space).  Note that this counter does not include any
             datagrams discarded due to a reassembly failure or a
             compression failure."
        ::= { lowpanStats 13 }

    lowpanInDelivers OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The total number of IPv6 packets successfully delivered
             to the IPv6 layer."
        ::= { lowpanStats 14 }

    lowpanOutRequests OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The total number of IPv6 packets supplied by the IPv6
             layer."
        ::= { lowpanStats 15 }

    lowpanOutCompReqds OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The total number of IPv6 packets for which header
             compression was attempted."
        ::= { lowpanStats 16 }

    lowpanOutCompFails OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The total number of IPv6 packets for which header
             compression failed."
        ::= { lowpanStats 17 }
```

```
    lowpanOutCompOKs OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The total number of IPv6 packets for which header
             compression was successful."
        ::= { lowpanStats 18 }

    lowpanOutFragReqds OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of IPv6 packets that required fragmentation
             in order to be transmitted."
        ::= { lowpanStats 19 }

    lowpanOutFragFails OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of IPv6 packets that have been discarded because
             fragmentation failed."
        ::= { lowpanStats 20 }

    lowpanOutFragOKs OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of IPv6 packets that have been successfully
             fragmented."
        ::= { lowpanStats 21 }

    lowpanOutFragCreates OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN fragments that have been
             generated as a result of fragmentation. This includes
             both FRAG1 and FRAGN 6LoWPAN datagrams."
        ::= { lowpanStats 22 }

    lowpanOutMeshHopLimitExceeds OBJECT-TYPE
        SYNTAX      Counter32
```

```
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams with a MESH header that
             were dropped because the hop limit has been exceeded."
        ::= { lowpanStats 23 }

    lowpanOutMeshNoRoutes OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams with a MESH header that
             were dropped because there was no forwarding information
             available."
        ::= { lowpanStats 24 }

    lowpanOutMeshRequests OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams requiring MESH header
             encapsulation."
        ::= { lowpanStats 25 }

    lowpanOutMeshForwds OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams with a MESH header for
             which suitable forwarding information was available."
        ::= { lowpanStats 26 }

    lowpanOutMeshTransmits OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams with a MESH header
             created."
        ::= { lowpanStats 27 }

    lowpanOutDiscards OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
```

```
        DESCRIPTION
            "The number of IPv6 packets for which no problem was
             encountered to prevent their transmission to their
             destination, but were discarded (e.g., for lack of
             buffer space)."
        ::= { lowpanStats 28 }

    lowpanOutTransmits OBJECT-TYPE
        SYNTAX       Counter32
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "The total number of 6LoWPAN datagram that this entity
             supplied to the lower layers for transmission."
        ::= { lowpanStats 29 }

    lowpanIfStatsTable OBJECT-TYPE
        SYNTAX       SEQUENCE OF LowpanIfStatsEntry
        MAX-ACCESS   not-accessible
        STATUS       current
        DESCRIPTION
            "A table providing per interface statistics."
        ::= { lowpanObjects 2 }

    lowpanIfStatsEntry OBJECT-TYPE
        SYNTAX       LowpanIfStatsEntry
        MAX-ACCESS   not-accessible
        STATUS       current
        DESCRIPTION
            "An entry providing statistics for a specific interface."
        INDEX        { ifIndex }
        ::= { lowpanIfStatsTable 1 }

    LowpanIfStatsEntry ::= SEQUENCE {
        lowpanIfReasmTimeout          Unsigned32,
        lowpanIfInReceives            Counter32,
        lowpanIfInHdrErrors           Counter32,
        lowpanIfInMeshReceives        Counter32,
        lowpanIfInMeshForwds          Counter32,
        lowpanIfInMeshDelivers        Counter32,
        lowpanIfInReasmReqds          Counter32,
        lowpanIfInReasmFails          Counter32,
        lowpanIfInReasmOKs            Counter32,
        lowpanIfInCompReqds           Counter32,
        lowpanIfInCompFails           Counter32,
        lowpanIfInCompOKs             Counter32,
        lowpanIfInDiscards            Counter32,
        lowpanIfInDelivers            Counter32,
```

```
        lowpanIfOutRequests         Counter32,
        lowpanIfOutCompReqds        Counter32,
        lowpanIfOutCompFails        Counter32,
        lowpanIfOutCompOKs          Counter32,
        lowpanIfOutFragReqds        Counter32,
        lowpanIfOutFragFails        Counter32,
        lowpanIfOutFragOKs          Counter32,
        lowpanIfOutFragCreates      Counter32,
        lowpanIfOutMeshHopLimitExceeds Counter32,
        lowpanIfOutMeshNoRoutes     Counter32,
        lowpanIfOutMeshRequests     Counter32,
        lowpanIfOutMeshForwds       Counter32,
        lowpanIfOutMeshTransmits    Counter32,
        lowpanIfOutDiscards         Counter32,
        lowpanIfOutTransmits        Counter32
    }

    lowpanIfReasmTimeout OBJECT-TYPE
        SYNTAX      Unsigned32
        UNITS       "seconds"
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The maximum number of seconds that received fragments are
             held while they are awaiting reassembly at this interface."
        ::= { lowpanIfStatsEntry 1 }

    lowpanIfInReceives OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The total number of 6LoWPAN datagrams received on this
             interface, including those received in error."
        ::= { lowpanIfStatsEntry 2 }

    lowpanIfInHdrErrors OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams received on this
             interface that were discarded due to errors in
             their headers, including unknown dispatch values."
        ::= { lowpanIfStatsEntry 3 }

    lowpanIfInMeshReceives OBJECT-TYPE
        SYNTAX      Counter32
```

```
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams reveived on this
             interface with a MESH header."
        ::= { lowpanIfStatsEntry 4 }

    lowpanIfInMeshForwds OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams received on this
             interface requiring MESH forwarding."
        ::= { lowpanIfStatsEntry 5 }

    lowpanIfInMeshDelivers OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN datagrams received on this
             interface with a MESH header delivered to the local
             system."
        ::= { lowpanIfStatsEntry 6 }

    lowpanIfInReasmReqds OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of 6LoWPAN fragments received on this
             interface that needed to be reassembled. This
             includes both FRAG1 and FRAGN 6LoWPAN datagrams."
        ::= { lowpanIfStatsEntry 7 }

    lowpanIfInReasmFails OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of failures detected by the re-assembly
             algorithm (e.g., timeouts) for datagrams received
             on this interface. Note that this is not necessarily
             a count of discarded 6LoWPAN fragments since
             implementations can lose track of the number
             of fragments by combining them as received."
        ::= { lowpanIfStatsEntry 8 }
```

    lowpanIfInReasmOKs OBJECT-TYPE
        SYNTAX   Counter32
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION
            "The number of IPv6 packets successfully reassembled
             from fragments received on this interface."
        ::= { lowpanIfStatsEntry 9 }

    lowpanIfInCompReqds OBJECT-TYPE
        SYNTAX   Counter32
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION
            "The number of 6LoWPAN datagrams received on this
             interface requiring header decompression."
        ::= { lowpanIfStatsEntry 10 }

    lowpanIfInCompFails OBJECT-TYPE
        SYNTAX   Counter32
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION
            "The number of 6LoWPAN datagrams received on this
             interface where header decompression failed (e.g.,
             because the necessary context information was
             not available)."
        ::= { lowpanIfStatsEntry 11 }

    lowpanIfInCompOKs OBJECT-TYPE
        SYNTAX   Counter32
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION
            "The number of 6LoWPAN datagrams received on this
             interface where header decompression was successful."
        ::= { lowpanIfStatsEntry 12 }

    lowpanIfInDiscards OBJECT-TYPE
        SYNTAX   Counter32
        MAX-ACCESS   read-only
        STATUS   current
        DESCRIPTION
            "The number of 6LoWPAN datagrams received on this
             interface for which no problems were encountered to
             prevent their continued processing, but were discarded
             (e.g., for lack of buffer space). Note that this
             counter does not include any datagrams discarded due

```
        to a reassembly failure or a compression failure."
    ::= { lowpanIfStatsEntry 13 }

lowpanIfInDelivers OBJECT-TYPE
    SYNTAX       Counter32
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The total number of IPv6 packets received on this
         interface that were successfully delivered to the
         IPv6 layer."
    ::= { lowpanIfStatsEntry 14 }

lowpanIfOutRequests OBJECT-TYPE
    SYNTAX       Counter32
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The total number of IPv6 packets supplied by the IPv6
         layer to be sent over this interface."
    ::= { lowpanIfStatsEntry 15 }

lowpanIfOutCompReqds OBJECT-TYPE
    SYNTAX       Counter32
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The total number of IPv6 packets to be sent over
         this interface for which header compression was
         attempted."
    ::= { lowpanIfStatsEntry 16 }

lowpanIfOutCompFails OBJECT-TYPE
    SYNTAX       Counter32
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The total number of IPv6 packets to be sent over
         this interface for which header compression failed."
    ::= { lowpanIfStatsEntry 17 }

lowpanIfOutCompOKs OBJECT-TYPE
    SYNTAX       Counter32
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The total number of IPv6 packets to be sent over
         this interface for which header compression was
```

             successful."
         ::= { lowpanIfStatsEntry 18 }

     lowpanIfOutFragReqds OBJECT-TYPE
         SYNTAX   Counter32
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION
             "The number of IPv6 packets to be sent over this
              interface that required fragmentation in order
              to be transmitted."
         ::= { lowpanIfStatsEntry 19 }

     lowpanIfOutFragFails OBJECT-TYPE
         SYNTAX   Counter32
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION
             "The number of IPv6 packets to be sent over this
              interface that have been discarded because
              fragmentation failed."
         ::= { lowpanIfStatsEntry 20 }

     lowpanIfOutFragOKs OBJECT-TYPE
         SYNTAX   Counter32
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION
             "The number of IPv6 packets to be sent over this
              interface that have been successfully fragmented."
         ::= { lowpanIfStatsEntry 21 }

     lowpanIfOutFragCreates OBJECT-TYPE
         SYNTAX   Counter32
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION
             "The number of 6LoWPAN fragments that have been
              generated on this interface as a result of
              fragmentation. This includes both FRAG1 and FRAGN
              6LoWPAN datagrams."
         ::= { lowpanIfStatsEntry 22 }

     lowpanIfOutMeshHopLimitExceeds OBJECT-TYPE
         SYNTAX   Counter32
         MAX-ACCESS   read-only
         STATUS   current
         DESCRIPTION

          "The number of 6LoWPAN datagrams to be sent on this
           interface with a MESH header that were dropped
           because the hop limit has been exceeded."
       ::= { lowpanIfStatsEntry 23 }

   lowpanIfOutMeshNoRoutes OBJECT-TYPE
       SYNTAX   Counter32
       MAX-ACCESS   read-only
       STATUS   current
       DESCRIPTION
           "The number of 6LoWPAN datagrams to be sent on this
            interface with a MESH header that were dropped
            because there was no forwarding information available."
       ::= { lowpanIfStatsEntry 24 }

   lowpanIfOutMeshRequests OBJECT-TYPE
       SYNTAX   Counter32
       MAX-ACCESS   read-only
       STATUS   current
       DESCRIPTION
           "The number of 6LoWPAN datagrams to be sent on this
            interface requiring MESH header encapsulation."
       ::= { lowpanIfStatsEntry 25 }

   lowpanIfOutMeshForwds OBJECT-TYPE
       SYNTAX   Counter32
       MAX-ACCESS   read-only
       STATUS   current
       DESCRIPTION
           "The number of 6LoWPAN datagrams to be sent on this
            interface with a MESH header for which suitable
            forwarding information was available."
       ::= { lowpanIfStatsEntry 26 }

   lowpanIfOutMeshTransmits OBJECT-TYPE
       SYNTAX   Counter32
       MAX-ACCESS   read-only
       STATUS   current
       DESCRIPTION
           "The number of 6LoWPAN datagrams to be send on this
            interface with a MESH header created."
       ::= { lowpanIfStatsEntry 27 }

   lowpanIfOutDiscards OBJECT-TYPE
       SYNTAX   Counter32
       MAX-ACCESS   read-only
       STATUS   current
       DESCRIPTION

```
             "The number of IPv6 packets to be sent over this
              interface for which no problem was encountered to
              prevent their transmission to their destination, but
              were discarded (e.g., for lack of buffer space)."
         ::= { lowpanIfStatsEntry 28 }

     lowpanIfOutTransmits OBJECT-TYPE
         SYNTAX      Counter32
         MAX-ACCESS  read-only
         STATUS      current
         DESCRIPTION
             "The total number of 6LoWPAN datagrams to be sent on
              this interface that this entity supplied to the lower
              layers for transmission."
         ::= { lowpanIfStatsEntry 29 }

     -- conformance definitions

     lowpanGroups      OBJECT IDENTIFIER ::= { lowpanConformance 1 }
     lowpanCompliances OBJECT IDENTIFIER ::= { lowpanConformance 2 }

     lowpanCompliance MODULE-COMPLIANCE
         STATUS      current
         DESCRIPTION
             "Compliance statement for systems that implement 6LoWPAN."
         MODULE      -- this module
         MANDATORY-GROUPS {
             lowpanStatsGroup
         }
         GROUP       lowpanStatsMeshGroup
         DESCRIPTION
           "This group is mandatory for implementations that process
            or forward 6LoWPAN datagrams with mesh headers."
         GROUP       lowpanIfStatsGroup
         DESCRIPTION
           "This group is mandatory for implementations that expose
            per interface statistics."
         GROUP       lowpanIfStatsMeshGroup
         DESCRIPTION
           "This group is mandatory for implementations that expose
            per interface statistics and that process or forward
            6LoWPAN datagrams with mesh headers."
         ::= { lowpanCompliances 1 }

     lowpanStatsGroup OBJECT-GROUP
         OBJECTS {
             lowpanReasmTimeout,
             lowpanInReceives,
```

```
            lowpanInHdrErrors,
            lowpanInMeshReceives,
            lowpanInReasmReqds,
            lowpanInReasmFails,
            lowpanInReasmOKs,
            lowpanInCompReqds,
            lowpanInCompFails,
            lowpanInCompOKs,
            lowpanInDiscards,
            lowpanInDelivers,
            lowpanOutRequests,
            lowpanOutCompReqds,
            lowpanOutCompFails,
            lowpanOutCompOKs,
            lowpanOutFragReqds,
            lowpanOutFragFails,
            lowpanOutFragOKs,
            lowpanOutFragCreates,
            lowpanOutDiscards,
            lowpanOutTransmits
        }
        STATUS       current
        DESCRIPTION
            "A collection of objects providing information and
             statistics about the processing of 6LoWPAN datagrams,
             excluding counters covering the processing of datagrams
             with a mesh headers."
        ::= { lowpanGroups 1 }

    lowpanStatsMeshGroup OBJECT-GROUP
        OBJECTS {
            lowpanInMeshForwds,
            lowpanInMeshDelivers,
            lowpanOutMeshHopLimitExceeds,
            lowpanOutMeshNoRoutes,
            lowpanOutMeshRequests,
            lowpanOutMeshForwds,
            lowpanOutMeshTransmits
        }
        STATUS       current
        DESCRIPTION
            "A collection of objects providing information and
             statistics about the processing of 6LoWPAN datagrams
             with a 6LoWPAN mesh header."
        ::= { lowpanGroups 2 }

    lowpanIfStatsGroup OBJECT-GROUP
        OBJECTS {
```

```
        lowpanIfReasmTimeout,
        lowpanIfInReceives,
        lowpanIfInHdrErrors,
        lowpanIfInMeshReceives,
        lowpanIfInReasmReqds,
        lowpanIfInReasmFails,
        lowpanIfInReasmOKs,
        lowpanIfInCompReqds,
        lowpanIfInCompFails,
        lowpanIfInCompOKs,
        lowpanIfInDiscards,
        lowpanIfInDelivers,
        lowpanIfOutRequests,
        lowpanIfOutCompReqds,
        lowpanIfOutCompFails,
        lowpanIfOutCompOKs,
        lowpanIfOutFragReqds,
        lowpanIfOutFragFails,
        lowpanIfOutFragOKs,
        lowpanIfOutFragCreates,
        lowpanIfOutDiscards,
        lowpanIfOutTransmits
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing per interface
         information and statistics about the processing
         of 6LoWPAN datagrams, excluding counters covering
         the processing of datagrams with a mesh headers."
    ::= { lowpanGroups 3 }

lowpanIfStatsMeshGroup OBJECT-GROUP
    OBJECTS {
        lowpanIfInMeshForwds,
        lowpanIfInMeshDelivers,
        lowpanIfOutMeshHopLimitExceeds,
        lowpanIfOutMeshNoRoutes,
        lowpanIfOutMeshRequests,
        lowpanIfOutMeshForwds,
        lowpanIfOutMeshTransmits
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing per interface
         information and statistics about the processing
         of 6LoWPAN datagrams with a 6LoWPAN mesh header."
    ::= { lowpanGroups 4 }
```

    END

7. Security Considerations

    There are no management objects defined in this MIB module that have
    a MAX-ACCESS clause of read-write and/or read-create. So, if this
    MIB module is implemented correctly, then there is no risk that an
    intruder can alter or create any management objects of this MIB
    module via direct SNMP SET 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 read-only counters provide insights into the amount of 6LoWPAN
    traffic a node is receiving or transmitting. This might provide
    information whether a device is regularly exchanging information with
    other devices or whether a device is mostly not participating in any
    communication (e.g., the device might be "easier" to take away
    unnoticed). The reassembly counters could be used to direct denial
    of service attacks on the reassembly mechanism.

    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 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.

8. IANA Considerations

   IANA and RFC Ed.: IANA is requested to assign a value for "YYYY"
   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 "YYYY" (here and in the MIB module) with the
   assigned value and to remove this note.

   The MIB module in this document uses the following IANA-assigned
   OBJECT IDENTIFIER values recorded in the SMI Numbers registry:

           Descriptor   OBJECT IDENTIFIER value
           ----------   -----------------------
           lowpanMIB   { mib-2 YYYY }

9. Acknowledgements

   This specification borrows heavily from the IP-MIB defined in
   [RFC4293].

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