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.

```
+-----------------+   +--------------------------+
|   CoAP  [RFC7252] |   | 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, ... |
```

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 */
```
```plaintext
Internet-Draft                 LOWPAN-MIB                 September 2014

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

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  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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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."
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 2 }

lowpanInMeshReceives OBJECT-TYPE
SYNTAX Counter32
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"The number of received 6LoWPAN datagrams with a MESH
header."
::= { lowpanStats 3 }

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

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 5 }

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 }

lowpanInCompRegds 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 }

lowpanOutFragReqs 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
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 6LoWPAN datagrams with a MESH header that were dropped because the hop limit has been exceeded."
::= { lowpanStats 23 }
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,
  lowpanIfInReasmRegds           Counter32,
  lowpanIfInReasmFails           Counter32,
  lowpanIfInReasmOKs             Counter32,
  lowpanIfInCompRegds            Counter32,
  lowpanIfInCompFails            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

{ lowpanIfStatsEntry 1 }

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 received 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,
lowpanIfOutForwds,
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 }
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:

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>OBJECT IDENTIFIER value</th>
</tr>
</thead>
<tbody>
<tr>
<td>lowpanMIB</td>
<td>{ mib-2 YYYY }</td>
</tr>
</tbody>
</table>

9. Acknowledgements

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

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10. References

10.1. Normative References


10.2. Informative References


Authors’ Addresses