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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.

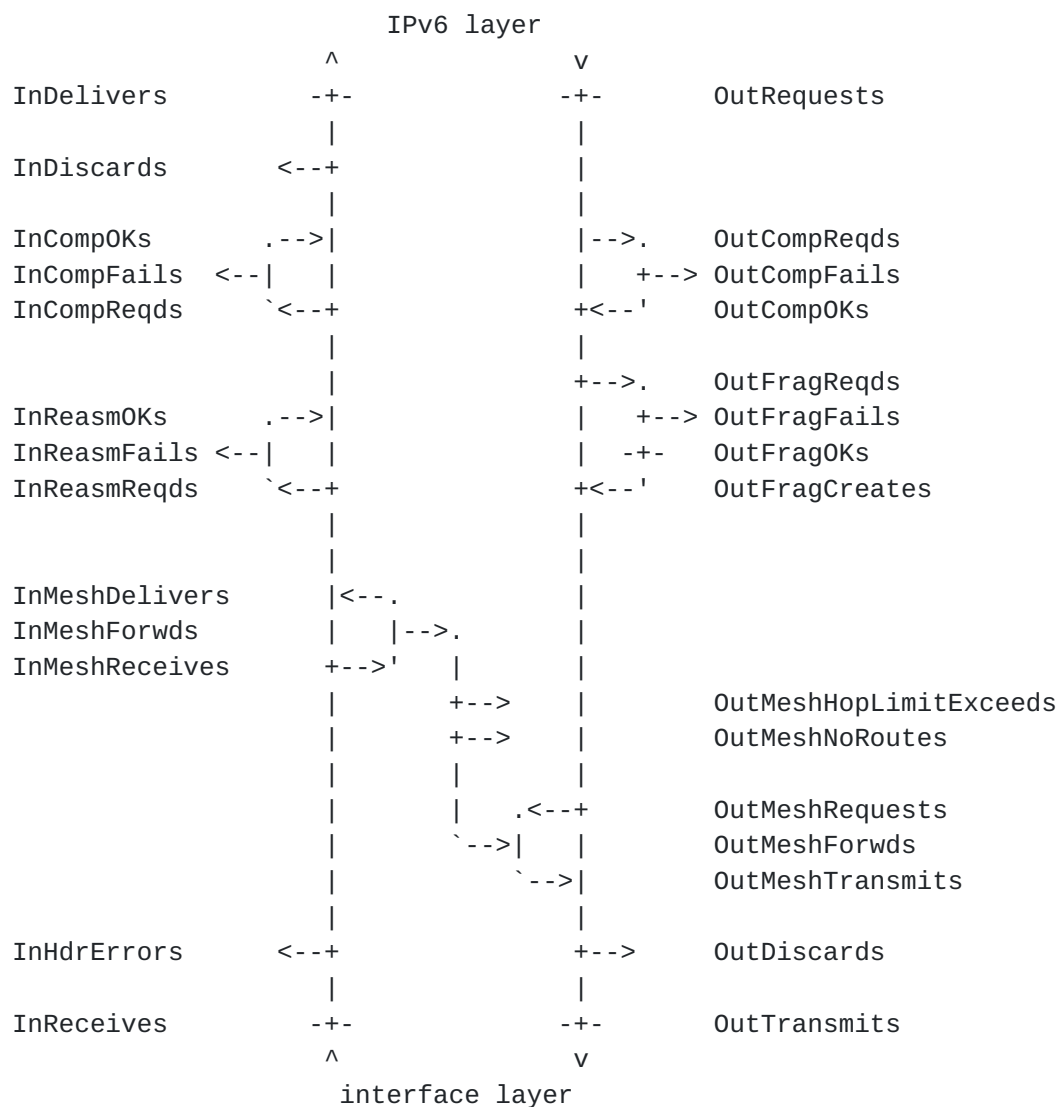


Figure 2: Conceptual Relationship between LOWPAN-MIB Counters

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
```

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        Jacobs University Bremen
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        Email: j.schoenwaelder@jacobs-university.de
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        Anuj Sehgal
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        Jacobs University Bremen
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        Email: s.anuj@jacobs-university.de
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        Huawei Technologies
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        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."


```
::= { 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 }

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

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 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 }
```

lowpanIfOutFragReqs 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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10. References

10.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC2578] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Structure of Management Information Version 2 (SMIv2)", STD 58, [RFC 2578](#), April 1999.
- [RFC2579] McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Textual Conventions for SMIv2", STD 58, [RFC 2579](#), April 1999.
- [RFC2580] McCloghrie, K., Perkins, D., and J. Schoenwaelder, "Conformance Statements for SMIv2", STD 58, [RFC 2580](#), April 1999.
- [RFC4944] Montenegro, G., Kushalnagar, N., Hui, J., and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", [RFC 4944](#), September 2007.

- [RFC2863] McCloghrie, K. and F. Kastenholz, "The Interfaces Group MIB", [RFC 2863](#), June 2000.

[10.2.](#) Informative References

- [RFC0768] Postel, J., "User Datagram Protocol", STD 6, [RFC 768](#), August 1980.
- [RFC2460] Deering, S. and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification", [RFC 2460](#), December 1998.
- [RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", [RFC 3410](#), December 2002.
- [RFC4113] Fenner, B. and J. Flick, "Management Information Base for the User Datagram Protocol (UDP)", [RFC 4113](#), June 2005.
- [RFC4292] Haberman, B., "IP Forwarding Table MIB", [RFC 4292](#), April 2006.
- [RFC4293] Routhier, S., "Management Information Base for the Internet Protocol (IP)", [RFC 4293](#), April 2006.
- [RFC4443] Conta, A., Deering, S., and M. Gupta, "Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification", [RFC 4443](#), March 2006.
- [RFC7252] Shelby, Z., Hartke, K., and C. Bormann, "The Constrained Application Protocol (CoAP)", [RFC 7252](#), June 2014.
- [I-D.ietf-6lo-btle]
Niemenen, J., Savolainen, T., Isomaki, M., Patil, B., Shelby, Z., and C. Gomez, "Transmission of IPv6 Packets over BLUETOOTH(R) Low Energy", [draft-ietf-6lo-btle-03](#) (work in progress), September 2014.
- [CASE] Case, J. and C. Partridge, "Case Diagrams: A First Step to Diagrammed Management Information Bases", Computer Communications Review 19(1), January 1989.

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