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Definitions of Managed Objects for BGP-4

Status of This Memo

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

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Abstract

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it describes managed objects used for managing the Border Gateway Protocol Version 4 or lower.

The origin of this memo is from RFC 1269 "Definitions of Managed Objects for the Border Gateway Protocol (Version 3)", which was updated to support BGP-4 in RFC 1657. This memo fixes errors introduced when the MIB module was converted to use the SMIV2 language. This memo also updates references to the current SNMP framework documents.

This memo is intended to document deployed implementations of this MIB module in a historical context, to provide clarifications of some items, and to note errors where the MIB module fails to fully represent the BGP protocol. Work is currently in progress to replace this MIB module with a new one representing the current state of the BGP protocol and its extensions.

This document obsoletes RFC 1269 and RFC 1657.

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1. Introduction

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it describes managed objects used for managing the Border Gateway Protocol Version 4 or lower [BGP4, BGP4APP].

This memo obsoletes RFC 1657 and RFC 1269.

2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies a MIB module that is compliant to the SMIV2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

3. Overview

These objects are used to control and manage a BGP-4 implementation.

Apart from a few system-wide scalar objects, this MIB is broken into three tables: the BGP Peer Table, the BGP Received Path Attribute Table, and the BGP-4 Received Path Attribute Table. The BGP Peer Table contains information about state and current activity of connections with the BGP peers. The BGP Received Path Attribute Table contains path attributes received from all peers running BGP version 3 or less. The BGP-4 Received Path Attribute Table contains path attributes received from all BGP-4 peers. The actual attributes used in determining a route are a subset of the received attribute tables after local routing policy has been applied.

4. Definitions

BGP4-MIB DEFINITIONS ::= BEGIN

IMPORTS

MODULE-IDENTITY, OBJECT-TYPE, NOTIFICATION-TYPE,
IpAddress, Integer32, Counter32, Gauge32, mib-2
FROM SNMPv2-SMI
MODULE-COMPLIANCE, OBJECT-GROUP, NOTIFICATION-GROUP
FROM SNMPv2-CONF;

bgp MODULE-IDENTITY

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DESCRIPTION

"The MIB module for the BGP-4 protocol.

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version of this MIB module is part of RFC 4273;
see the RFC itself for full legal notices."

REVISION "200601110000Z"

DESCRIPTION

"Changes from RFC 1657:

- 1) Fixed the definitions of the notifications
to make them equivalent to their initial
definition in RFC 1269.
- 2) Added compliance and conformance info.
- 3) Updated information for the values of
bgpPeerNegotiatedVersion, bgp4PathAttrLocalPref,
bgp4PathAttrCalcLocalPref,
bgp4PathAttrMultiExitDisc,
bgp4PathAttrASPathSegment.
- 4) Added additional clarification comments where
needed.

- 5) Noted where objects do not fully reflect the protocol as Known Issues.
- 6) Updated the DESCRIPTION for the bgp4PathAttrAtomicAggregate object.
- 7) The following objects have had their DESCRIPTION clause modified to remove the text that suggested (using 'should' verb) initializing the counter to zero on a transition to the established state:
 - bgpPeerInUpdates, bgpPeerOutUpdates,
 - bgpPeerInTotalMessages, bgpPeerOutTotalMessages
 Those implementations that still do this are still compliant with this new wording. Applications should not assume counters have started at zero.

Published as RFC 4273."

REVISION "199405050000Z"

DESCRIPTION

"Translated to SMIV2 and published as RFC 1657."

REVISION "199110261839Z"

DESCRIPTION

"Initial version, published as RFC 1269."

::= { mib-2 15 }

bgpVersion OBJECT-TYPE

SYNTAX OCTET STRING (SIZE (1..255))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"Vector of supported BGP protocol version numbers. Each peer negotiates the version from this vector. Versions are identified via the string of bits contained within this object. The first octet contains bits 0 to 7, the second octet contains bits 8 to 15, and so on, with the most significant bit referring to the lowest bit number in the octet (e.g., the MSB of the first octet refers to bit 0). If a bit, i, is present and set, then the version (i+1) of the BGP is supported."

REFERENCE

"RFC 4271, Section 4.2."

::= { bgp 1 }

bgpLocalAs OBJECT-TYPE

```

SYNTAX      Integer32 (0..65535)
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "The local autonomous system number."
REFERENCE
    "RFC 4271, Section 4.2, 'My Autonomous System'."
 ::= { bgp 2 }

```

```

-- BGP Peer table. This table contains, one entry per
-- BGP peer, information about the BGP peer.

```

```

bgpPeerTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF BgpPeerEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "BGP peer table. This table contains,
         one entry per BGP peer, information about the
         connections with BGP peers."
    ::= { bgp 3 }

```

```

bgpPeerEntry OBJECT-TYPE
    SYNTAX      BgpPeerEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Entry containing information about the
         connection with a BGP peer."
    INDEX { bgpPeerRemoteAddr }
    ::= { bgpPeerTable 1 }

```

```

BgpPeerEntry ::= SEQUENCE {
    bgpPeerIdentifier
        IpAddress,
    bgpPeerState
        INTEGER,
    bgpPeerAdminStatus
        INTEGER,
    bgpPeerNegotiatedVersion
        Integer32,
    bgpPeerLocalAddr
        IpAddress,
    bgpPeerLocalPort
        Integer32,
    bgpPeerRemoteAddr
        IpAddress,
    bgpPeerRemotePort

```

```

        Integer32,
bgpPeerRemoteAs
        Integer32,
bgpPeerInUpdates
        Counter32,
bgpPeerOutUpdates
        Counter32,
bgpPeerInTotalMessages
        Counter32,
bgpPeerOutTotalMessages
        Counter32,
bgpPeerLastError
        OCTET STRING,
bgpPeerFsmEstablishedTransitions
        Counter32,
bgpPeerFsmEstablishedTime
        Gauge32,
bgpPeerConnectRetryInterval
        Integer32,
bgpPeerHoldTime
        Integer32,
bgpPeerKeepAlive
        Integer32,
bgpPeerHoldTimeConfigured
        Integer32,
bgpPeerKeepAliveConfigured
        Integer32,
bgpPeerMinASOriginationInterval
        Integer32,
bgpPeerMinRouteAdvertisementInterval
        Integer32,
bgpPeerInUpdateElapsedTime
        Gauge32
    }

```

bgpPeerIdentifier OBJECT-TYPE

SYNTAX IpAddress

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The BGP Identifier of this entry's BGP peer.
This entry MUST be 0.0.0.0 unless the
bgpPeerState is in the openconfirm or the
established state."

REFERENCE

"RFC 4271, Section 4.2, 'BGP Identifier'."

::= { bgpPeerEntry 1 }

```

bgpPeerState OBJECT-TYPE
    SYNTAX      INTEGER {
                                idle(1),
                                connect(2),
                                active(3),
                                opensent(4),
                                openconfirm(5),
                                established(6)
                        }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The BGP peer connection state."
    REFERENCE
        "RFC 4271, Section 8.2.2."
    ::= { bgpPeerEntry 2 }

```

```

bgpPeerAdminStatus OBJECT-TYPE
    SYNTAX      INTEGER {
                                stop(1),
                                start(2)
                        }
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The desired state of the BGP connection.
        A transition from 'stop' to 'start' will cause
        the BGP Manual Start Event to be generated.
        A transition from 'start' to 'stop' will cause
        the BGP Manual Stop Event to be generated.
        This parameter can be used to restart BGP peer
        connections. Care should be used in providing
        write access to this object without adequate
        authentication."
    REFERENCE
        "RFC 4271, Section 8.1.2."
    ::= { bgpPeerEntry 3 }

```

```

bgpPeerNegotiatedVersion OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The negotiated version of BGP running between
        the two peers.

        This entry MUST be zero (0) unless the
        bgpPeerState is in the openconfirm or the

```

established state.

Note that legal values for this object are between 0 and 255."

REFERENCE

"RFC 4271, Section 4.2.

RFC 4271, Section 7."

::= { bgpPeerEntry 4 }

bgpPeerLocalAddr OBJECT-TYPE

SYNTAX IpAddress

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The local IP address of this entry's BGP connection."

::= { bgpPeerEntry 5 }

bgpPeerLocalPort OBJECT-TYPE

SYNTAX Integer32 (0..65535)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The local port for the TCP connection between the BGP peers."

::= { bgpPeerEntry 6 }

bgpPeerRemoteAddr OBJECT-TYPE

SYNTAX IpAddress

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The remote IP address of this entry's BGP peer."

::= { bgpPeerEntry 7 }

bgpPeerRemotePort OBJECT-TYPE

SYNTAX Integer32 (0..65535)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The remote port for the TCP connection between the BGP peers. Note that the objects bgpPeerLocalAddr, bgpPeerLocalPort, bgpPeerRemoteAddr, and bgpPeerRemotePort provide the appropriate reference to the standard MIB TCP connection table."

::= { bgpPeerEntry 8 }

bgpPeerRemoteAs OBJECT-TYPE

SYNTAX Integer32 (0..65535)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The remote autonomous system number received in
the BGP OPEN message."

REFERENCE

"RFC 4271, Section 4.2."

::= { bgpPeerEntry 9 }

bgpPeerInUpdates OBJECT-TYPE

SYNTAX Counter32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The number of BGP UPDATE messages
received on this connection."

REFERENCE

"RFC 4271, Section 4.3."

::= { bgpPeerEntry 10 }

bgpPeerOutUpdates OBJECT-TYPE

SYNTAX Counter32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The number of BGP UPDATE messages
transmitted on this connection."

REFERENCE

"RFC 4271, Section 4.3."

::= { bgpPeerEntry 11 }

bgpPeerInTotalMessages OBJECT-TYPE

SYNTAX Counter32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The total number of messages received
from the remote peer on this connection."

REFERENCE

"RFC 4271, Section 4."

::= { bgpPeerEntry 12 }

bgpPeerOutTotalMessages OBJECT-TYPE

SYNTAX Counter32

MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The total number of messages transmitted to
 the remote peer on this connection."
REFERENCE
 "RFC 4271, Section 4."
 ::= { bgpPeerEntry 13 }

bgpPeerLastError OBJECT-TYPE
SYNTAX OCTET STRING (SIZE (2))
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The last error code and subcode seen by this
 peer on this connection. If no error has
 occurred, this field is zero. Otherwise, the
 first byte of this two byte OCTET STRING
 contains the error code, and the second byte
 contains the subcode."
REFERENCE
 "RFC 4271, Section 4.5."
 ::= { bgpPeerEntry 14 }

bgpPeerFsmEstablishedTransitions OBJECT-TYPE
SYNTAX Counter32
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The total number of times the BGP FSM
 transitioned into the established state
 for this peer."
REFERENCE
 "RFC 4271, Section 8."
 ::= { bgpPeerEntry 15 }

bgpPeerFsmEstablishedTime OBJECT-TYPE
SYNTAX Gauge32
UNITS "seconds"
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "This timer indicates how long (in
 seconds) this peer has been in the
 established state or how long
 since this peer was last in the
 established state. It is set to zero when
 a new peer is configured or when the router is

booted."

REFERENCE

"RFC 4271, Section 8."

::= { bgpPeerEntry 16 }

bgpPeerConnectRetryInterval OBJECT-TYPE

SYNTAX Integer32 (1..65535)

UNITS "seconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"Time interval (in seconds) for the ConnectRetry timer. The suggested value for this timer is 120 seconds."

REFERENCE

"RFC 4271, Section 8.2.2. This is the value used to initialize the 'ConnectRetryTimer'."

::= { bgpPeerEntry 17 }

bgpPeerHoldTime OBJECT-TYPE

SYNTAX Integer32 (0 | 3..65535)

UNITS "seconds"

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"Time interval (in seconds) for the Hold Timer established with the peer. The value of this object is calculated by this BGP speaker, using the smaller of the values in bgpPeerHoldTimeConfigured and the Hold Time received in the OPEN message.

This value must be at least three seconds if it is not zero (0).

If the Hold Timer has not been established with the peer this object MUST have a value of zero (0).

If the bgpPeerHoldTimeConfigured object has a value of (0), then this object MUST have a value of (0)."

REFERENCE

"RFC 4271, Section 4.2."

::= { bgpPeerEntry 18 }

bgpPeerKeepAlive OBJECT-TYPE

SYNTAX Integer32 (0 | 1..21845)

UNITS "seconds"
 MAX-ACCESS read-only
 STATUS current
 DESCRIPTION

"Time interval (in seconds) for the KeepAlive timer established with the peer. The value of this object is calculated by this BGP speaker such that, when compared with bgpPeerHoldTime, it has the same proportion that bgpPeerKeepAliveConfigured has, compared with bgpPeerHoldTimeConfigured.

If the KeepAlive timer has not been established with the peer, this object MUST have a value of zero (0).

If the of bgpPeerKeepAliveConfigured object has a value of (0), then this object MUST have a value of (0)."

REFERENCE

"RFC 4271, Section 4.4."

::= { bgpPeerEntry 19 }

bgpPeerHoldTimeConfigured OBJECT-TYPE

SYNTAX Integer32 (0 | 3..65535)
 UNITS "seconds"
 MAX-ACCESS read-write
 STATUS current
 DESCRIPTION

"Time interval (in seconds) for the Hold Time configured for this BGP speaker with this peer. This value is placed in an OPEN message sent to this peer by this BGP speaker, and is compared with the Hold Time field in an OPEN message received from the peer when determining the Hold Time (bgpPeerHoldTime) with the peer. This value must not be less than three seconds if it is not zero (0). If it is zero (0), the Hold Time is NOT to be established with the peer. The suggested value for this timer is 90 seconds."

REFERENCE

"RFC 4271, Section 4.2.

RFC 4271, Section 10."

::= { bgpPeerEntry 20 }

bgpPeerKeepAliveConfigured OBJECT-TYPE

```

SYNTAX      Integer32 ( 0 | 1..21845 )
UNITS       "seconds"
MAX-ACCESS  read-write
STATUS      current
DESCRIPTION
    "Time interval (in seconds) for the
    KeepAlive timer configured for this BGP
    speaker with this peer. The value of this
    object will only determine the
    KEEPALIVE messages' frequency relative to
    the value specified in
    bgpPeerHoldTimeConfigured; the actual
    time interval for the KEEPALIVE messages is
    indicated by bgpPeerKeepAlive. A
    reasonable maximum value for this timer
    would be one third of that of
    bgpPeerHoldTimeConfigured.
    If the value of this object is zero (0),
    no periodical KEEPALIVE messages are sent
    to the peer after the BGP connection has
    been established. The suggested value for
    this timer is 30 seconds."
REFERENCE
    "RFC 4271, Section 4.4.
    RFC 4271, Section 10."
 ::= { bgpPeerEntry 21 }

```

bgpPeerMinASOriginationInterval OBJECT-TYPE

```

SYNTAX      Integer32 (1..65535)
UNITS       "seconds"
MAX-ACCESS  read-write
STATUS      current
DESCRIPTION
    "Time interval (in seconds) for the
    MinASOriginationInterval timer.
    The suggested value for this timer is 15
    seconds."
REFERENCE
    "RFC 4271, Section 9.2.1.2.
    RFC 4271, Section 10."
 ::= { bgpPeerEntry 22 }

```

bgpPeerMinRouteAdvertisementInterval OBJECT-TYPE

```

SYNTAX      Integer32 (1..65535)
UNITS       "seconds"
MAX-ACCESS  read-write
STATUS      current
DESCRIPTION

```

"Time interval (in seconds) for the MinRouteAdvertisementInterval timer. The suggested value for this timer is 30 seconds for EBGp connections and 5 seconds for IBGP connections."

REFERENCE

"RFC 4271, Section 9.2.1.1.
RFC 4271, Section 10."

::= { bgpPeerEntry 23 }

bgpPeerInUpdateElapsedTime OBJECT-TYPE

SYNTAX Gauge32
UNITS "seconds"
MAX-ACCESS read-only
STATUS current
DESCRIPTION

"Elapsed time (in seconds) since the last BGP UPDATE message was received from the peer. Each time bgpPeerInUpdates is incremented, the value of this object is set to zero (0)."

REFERENCE

"RFC 4271, Section 4.3.
RFC 4271, Section 8.2.2, Established state."

::= { bgpPeerEntry 24 }

bgpIdentifier OBJECT-TYPE

SYNTAX IPAddress
MAX-ACCESS read-only
STATUS current
DESCRIPTION

"The BGP Identifier of the local system."

REFERENCE

"RFC 4271, Section 4.2."

::= { bgp 4 }

-- BGP Received Path Attribute Table. This table contains
-- one entry per path to a network, and path attributes
-- received from all peers running BGP version 3 or less.
-- This table is obsolete, having been replaced in
-- functionality by the bgp4PathAttrTable.

bgpRcvdPathAttrTable OBJECT-TYPE

SYNTAX SEQUENCE OF BgpPathAttrEntry
MAX-ACCESS not-accessible
STATUS obsolete
DESCRIPTION

"The BGP Received Path Attribute Table contains information about paths to

```

        destination networks, received from all
        peers running BGP version 3 or less."
 ::= { bgp 5 }

bgpPathAttrEntry OBJECT-TYPE
    SYNTAX      BgpPathAttrEntry
    MAX-ACCESS  not-accessible
    STATUS      obsolete
    DESCRIPTION
        "Information about a path to a network."
    INDEX { bgpPathAttrDestNetwork,
            bgpPathAttrPeer
          }
    ::= { bgpRcvdPathAttrTable 1 }

BgpPathAttrEntry ::= SEQUENCE {
    bgpPathAttrPeer
        IPAddress,
    bgpPathAttrDestNetwork
        IPAddress,
    bgpPathAttrOrigin
        INTEGER,
    bgpPathAttrASPath
        OCTET STRING,
    bgpPathAttrNextHop
        IPAddress,
    bgpPathAttrInterASMetric
        Integer32
}

bgpPathAttrPeer OBJECT-TYPE
    SYNTAX      IPAddress
    MAX-ACCESS  read-only
    STATUS      obsolete
    DESCRIPTION
        "The IP address of the peer where the path
        information was learned."
    ::= { bgpPathAttrEntry 1 }

bgpPathAttrDestNetwork OBJECT-TYPE
    SYNTAX      IPAddress
    MAX-ACCESS  read-only
    STATUS      obsolete
    DESCRIPTION
        "The address of the destination network."
    REFERENCE
        "RFC 1267, Section 4.3."
    ::= { bgpPathAttrEntry 2 }

```

```

bgpPathAttrOrigin OBJECT-TYPE
    SYNTAX      INTEGER {
        igp(1), -- networks are interior
        egp(2), -- networks learned via the
                -- EGP protocol
        incomplete(3) -- networks that
                -- are learned by some other
                -- means
    }
    MAX-ACCESS read-only
    STATUS      obsolete
    DESCRIPTION
        "The ultimate origin of the path information."
    REFERENCE
        "RFC 1267, Section 4.3.
         RFC 1267, Section 5."
    ::= { bgpPathAttrEntry 3 }

bgpPathAttrASPath OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (2..255))
    MAX-ACCESS read-only
    STATUS      obsolete
    DESCRIPTION
        "The set of ASes that must be traversed to reach
         the network. This object is probably best
         represented as SEQUENCE OF INTEGER. For SMI
         compatibility, though, it is represented as
         OCTET STRING. Each AS is represented as a pair
         of octets according to the following algorithm:

                first-byte-of-pair = ASNumber / 256;
                second-byte-of-pair = ASNumber & 255;"
    REFERENCE
        "RFC 1267, Section 4.3.
         RFC 1267, Section 5."
    ::= { bgpPathAttrEntry 4 }

bgpPathAttrNextHop OBJECT-TYPE
    SYNTAX      IpAddress
    MAX-ACCESS read-only
    STATUS      obsolete
    DESCRIPTION
        "The address of the border router that should
         be used for the destination network."
    REFERENCE
        "RFC 1267, Section 4.3.
         RFC 1267, Section 5."
    ::= { bgpPathAttrEntry 5 }

```

```

bgpPathAttrInterASMetric OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-only
    STATUS      obsolete
    DESCRIPTION
        "The optional inter-AS metric.  If this
         attribute has not been provided for this route,
         the value for this object is 0."
    REFERENCE
        "RFC 1267, Section 4.3.
         RFC 1267, Section 5."
    ::= { bgpPathAttrEntry 6 }

-- BGP-4 Received Path Attribute Table.  This table
-- contains one entry per path to a network, and path
-- attributes received from all peers running BGP-4.

bgp4PathAttrTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Bgp4PathAttrEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The BGP-4 Received Path Attribute Table
         contains information about paths to
         destination networks, received from all
         BGP4 peers."
    ::= { bgp 6 }

bgp4PathAttrEntry OBJECT-TYPE
    SYNTAX      Bgp4PathAttrEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Information about a path to a network."
    INDEX { bgp4PathAttrIpAddressPrefix,
            bgp4PathAttrIpAddressPrefixLen,
            bgp4PathAttrPeer
          }
    ::= { bgp4PathAttrTable 1 }

Bgp4PathAttrEntry ::= SEQUENCE {
    bgp4PathAttrPeer
        IpAddress,
    bgp4PathAttrIpAddressPrefixLen
        Integer32,
    bgp4PathAttrIpAddressPrefix
        IpAddress,
    bgp4PathAttrOrigin
        INTEGER,

```

```

    bgp4PathAttrASPathSegment
        OCTET STRING,
    bgp4PathAttrNextHop
        IPAddress,
    bgp4PathAttrMultiExitDisc
        Integer32,
    bgp4PathAttrLocalPref
        Integer32,
    bgp4PathAttrAtomicAggregate
        INTEGER,
    bgp4PathAttrAggregatorAS
        Integer32,
    bgp4PathAttrAggregatorAddr
        IPAddress,
    bgp4PathAttrCalcLocalPref
        Integer32,
    bgp4PathAttrBest
        INTEGER,
    bgp4PathAttrUnknown
        OCTET STRING
}

bgp4PathAttrPeer OBJECT-TYPE
    SYNTAX      IPAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The IP address of the peer where the path
         information was learned."
    ::= { bgp4PathAttrEntry 1 }

bgp4PathAttrIpAddrPrefixLen OBJECT-TYPE
    SYNTAX      Integer32 (0..32)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Length in bits of the IP address prefix in
         the Network Layer Reachability
         Information field."
    ::= { bgp4PathAttrEntry 2 }

bgp4PathAttrIpAddrPrefix OBJECT-TYPE
    SYNTAX      IPAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "An IP address prefix in the Network Layer
         Reachability Information field.  This object

```

is an IP address containing the prefix with length specified by `bgp4PathAttrIpAddrPrefixLen`. Any bits beyond the length specified by `bgp4PathAttrIpAddrPrefixLen` are zeroed."

REFERENCE

"RFC 4271, Section 4.3."

::= { `bgp4PathAttrEntry 3` }

`bgp4PathAttrOrigin` OBJECT-TYPE

SYNTAX INTEGER {
 `igp(1)`, -- networks are interior
 `egp(2)`, -- networks learned via the
 -- EGP protocol
 `incomplete(3)` -- networks that
 -- are learned by some other
 -- means
 }

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The ultimate origin of the path information."

REFERENCE

"RFC 4271, Section 4.3."

RFC 4271, Section 5.1.1."

::= { `bgp4PathAttrEntry 4` }

`bgp4PathAttrASPathSegment` OBJECT-TYPE

SYNTAX OCTET STRING (SIZE (2..255))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The sequence of AS path segments. Each AS path segment is represented by a triple <type, length, value>."

The type is a 1-octet field that has two possible values:

- 1 `AS_SET`: unordered set of ASes that a route in the UPDATE message has traversed
- 2 `AS_SEQUENCE`: ordered set of ASes that a route in the UPDATE message has traversed.

The length is a 1-octet field containing the

number of ASes in the value field.

The value field contains one or more AS numbers. Each AS is represented in the octet string as a pair of octets according to the following algorithm:

```
first-byte-of-pair = ASNumber / 256;
second-byte-of-pair = ASNumber & 255;
```

Known Issues:

- o BGP Confederations will result in a type of either 3 or 4.
- o An AS Path may be longer than 255 octets. This may result in this object containing a truncated AS Path."

REFERENCE

```
"RFC 4271, Section 4.3.
RFC 4271, Section 5.1.2."
```

```
::= { bgp4PathAttrEntry 5 }
```

bgp4PathAttrNextHop OBJECT-TYPE

```
SYNTAX      IpAddress
MAX-ACCESS  read-only
STATUS      current
```

DESCRIPTION

"The address of the border router that should be used for the destination network. This address is the NEXT_HOP address received in the UPDATE packet."

REFERENCE

```
"RFC 4271, Section 4.3.
RFC 4271, Section 5.1.3."
```

```
::= { bgp4PathAttrEntry 6 }
```

bgp4PathAttrMultiExitDisc OBJECT-TYPE

```
SYNTAX      Integer32 (-1..2147483647)
MAX-ACCESS  read-only
STATUS      current
```

DESCRIPTION

"This metric is used to discriminate between multiple exit points to an adjacent autonomous system. A value of -1 indicates the absence of this attribute.

Known Issues:

- o The BGP-4 specification uses an unsigned 32 bit number. Thus, this

object cannot represent the full range of the protocol."

REFERENCE

"RFC 4271, Section 4.3.
RFC 4271, Section 5.1.4."

::= { bgp4PathAttrEntry 7 }

bgp4PathAttrLocalPref OBJECT-TYPE

SYNTAX Integer32 (-1..2147483647)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The originating BGP4 speaker's degree of preference for an advertised route. A value of -1 indicates the absence of this attribute.

Known Issues:

- o The BGP-4 specification uses an unsigned 32 bit number and thus this object cannot represent the full range of the protocol."

REFERENCE

"RFC 4271, Section 4.3.
RFC 4271, Section 5.1.5."

::= { bgp4PathAttrEntry 8 }

bgp4PathAttrAtomicAggregate OBJECT-TYPE

SYNTAX INTEGER {
 lessSpecificRouteNotSelected(1),
 -- Typo corrected from RFC 1657
 lessSpecificRouteSelected(2)
}

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"If the ATOMIC_AGGREGATE attribute is present in the Path Attributes then this object MUST have a value of 'lessSpecificRouteNotSelected'.

If the ATOMIC_AGGREGATE attribute is missing in the Path Attributes then this object MUST have a value of 'lessSpecificRouteSelected'.

Note that ATOMIC_AGGREGATE is now a primarily informational attribute."

REFERENCE

"RFC 4271, Sections 5.1.6 and 9.1.4."

::= { bgp4PathAttrEntry 9 }

bgp4PathAttrAggregatorAS OBJECT-TYPE

SYNTAX Integer32 (0..65535)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The AS number of the last BGP4 speaker that performed route aggregation. A value of zero (0) indicates the absence of this attribute."

Note that propagation of AS of zero is illegal in the Internet."

REFERENCE

"RFC 4271, Section 5.1.7.

RFC 4271, Section 9.2.2.2."

::= { bgp4PathAttrEntry 10 }

bgp4PathAttrAggregatorAddr OBJECT-TYPE

SYNTAX IpAddress

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The IP address of the last BGP4 speaker that performed route aggregation. A value of 0.0.0.0 indicates the absence of this attribute."

REFERENCE

"RFC 4271, Section 5.1.7.

RFC 4271, Section 9.2.2.2."

::= { bgp4PathAttrEntry 11 }

bgp4PathAttrCalcLocalPref OBJECT-TYPE

SYNTAX Integer32 (-1..2147483647)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The degree of preference calculated by the receiving BGP4 speaker for an advertised route. A value of -1 indicates the absence of this attribute."

Known Issues:

- o The BGP-4 specification uses an unsigned 32 bit number and thus this object cannot represent the full range of the protocol."

REFERENCE

"RFC 4271, Section 9.1.1."

::= { bgp4PathAttrEntry 12 }

bgp4PathAttrBest OBJECT-TYPE

SYNTAX INTEGER {
 false(1), -- not chosen as best route
 true(2) -- chosen as best route
 }

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"An indication of whether this route was chosen as the best BGP4 route for this destination."

REFERENCE

"RFC 4271, Section 9.1.2."

::= { bgp4PathAttrEntry 13 }

bgp4PathAttrUnknown OBJECT-TYPE

SYNTAX OCTET STRING (SIZE(0..255))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"One or more path attributes not understood by this BGP4 speaker."

Path attributes are recorded in the Update Path attribute format of type, length, value.

Size zero (0) indicates the absence of such attributes.

Octets beyond the maximum size, if any, are not recorded by this object.

Known Issues:

- o Attributes understood by this speaker, but not represented in this MIB, are unavailable to the agent."

REFERENCE

"RFC 4271, Section 5."

::= { bgp4PathAttrEntry 14 }

-- Traps.

-- Note that in RFC 1657, bgpTraps was incorrectly

-- assigned a value of { bgp 7 } and each of the

-- traps had the bgpPeerRemoteAddr object inappropriately

```
-- removed from their OBJECTS clause. The following
-- definitions restore the semantics of the traps as
-- they were initially defined in RFC 1269.

bgpNotification OBJECT IDENTIFIER ::= { bgp 0 }

bgpEstablishedNotification NOTIFICATION-TYPE
    OBJECTS { bgpPeerRemoteAddr,
               bgpPeerLastError,
               bgpPeerState      }
    STATUS   current
    DESCRIPTION
        "The bgpEstablishedNotification event is generated
        when the BGP FSM enters the established state.

        This Notification replaces the bgpEstablished
        Notification."
    ::= { bgpNotification 1 }

bgpBackwardTransNotification NOTIFICATION-TYPE
    OBJECTS { bgpPeerRemoteAddr,
               bgpPeerLastError,
               bgpPeerState      }
    STATUS   current
    DESCRIPTION
        "The bgpBackwardTransNotification event is
        generated when the BGP FSM moves from a higher
        numbered state to a lower numbered state.

        This Notification replaces the
        bgpBackwardsTransition Notification."
    ::= { bgpNotification 2 }

-- { bgp 7 } is deprecated. Do not allocate new objects or
-- notifications underneath this branch.

bgpTraps          OBJECT IDENTIFIER ::= { bgp 7 } -- deprecated

bgpEstablished NOTIFICATION-TYPE
    OBJECTS { bgpPeerLastError,
               bgpPeerState      }
    STATUS   deprecated
    DESCRIPTION
        "The bgpEstablished event is generated when
        the BGP FSM enters the established state.

        This Notification has been replaced by the
        bgpEstablishedNotification Notification."
```

```

 ::= { bgpTraps 1 }

bgpBackwardTransition NOTIFICATION-TYPE
  OBJECTS { bgpPeerLastError,
             bgpPeerState      }
  STATUS deprecated
  DESCRIPTION
    "The bgpBackwardTransition event is generated
     when the BGP FSM moves from a higher numbered
     state to a lower numbered state.

     This Notification has been replaced by the
     bgpBackwardTransNotification Notification."
 ::= { bgpTraps 2 }

-- Conformance information

bgp4MIBConformance OBJECT IDENTIFIER
  ::= { bgp 8 }
bgp4MIBCompliances OBJECT IDENTIFIER
  ::= { bgp4MIBConformance 1 }
bgp4MIBGroups      OBJECT IDENTIFIER
  ::= { bgp4MIBConformance 2 }

-- Compliance statements

bgp4MIBCompliance MODULE-COMPLIANCE
  STATUS current
  DESCRIPTION
    "The compliance statement for entities which
     implement the BGP4 mib."
  MODULE -- this module
    MANDATORY-GROUPS { bgp4MIBGlobalsGroup,
                       bgp4MIBPeerGroup,
                       bgp4MIBPathAttrGroup }
    GROUP bgp4MIBNotificationGroup
  DESCRIPTION
    "Implementation of BGP Notifications are
     completely optional in this MIB."
 ::= { bgp4MIBCompliances 1 }

bgp4MIBDeprecatedCompliances MODULE-COMPLIANCE
  STATUS deprecated
  DESCRIPTION
    "The compliance statement documenting deprecated
     objects in the BGP4 mib."
  MODULE -- this module
    GROUP bgp4MIBTrapGroup

```

```

        DESCRIPTION
            "Group containing TRAP objects that were
            improperly converted from SMIV1 in RFC 1657.
            The proper semantics have been restored
            with the objects in bgp4MIBNotificationGroup."
        ::= { bgp4MIBCompliances 2 }

bgp4MIBObsoleteCompliances MODULE-COMPLIANCE
    STATUS    obsolete
    DESCRIPTION
        "The compliance statement documenting obsolete
        objects in the BGP4 mib."
    MODULE -- this module
        GROUP bgpRcvdPathAttrGroup
        DESCRIPTION
            "Group containing objects relevant to BGP-3
            and earlier objects."
        ::= { bgp4MIBCompliances 3 }

-- Units of conformance

bgp4MIBGlobalsGroup OBJECT-GROUP
    OBJECTS { bgpVersion,
              bgpLocalAs,
              bgpIdentifier }
    STATUS    current
    DESCRIPTION
        "A collection of objects providing
        information on global BGP state."
    ::= { bgp4MIBGroups 1 }

bgp4MIBPeerGroup OBJECT-GROUP
    OBJECTS { bgpPeerIdentifier,
              bgpPeerState,
              bgpPeerAdminStatus,
              bgpPeerNegotiatedVersion,
              bgpPeerLocalAddr,
              bgpPeerLocalPort,
              bgpPeerRemoteAddr,
              bgpPeerRemotePort,
              bgpPeerRemoteAs,
              bgpPeerInUpdates,
              bgpPeerOutUpdates,
              bgpPeerInTotalMessages,
              bgpPeerOutTotalMessages,
              bgpPeerLastError,
              bgpPeerFsmEstablishedTransitions,
              bgpPeerFsmEstablishedTime,

```

```

        bgpPeerConnectRetryInterval,
        bgpPeerHoldTime,
        bgpPeerKeepAlive,
        bgpPeerHoldTimeConfigured,
        bgpPeerKeepAliveConfigured,
        bgpPeerMinASOriginationInterval,
        bgpPeerMinRouteAdvertisementInterval,
        bgpPeerInUpdateElapsedTime }
STATUS    current
DESCRIPTION
    "A collection of objects for managing
    BGP peers."
 ::= { bgp4MIBGroups 2 }

bgpRcvdPathAttrGroup OBJECT-GROUP
OBJECTS { bgpPathAttrPeer,
          bgpPathAttrDestNetwork,
          bgpPathAttrOrigin,
          bgpPathAttrASPath,
          bgpPathAttrNextHop,
          bgpPathAttrInterASMetric }
STATUS    obsolete
DESCRIPTION
    "A collection of objects for managing BGP-3 and
    earlier path entries.

    This conformance group, like BGP-3, is obsolete."
 ::= { bgp4MIBGroups 3 }

bgp4MIBPathAttrGroup OBJECT-GROUP
OBJECTS { bgp4PathAttrPeer,
          bgp4PathAttrIpAddressPrefixLen,
          bgp4PathAttrIpAddressPrefix,
          bgp4PathAttrOrigin,
          bgp4PathAttrASPathSegment,
          bgp4PathAttrNextHop,
          bgp4PathAttrMultiExitDisc,
          bgp4PathAttrLocalPref,
          bgp4PathAttrAtomicAggregate,
          bgp4PathAttrAggregatorAS,
          bgp4PathAttrAggregatorAddr,
          bgp4PathAttrCalcLocalPref,
          bgp4PathAttrBest,
          bgp4PathAttrUnknown }
STATUS    current
DESCRIPTION
    "A collection of objects for managing
    BGP path entries."

```

```

 ::= { bgp4MIBGroups 4 }

bgp4MIBTrapGroup NOTIFICATION-GROUP
  NOTIFICATIONS { bgpEstablished,
                  bgpBackwardTransition }
  STATUS deprecated
  DESCRIPTION
    "A collection of notifications for signaling
     changes in BGP peer relationships.

     Obsoleted by bgp4MIBNotificationGroup"
 ::= { bgp4MIBGroups 5 }

bgp4MIBNotificationGroup NOTIFICATION-GROUP
  NOTIFICATIONS { bgpEstablishedNotification,
                  bgpBackwardTransNotification }
  STATUS current
  DESCRIPTION
    "A collection of notifications for signaling
     changes in BGP peer relationships.

     Obsoletes bgp4MIBTrapGroup."
 ::= { bgp4MIBGroups 6 }

END

```

5. Security Considerations

This MIB relates to a system providing inter-domain routing. As such, improper manipulation of the objects represented by this MIB may result in denial of service to a large number of end-users.

There are several management objects defined in this MIB that have a MAX-ACCESS clause of read-write and/or read-create. Such objects should be considered sensitive or vulnerable in most network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These objects include:

- o bgpPeerAdminStatus

Improper change of bgpPeerAdminStatus, from start to stop, can cause significant disruption of the connectivity to those portions of the Internet reached via the applicable remote BGP peer.

- o bgpPeerConnectRetryInterval

Improper change of this object can cause connections to be disrupted for extremely long time periods when otherwise they would be restored in a relatively short period of time.

- o bgpPeerHoldTimeConfigured, bgpPeerKeepAliveConfigured

Misconfiguration of these objects can make BGP sessions more fragile and less resilient to denial of service attacks on the inter-domain routing system.

- o bgpPeerMinASOriginationInterval,
bgpPeerMinRouteAdvertisementInterval

Misconfiguration of these objects may adversely affect global Internet convergence of the routes advertised by this BGP speaker. This may result in long-lived routing loops and blackholes for the portions of the Internet that utilize these routes.

There are a number of managed objects in this MIB that contain sensitive information regarding the operation of a network. For example, a BGP peer's local and remote addresses might be sensitive for ISPs who want to keep interface addresses on routers confidential in order to prevent router addresses used for a denial of service attack or spoofing.

Therefore, it is important in most environments to control read access to these objects and possibly to even encrypt the values of these object when sending them over the network via SNMP.

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.

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7. Normative References

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