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Definitions of Managed Objects for the Fourth Version of Border Gateway
Protocol (BGP-4), Second Version
[draft-ietf-idr-bgp4-mibv2-11](#)

Abstract

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols. In particular it defines objects for managing the Border Gateway Protocol, Version 4.

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1. Introduction

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols. In particular it defines objects for managing the Border Gateway Protocol, Version 4 [[RFC4271](#)].

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. Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [[RFC2119](#)].

4. Overview

As part of the IETF standardization effort for the BGP-4 protocol, [[RFC4273](#)] was written to address open issues in the previous version of the BGP-4 MIB, [[RFC1657](#)]. However, that RFC was primarily intended to address the base BGP-4 protocol as documented in [[RFC4271](#)].

The BGP-4 protocol has greatly increased in scope over the years from its original definition. Scaling mechanisms such as Route Reflection [[RFC4456](#)] and Confederations [[RFC5065](#)] have been introduced. Multi-protocol extensions [[RFC4760](#)] were introduced which allowed advertisement of reachability such as IPv6 [[RFC2545](#)], MPLS Labeled routes [[RFC3107](#)], etc.

This MIB addresses several of the deficiencies of the previous BGP-4 MIB. In particular:

- o Add the ability to monitor IPv6 BGP-4 peering sessions and carry IPv6 reachability. Other forms of reachability can be added at a later date courtesy of the address-family independent manner in which this was done.
- o Add several counters of operational interest. For example, the number of routes received from a given BGP peer.
- o Replaces objects that were incapable of carrying the full range of their values with ones that can.
- o Provides human-readable output for some complex data structures, such as the AS_PATH while also preserving a version of the data that is canonically machine readable.

5. Structure of the MIB Module

5.1. Notifications

- o `bgp4V2EstablishedNotification` - Sent when a BGP peer transitions into the Established state. Replaces the previous `bgpEstablishedNotification` from [RFC 4273](#) which was not address family independent.
- o `bgp4V2BackwardTransitionNotification` - Sent when a BGP peer transitions out of the Established state. Replaces the previous `bgpBackwardTransNotification`, which was not address family independent.

5.2. Tables

- o `bgp4V2DiscontinuityTable` - This MIB allows management of more than one instance of the BGP-4 protocol. This table provides the ability to show when a given instance of BGP-4 has suffered an event that may lead to a discontinuity in its objects.
- o `bgp4V2PeerTable` - The BGP peer table. This table is capable of representing IPv6 and other address-family independent peering sessions. This table replaces the `bgpPeerTable` from [RFC 4273](#).
- o `bgp4V2PeerErrorsTable` - A table of peering session errors. This table covers information previously present in `bgpPeerTable` from [RFC 4273](#).
- o `bgp4V2PeerEventTimesTable` - A table of peer-specific event timers. This table covers information previously present in `bgpPeerTable` in [RFC 4273](#).

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- o bgp4V2PeerConfiguredTimersTable - A table of the configured values of peer-specific event timers. This table covers information previously present in bgpPeerTable from [RFC 4273](#).
- o bgp4V2PeerNegotiatedTimersTable - A table of per-peer negotiated timers. This information covers information previously derived from the bgpPeerTable from [RFC 4273](#).
- o bgp4V2PeerCountersTable - A table of per-peer counters for messages and the BGP FSM.
- o bgp4V2PrefixGaugesTable - A table of per-peer per Address Family Identifier-Subsequent Address Family Identifier (AFI-SAFI) [[RFC4760](#)] gauges for prefixes.
- o bgp4V2NlriTable - A table of per-peer per AFI-SAFI prefix data. This table covers information previously present in bgp4PathAttrTable from [RFC 4273](#).
- o bgp4V2AdjRibsOutTable - A per-peer per AFI-SAFI table indicating what reachability has been advertised to a given peer.

6. Relationship to Other MIB Modules

6.1. Relationship to the TCP-MIB

The bgp4V2PeerLocalAddrType/bgp4V2PeerLocalAddr/bgp4V2PeerLocalPort and bgp4V2PeerRemoteAddrType/bgp4V2PeerRemoteAddr/bgp4V2PeerRemotePort objects may provide a suitable index for monitoring the BGP peering session's TCP session via the TCP-MIB [[RFC4022](#)].

Note that conducting BGP peering sessions over transport protocols other than TCP over IP are out of scope of the current BGP specifications.

6.2. MIB modules required for IMPORTS

The following MIB module IMPORTS objects from BGP4V2-TC-MIB [I-D.[draft-ietf-idr-bgp4-mibv2-tc](#)], SNMPv2-SMI [[RFC2578](#)], SNMPv2-TC [[RFC2579](#)], SNMPv2-CONF [[RFC2580](#)], INET-ADDRESS-MIB [[RFC4001](#)] and SNMP-FRAMEWORK-MIB [[RFC3411](#)].

7. Definitions

BGP4V2-MIB DEFINITIONS ::= BEGIN

IMPORTS


```
MODULE-IDENTITY, OBJECT-TYPE, NOTIFICATION-TYPE,
mib-2, Counter32, Gauge32, Unsigned32
    FROM SNMPv2-SMI
InetAddressType, InetAddress, InetPortNumber,
InetAutonomousSystemNumber, InetAddressPrefixLength
    FROM INET-ADDRESS-MIB
TruthValue, RowPointer, TimeStamp
    FROM SNMPv2-TC
MODULE-COMPLIANCE, OBJECT-GROUP, NOTIFICATION-GROUP
    FROM SNMPv2-CONF
SnmpAdminString
    FROM SNMP-FRAMEWORK-MIB
Bgp4V2IdentifierTC, Bgp4V2AddressFamilyIdentifierTC,
Bgp4V2SubsequentAddressFamilyIdentifierTC
    FROM BGP4V2-TC-MIB;
```

```
bgp4V2 MODULE-IDENTITY
    LAST-UPDATED "201101170000Z"
    ORGANIZATION "IETF IDR Working Group"
    CONTACT-INFO "E-mail: idr@ietf.org"
```

DESCRIPTION

"The MIB module for the BGP-4 protocol.

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

-- RFC Editor - replace XXX with RFC number

REVISION "201101170000Z"

DESCRIPTION

"This MIB updates and replaces the BGP MIB defined in
[RFC 4273](#)."

::= { mib-2 XXX }

-- Top level components of this MIB module

-- Notifications

bgp4V2Notifications OBJECT IDENTIFIER ::= { bgp4V2 0 }

-- Objects

bgp4V2Objects OBJECT IDENTIFIER ::= { bgp4V2 1 }

-- Conformance

bgp4V2Conformance OBJECT IDENTIFIER ::= { bgp4V2 2 }

--


```
-- Per-instance BGP discontinuities
--
```

```
bgp4V2DiscontinuityTable OBJECT-TYPE
```

```
    SYNTAX      SEQUENCE OF Bgp4V2DiscontinuityEntry
```

```
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "Table of BGP-4 discontinuities. Discontinuities that have
        external visibility occur on a per-BGP instance basis.
        Transitions by a given BGP peer will result in a consistent
        BGP view within that instance and thus do not represent a
        discontinuity from a protocol standpoint."
```

```
    ::= { bgp4V2Objects 1 }
```

```
bgp4V2DiscontinuityEntry OBJECT-TYPE
```

```
    SYNTAX      Bgp4V2DiscontinuityEntry
```

```
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "Entry representing information about a discontinuity event
        for a given BGP instance."
```

```
    INDEX {
```

```
        bgp4V2PeerInstance
```

```
    }
```

```
    ::= { bgp4V2DiscontinuityTable 1 }
```

```
Bgp4V2DiscontinuityEntry ::= SEQUENCE {
```

```
    bgp4V2DiscontinuityTime
```

```
    TimeStamp
```

```
}
```

```
bgp4V2DiscontinuityTime OBJECT-TYPE
```

```
    SYNTAX      TimeStamp
```

```
    MAX-ACCESS  read-only
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "The value of sysUpTime at the most recent occasion at which
        this BGP management instance has suffered a discontinuity."
```

```
    ::= { bgp4V2DiscontinuityEntry 1 }
```

```
--
```

```
-- Per-peer session management information.
```

```
--
```

```
bgp4V2PeerTable OBJECT-TYPE
```

```
    SYNTAX      SEQUENCE OF Bgp4V2PeerEntry
```

```
    MAX-ACCESS  not-accessible
```

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```
STATUS      current
DESCRIPTION
    "BGP peer table.  This table contains, one entry per BGP
    peer, information about the connections with BGP peers."
 ::= { bgp4V2Objects 2 }

bgp4V2PeerEntry OBJECT-TYPE
SYNTAX      Bgp4V2PeerEntry
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
    "Entry containing information about the connection with
    a remote BGP peer."
INDEX {
    bgp4V2PeerInstance,
    bgp4V2PeerRemoteAddrType,
    bgp4V2PeerRemoteAddr
}
 ::= { bgp4V2PeerTable 1 }

Bgp4V2PeerEntry ::= SEQUENCE {
    -- INDEX information
    bgp4V2PeerInstance
        Unsigned32,
    bgp4V2PeerLocalAddrType
        InetAddressType,
    bgp4V2PeerLocalAddr
        InetAddress,
    bgp4V2PeerRemoteAddrType
        InetAddressType,
    bgp4V2PeerRemoteAddr
        InetAddress,

    -- Local
    bgp4V2PeerLocalPort
        InetPortNumber,
    bgp4V2PeerLocalAs
        InetAutonomousSystemNumber,
    bgp4V2PeerLocalIdentifier
        Bgp4V2IdentifierTC,

    -- Remote
    bgp4V2PeerRemotePort
        InetPortNumber,
    bgp4V2PeerRemoteAs
        InetAutonomousSystemNumber,
    bgp4V2PeerRemoteIdentifier
        Bgp4V2IdentifierTC,
```



```
-- Session status
bgp4V2PeerAdminStatus
    INTEGER,
bgp4V2PeerState
    INTEGER,
bgp4V2PeerDescription
    SnmpAdminString
}

bgp4V2PeerInstance OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4294967295)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The routing instance index.

        Some BGP implementations permit the creation of
        multiple instances of a BGP routing process. An
        example includes routers running BGP/MPLS IP Virtual
        Private Networks.

        Implementations that do not support multiple
        routing instances should return 1 for this object."
    ::= { bgp4V2PeerEntry 1 }

bgp4V2PeerLocalAddrType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The address family of the local end of the peering
        session."
    ::= { bgp4V2PeerEntry 2 }

bgp4V2PeerLocalAddr OBJECT-TYPE
    SYNTAX      InetAddress
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The local IP address of this entry's BGP connection."
    ::= { bgp4V2PeerEntry 3 }

bgp4V2PeerRemoteAddrType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The address family of the remote end of the peering
```



```
        session."
 ::= { bgp4V2PeerEntry 4 }

bgp4V2PeerRemoteAddr OBJECT-TYPE
    SYNTAX      InetAddress
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The remote IP address of this entry's BGP peer."
    ::= { bgp4V2PeerEntry 5 }

bgp4V2PeerLocalPort OBJECT-TYPE
    SYNTAX      InetPortNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The local port for the TCP connection between the BGP
        peers."
    ::= { bgp4V2PeerEntry 6 }

bgp4V2PeerLocalAs OBJECT-TYPE
    SYNTAX      InetAutonomousSystemNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Some implementations of BGP can represent themselves
        as multiple ASes. This is the AS that this peering
        session is representing itself as to the remote peer."
    ::= { bgp4V2PeerEntry 7 }

bgp4V2PeerLocalIdentifier OBJECT-TYPE
    SYNTAX      Bgp4V2IdentifierTC
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The BGP Identifier of the local system for this peering
        session. It is REQUIRED that all bgp4V2PeerLocalIdentifier
        values for the same bgp4V2PeerInstance be identical."
    REFERENCE
        "RFC 4271, Section 4.2, 'BGP Identifier'."
    ::= { bgp4V2PeerEntry 8 }

bgp4V2PeerRemotePort OBJECT-TYPE
    SYNTAX      InetPortNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The remote port for the TCP connection between the BGP
```

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peers.

Note that the objects `bgp4V2PeerLocalAddr`,
`bgp4V2PeerLocalPort`, `bgp4V2PeerRemoteAddr` and
`bgp4V2PeerRemotePort` provide the appropriate reference to
the standard MIB TCP connection table, or even the ipv6
TCP MIB as in [RFC 4022](#)."

REFERENCE

"[RFC 2012](#) - SNMPv2 Management Information Base for the
Transmission Control Protocol using SMIV2.

[RFC 4022](#) - IP Version 6 Management Information Base
for the Transmission Control Protocol."

::= { bgp4V2PeerEntry 9 }

`bgp4V2PeerRemoteAs` OBJECT-TYPE

SYNTAX InetAutonomousSystemNumber

MAX-ACCESS read-only

STATUS current

DESCRIPTION

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

REFERENCE

"[RFC 4271, Section 4.2](#)."

::= { bgp4V2PeerEntry 10 }

`bgp4V2PeerRemoteIdentifier` OBJECT-TYPE

SYNTAX Bgp4V2IdentifierTC

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The BGP Identifier of this entry's remote BGP peer.

This entry should be 0.0.0.0 unless the
`bgp4V2PeerState` is in the openconfirm or the
established state."

REFERENCE

"[RFC 4271, Section 4.2](#), 'BGP Identifier'."

::= { bgp4V2PeerEntry 11 }

`bgp4V2PeerAdminStatus` OBJECT-TYPE

SYNTAX INTEGER {
halted(1),
running(2)
}

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"Whether or not the BGP FSM for this remote peer is

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halted or running. The BGP FSM for a remote peer is halted after processing a Stop event. Likewise, it is in the running state after a Start event.

The bgp4V2PeerState will generally be in the idle state when the FSM is halted, although some extensions such as Graceful Restart will leave the peer in the Idle state but with the FSM running."

REFERENCE

"[RFC 4271, Section 8.1.2.](#)"

::= { bgp4V2PeerEntry 12 }

bgp4V2PeerState 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.](#)"

::= { bgp4V2PeerEntry 13 }

bgp4V2PeerDescription OBJECT-TYPE

SYNTAX SnmpAdminString

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"A user configured description identifying this peer. When this object is not the empty string, this object SHOULD contain a description that is unique within a given BGP instance for this peer."

::= { bgp4V2PeerEntry 14 }

--

-- Per-peer error management information.

--

bgp4V2PeerErrorsTable OBJECT-TYPE

SYNTAX SEQUENCE OF Bgp4V2PeerErrorsEntry

MAX-ACCESS not-accessible
STATUS current
DESCRIPTION
 "On a per-peer basis, this table reflects the last
 protocol-defined error encountered and reported on
 the peer session."
::= { bgp4V2Objects 3 }

bgp4V2PeerErrorsEntry OBJECT-TYPE
SYNTAX Bgp4V2PeerErrorsEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION
 "Each entry contains information about errors sent
 and received for a particular BGP peer."
AUGMENTS {
 bgp4V2PeerEntry
}
::= { bgp4V2PeerErrorsTable 1 }

Bgp4V2PeerErrorsEntry ::= SEQUENCE {
 bgp4V2PeerLastErrorCodeReceived
 Unsigned32,
 bgp4V2PeerLastErrorSubCodeReceived
 Unsigned32,
 bgp4V2PeerLastErrorReceivedTime
 TimeStamp,
 bgp4V2PeerLastErrorReceivedText
 SnmpAdminString,
 bgp4V2PeerLastErrorReceivedData
 OCTET STRING,
 bgp4V2PeerLastErrorCodeSent
 Unsigned32,
 bgp4V2PeerLastErrorSubCodeSent
 Unsigned32,
 bgp4V2PeerLastErrorSentTime
 TimeStamp,
 bgp4V2PeerLastErrorSentText
 SnmpAdminString,
 bgp4V2PeerLastErrorSentData
 OCTET STRING
}

bgp4V2PeerLastErrorCodeReceived OBJECT-TYPE
SYNTAX Unsigned32 (0..255)
MAX-ACCESS read-only
STATUS current
DESCRIPTION

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"The last error code received from this peer via NOTIFICATION message on this connection. If no error has occurred, this field is zero."

REFERENCE

"[RFC 4271, Section 4.5.](#)

[RFC 4486](#) optionally supported.

[RFC 3362, Section 5](#) optionally supported."

::= { bgp4V2PeerErrorsEntry 1 }

bgp4V2PeerLastErrorSubCodeReceived OBJECT-TYPE

SYNTAX Unsigned32 (0..255)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The last subcode received from this peer via NOTIFICATION message on this connection. If no error has occurred, this field is zero."

REFERENCE

"[RFC 4271, Section 4.5.](#)

[RFC 4486](#) optionally supported.

[RFC 3362, Section 5](#) optionally supported."

::= { bgp4V2PeerErrorsEntry 2 }

bgp4V2PeerLastErrorReceivedTime OBJECT-TYPE

SYNTAX TimeStamp

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The timestamp that the last NOTIFICATION was received from this peer."

REFERENCE

"[RFC 4271, Section 4.5.](#)"

::= { bgp4V2PeerErrorsEntry 3 }

bgp4V2PeerLastErrorReceivedText OBJECT-TYPE

SYNTAX SnmpAdminString

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object contains an implementation specific explanation of the error that was reported."

::= { bgp4V2PeerErrorsEntry 4 }

bgp4V2PeerLastErrorReceivedData OBJECT-TYPE

SYNTAX OCTET STRING (SIZE(0..4075))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

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"The last error code's data seen by this peer.

Per [RFC 2578](#), some implementations may have limitations dealing with OCTET STRINGS larger than 255. Thus, this data may be truncated."

REFERENCE

"[RFC 4271, Section 4.5](#),
[RFC 2578, Section 7.1.2](#),
[RFC 4486](#) optionally supported.
[RFC 3362, Section 5](#) optionally supported."

::= { bgp4V2PeerErrorsEntry 5 }

bgp4V2PeerLastErrorCodeSent OBJECT-TYPE

SYNTAX Unsigned32 (0..255)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The last error code sent to this peer via NOTIFICATION message on this connection. If no error has occurred, this field is zero."

REFERENCE

"[RFC 4271, Section 4.5](#).
[RFC 4486](#) optionally supported.
[RFC 3362, Section 5](#) optionally supported."

::= { bgp4V2PeerErrorsEntry 6 }

bgp4V2PeerLastErrorSubCodeSent OBJECT-TYPE

SYNTAX Unsigned32 (0..255)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The last subcode sent to this peer via NOTIFICATION message on this connection. If no error has occurred, this field is zero."

REFERENCE

"[RFC 4271, Section 4.5](#).
[RFC 4486](#) optionally supported.
[RFC 3362, Section 5](#) optionally supported."

::= { bgp4V2PeerErrorsEntry 7 }

bgp4V2PeerLastErrorSentTime OBJECT-TYPE

SYNTAX TimeStamp

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The timestamp that the last NOTIFICATION was sent to this peer."

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```
    "RFC 4271, Section 4.5."
 ::= { bgp4V2PeerErrorsEntry 8 }

bgp4V2PeerLastErrorSentText OBJECT-TYPE
    SYNTAX      SnmpAdminString
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object contains an implementation specific
         explanation of the error that is being reported."
 ::= { bgp4V2PeerErrorsEntry 9 }

bgp4V2PeerLastErrorSentData OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..4075))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The last error code's data sent to this peer.

        Per RFC 2578, some implementations may have limitations
        dealing with OCTET STRINGS larger than 255. Thus, this
        data may be truncated."
    REFERENCE
        "RFC 4271, Section 4.5,
         RFC 2578, Section 7.1.2
         RFC 4486 optionally supported.
         RFC 3362, Section 5 optionally supported."
 ::= { bgp4V2PeerErrorsEntry 10 }

--
-- Per-peer Event Times
--

bgp4V2PeerEventTimesTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Bgp4V2PeerEventTimesEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table reporting the per-peering session amount
         of time elapsed and update events since the peering
         session advanced into the established state."
 ::= { bgp4V2Objects 4 }

bgp4V2PeerEventTimesEntry OBJECT-TYPE
    SYNTAX      Bgp4V2PeerEventTimesEntry
    MAX-ACCESS  not-accessible
    STATUS      current
```


DESCRIPTION

"Each row contains a set of statistics about time spent and events encountered in the peer session established state."

AUGMENTS {

 bgp4V2PeerEntry

}

::= { bgp4V2PeerEventTimesTable 1 }

Bgp4V2PeerEventTimesEntry ::= SEQUENCE {

 bgp4V2PeerFsmEstablishedTime

 Gauge32,

 bgp4V2PeerInUpdatesElapsedTime

 Gauge32

}

bgp4V2PeerFsmEstablishedTime 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. If the peer has never reached the established state, the value remains zero."

REFERENCE

["RFC 4271, Section 8."](#)

::= { bgp4V2PeerEventTimesEntry 1 }

bgp4V2PeerInUpdatesElapsedTime 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."](#)

::= { bgp4V2PeerEventTimesEntry 2 }

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--

-- Per-Peer Configured Timers

--

bgp4V2PeerConfiguredTimersTable OBJECT-TYPE

SYNTAX SEQUENCE OF Bgp4V2PeerConfiguredTimersEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"Per peer management data on BGP session timers."

::= { bgp4V2Objects 5 }

bgp4V2PeerConfiguredTimersEntry OBJECT-TYPE

SYNTAX Bgp4V2PeerConfiguredTimersEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"Each entry corresponds to the current state of
BGP timers on a given peering session."

AUGMENTS {

bgp4V2PeerEntry

}

::= { bgp4V2PeerConfiguredTimersTable 1 }

Bgp4V2PeerConfiguredTimersEntry ::= SEQUENCE {

bgp4V2PeerConnectRetryInterval

Unsigned32,

bgp4V2PeerHoldTimeConfigured

Unsigned32,

bgp4V2PeerKeepAliveConfigured

Unsigned32,

bgp4V2PeerMinASOrigInterval

Unsigned32,

bgp4V2PeerMinRouteAdverInterval

Unsigned32

}

bgp4V2PeerConnectRetryInterval OBJECT-TYPE

SYNTAX Unsigned32 (1..65535)

UNITS "seconds"

MAX-ACCESS read-only

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'."


```
::= { bgp4V2PeerConfiguredTimersEntry 1 }
```

bgp4V2PeerHoldTimeConfigured OBJECT-TYPE

SYNTAX Unsigned32 (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.](#)"

```
::= { bgp4V2PeerConfiguredTimersEntry 2 }
```

bgp4V2PeerKeepAliveConfigured OBJECT-TYPE

SYNTAX Unsigned32 (0 | 1..21845)

UNITS "seconds"

MAX-ACCESS read-only

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 periodic 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.](#)"
 ::= { bgp4V2PeerConfiguredTimersEntry 3 }

bgp4V2PeerMinASOrigInterval OBJECT-TYPE
SYNTAX Unsigned32 (0..65535)
UNITS "seconds"
MAX-ACCESS read-only
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.](#)"
 ::= { bgp4V2PeerConfiguredTimersEntry 4 }

bgp4V2PeerMinRouteAdverInterval OBJECT-TYPE
SYNTAX Unsigned32 (0..65535)
UNITS "seconds"
MAX-ACCESS read-only
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.](#)"
 ::= { bgp4V2PeerConfiguredTimersEntry 5 }

--
-- Per-Peer Negotiated Timers
--

bgp4V2PeerNegotiatedTimersTable OBJECT-TYPE
SYNTAX SEQUENCE OF Bgp4V2PeerNegotiatedTimersEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION
"Configured values of per-peer timers are seen
in the bgp4V2PeerConfiguredTimersTable.

Values in this table reflect the current
operational values, after negotiation from values

derived from initial configuration."
 ::= { bgp4V2Objects 6 }

bgp4V2PeerNegotiatedTimersEntry OBJECT-TYPE

SYNTAX Bgp4V2PeerNegotiatedTimersEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"Each entry reflects a value of the currently operational, negotiated timer as reflected in the Bgp4V2PeerNegotiatedTimersEntry."

AUGMENTS {

bgp4V2PeerEntry

}

::= { bgp4V2PeerNegotiatedTimersTable 1 }

Bgp4V2PeerNegotiatedTimersEntry ::= SEQUENCE {

bgp4V2PeerHoldTime

Unsigned32,

bgp4V2PeerKeepAlive

Unsigned32

}

bgp4V2PeerHoldTime OBJECT-TYPE

SYNTAX Unsigned32 (0 | 3..65535)

UNITS "seconds"

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The value of this object is calculated by this BGP Speaker as being;

zero (0) - if this was the value sent by the peer and this value is permitted by this BGP Speaker. In this case, no keepalive messages are sent and the Hold Timer is not set.

At least three (3). This value is the smaller of the value sent by this peer in the OPEN message and bgp4V2PeerHoldTimeConfigured for this peer.

If the peer is not in the established state, the value of this object is zero (0)."

REFERENCE

"[RFC 4271, Section 4.2.](#)"

::= { bgp4V2PeerNegotiatedTimersEntry 1 }

bgp4V2PeerKeepAlive OBJECT-TYPE

SYNTAX Unsigned32 (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 bgp4V2PeerHoldTime, it has the same proportion as what bgp4V2PeerKeepAliveConfigured has when compared with bgp4V2PeerHoldTimeConfigured. If the value of this object is zero (0), it indicates that the KeepAlive timer has not been established with the peer, or, the value of bgp4V2PeerKeepAliveConfigured is zero (0).

If the peer is not in the established state, the value of this object is zero (0)."

REFERENCE

["RFC 4271, Section 4.4."](#)

::= { bgp4V2PeerNegotiatedTimersEntry 2 }

--

-- Per-peer counters

--

bgp4V2PeerCountersTable OBJECT-TYPE

SYNTAX SEQUENCE OF Bgp4V2PeerCountersEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The counters associated with a BGP Peer."

::= { bgp4V2Objects 7 }

bgp4V2PeerCountersEntry OBJECT-TYPE

SYNTAX Bgp4V2PeerCountersEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"Each entry contains counters of message transmissions and FSM transitions for a given BGP Peering session."

AUGMENTS {

 bgp4V2PeerEntry

}

::= { bgp4V2PeerCountersTable 1 }

Bgp4V2PeerCountersEntry ::= SEQUENCE {
 bgp4V2PeerInUpdates

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```
        Counter32,
    bgp4V2PeerOutUpdates
        Counter32,
    bgp4V2PeerInTotalMessages
        Counter32,
    bgp4V2PeerOutTotalMessages
        Counter32,
    bgp4V2PeerFsmEstablishedTransitions
        Counter32
}
```

bgp4V2PeerInUpdates OBJECT-TYPE

```
SYNTAX      Counter32
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "The number of BGP UPDATE messages received on this
    connection."
 ::= { bgp4V2PeerCountersEntry 1 }
```

bgp4V2PeerOutUpdates OBJECT-TYPE

```
SYNTAX      Counter32
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "The number of BGP UPDATE messages transmitted on this
    connection."
 ::= { bgp4V2PeerCountersEntry 2 }
```

bgp4V2PeerInTotalMessages OBJECT-TYPE

```
SYNTAX      Counter32
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "The total number of messages received from the remote
    peer on this connection."
 ::= { bgp4V2PeerCountersEntry 3 }
```

bgp4V2PeerOutTotalMessages OBJECT-TYPE

```
SYNTAX      Counter32
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "The total number of messages transmitted to the remote
    peer on this connection."
 ::= { bgp4V2PeerCountersEntry 4 }
```

bgp4V2PeerFsmEstablishedTransitions 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."
 ::= { bgp4V2PeerCountersEntry 5 }

--
-- Per-Peer Prefix Gauges
--

bgp4V2PrefixGaugesTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Bgp4V2PrefixCountersEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Additional per-peer, per AFI-SAFI counters for
        prefixes"
    ::= { bgp4V2Objects 8 }

bgp4V2PrefixGaugesEntry OBJECT-TYPE
    SYNTAX      Bgp4V2PrefixCountersEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Entry containing information about a bgp-peers prefix
        counters."
    INDEX {
        bgp4V2PeerInstance,
        bgp4V2PeerRemoteAddrType,
        bgp4V2PeerRemoteAddr,
        bgp4V2PrefixGaugesAfi,
        bgp4V2PrefixGaugesSafi
    }
    ::= { bgp4V2PrefixGaugesTable 1 }

Bgp4V2PrefixCountersEntry ::= SEQUENCE {
    bgp4V2PrefixGaugesAfi
        Bgp4V2AddressFamilyIdentifierTC,
    bgp4V2PrefixGaugesSafi
        Bgp4V2SubsequentAddressFamilyIdentifierTC,
    bgp4V2PrefixInPrefixes
        Gauge32,
    bgp4V2PrefixInPrefixesAccepted
        Gauge32,
    bgp4V2PrefixOutPrefixes
        Gauge32
```

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}

bgp4V2PrefixGaugesAfi OBJECT-TYPE

SYNTAX Bgp4V2AddressFamilyIdentifierTC

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The AFI index of the per-peer, per prefix counters"

::= { bgp4V2PrefixGaugesEntry 1 }

bgp4V2PrefixGaugesSafi OBJECT-TYPE

SYNTAX Bgp4V2SubsequentAddressFamilyIdentifierTC

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The SAFI index of the per-peer, per prefix counters"

::= { bgp4V2PrefixGaugesEntry 2 }

bgp4V2PrefixInPrefixes OBJECT-TYPE

SYNTAX Gauge32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The number of prefixes received from a peer and are stored in the Adj-Ribs-In for that peer."

Note that this number does not reflect prefixes that have been discarded due to policy."

REFERENCE

"[RFC 4271](#), Sections [3.2](#) and [9](#)."

::= { bgp4V2PrefixGaugesEntry 3 }

bgp4V2PrefixInPrefixesAccepted OBJECT-TYPE

SYNTAX Gauge32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The number of prefixes for a peer that are installed in the Adj-Ribs-In and are eligible to become active in the Loc-Rib."

REFERENCE

"[RFC 4271](#), Sections [3.2](#) and [9](#)."

::= { bgp4V2PrefixGaugesEntry 4 }

bgp4V2PrefixOutPrefixes OBJECT-TYPE

SYNTAX Gauge32

MAX-ACCESS read-only

STATUS current

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DESCRIPTION
 "The number of prefixes for a peer that are installed
 in that peer's Adj-Ribs-Out."
REFERENCE
 "[RFC 4271](#), Sections [3.2](#) and [9](#)."
::= { bgp4V2PrefixGaugesEntry 5 }

--
-- BGP NLRI
--

bgp4V2NlriTable OBJECT-TYPE
 SYNTAX SEQUENCE OF Bgp4V2NlriEntry
 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. Collectively, this
 represents the Adj-Ribs-In. The route where
 bgp4V2NlriBest is true represents, for this NLRI,
 the route that is installed in the LocRib from the
 Adj-Ribs-In."
 REFERENCE
 "[RFC 4271](#), Sections [3.2](#) and [9](#)."
::= { bgp4V2Objects 9 }

bgp4V2NlriEntry OBJECT-TYPE
 SYNTAX Bgp4V2NlriEntry
 MAX-ACCESS not-accessible
 STATUS current
 DESCRIPTION
 "Information about a path to a network."
 INDEX {
 bgp4V2PeerInstance,
 bgp4V2NlriAfi,
 bgp4V2NlriSafi,
 bgp4V2NlriPrefixType,
 bgp4V2NlriPrefix,
 bgp4V2NlriPrefixLen,
 bgp4V2PeerRemoteAddrType,
 bgp4V2PeerRemoteAddr,
 bgp4V2NlriIndex
 }
::= { bgp4V2NlriTable 1 }

Bgp4V2NlriEntry ::= SEQUENCE {
 bgp4V2NlriIndex

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```
    Unsigned32,
    bgp4V2NlriAfi
    Bgp4V2AddressFamilyIdentifierTC,
    bgp4V2NlriSafi
    Bgp4V2SubsequentAddressFamilyIdentifierTC,
    bgp4V2NlriPrefixType
    InetAddressType,
    bgp4V2NlriPrefix
    InetAddress,
    bgp4V2NlriPrefixLen
    InetAddressPrefixLength,
    bgp4V2NlriBest
    TruthValue,
    bgp4V2NlriCalcLocalPref
    Unsigned32,
    bgp4V2NlriOrigin
    INTEGER,
    bgp4V2NlriNextHopAddrType
    InetAddressType,
    bgp4V2NlriNextHopAddr
    InetAddress,
    bgp4V2NlriLinkLocalNextHopAddrType
    InetAddressType,
    bgp4V2NlriLinkLocalNextHopAddr
    InetAddress,
    bgp4V2NlriLocalPrefPresent
    TruthValue,
    bgp4V2NlriLocalPref
    Unsigned32,
    bgp4V2NlriMedPresent
    TruthValue,
    bgp4V2NlriMed
    Unsigned32,
    bgp4V2NlriAtomicAggregate
    INTEGER,
    bgp4V2NlriAggregatorPresent
    TruthValue,
    bgp4V2NlriAggregatorAS
    InetAutonomousSystemNumber,
    bgp4V2NlriAggregatorAddr
    Bgp4V2IdentifierTC,
    bgp4V2NlriAsPathCalcLength
    Unsigned32,
    bgp4V2NlriAsPathString
    SnmpAdminString,
    bgp4V2NlriAsPath
    OCTET STRING,
    bgp4V2NlriPathAttrUnknown
```


OCTET STRING
}

bgp4V2NlriIndex OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"This index allows for multiple instances of a base prefix for a certain AFI-SAFI from a given peer.

This is currently useful for two things:

1. Allowing for a peer in future implementations to send more than a single route instance.
2. Allow for extensions which extend the NLRI field to send the same prefix while utilizing other extension specific information. An example of this is [RFC 3107](#) - Carrying MPLS labels in BGP."

REFERENCE

"[RFC 3107](#) - Carrying Label Information in BGP-4."

::= { bgp4V2NlriEntry 1 }

bgp4V2NlriAfi OBJECT-TYPE

SYNTAX Bgp4V2AddressFamilyIdentifierTC

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The address family of the prefix for this NLRI.

Note that the AFI is not necessarily equivalent to the an InetAddressType."

REFERENCE

"[RFC 4760](#) - Multiprotocol Extensions for BGP-4"

::= { bgp4V2NlriEntry 2 }

bgp4V2NlriSafi OBJECT-TYPE

SYNTAX Bgp4V2SubsequentAddressFamilyIdentifierTC

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The subsequent address family of the prefix for this NLRI"

REFERENCE

"[RFC 4760](#) - Multiprotocol Extensions for BGP-4"

::= { bgp4V2NlriEntry 3 }

bgp4V2NlriPrefixType OBJECT-TYPE

SYNTAX InetAddressType

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The type of the IP address prefix in the Network Layer Reachability Information field. The value of this object is derived from the appropriate value from the bgp4V2NlriAfi field. Where an appropriate InetAddressType is not available, the value of the object must be unknown(0)."

::= { bgp4V2NlriEntry 4 }

bgp4V2NlriPrefix OBJECT-TYPE

SYNTAX InetAddress

MAX-ACCESS not-accessible

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 bgp4V2NlriPrefixLen. Any bits beyond the length specified by bgp4V2NlriPrefixLen are zeroed."

REFERENCE

["RFC 4271, Section 4.3."](#)

::= { bgp4V2NlriEntry 5 }

bgp4V2NlriPrefixLen OBJECT-TYPE

SYNTAX InetAddressPrefixLength

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"Length in bits of the address prefix in the Network Layer Reachability Information field."

::= { bgp4V2NlriEntry 6 }

bgp4V2NlriBest OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"An indication of whether or not this route was chosen as the best BGP4 route for this destination."

REFERENCE

["RFC 4271, Section 9.1.2."](#)

::= { bgp4V2NlriEntry 7 }

bgp4V2NlriCalcLocalPref OBJECT-TYPE

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SYNTAX Unsigned32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The degree of preference calculated by the receiving BGP4 speaker for an advertised route.

In the case where this prefix is ineligible, the value of this object will be zero (0)."

REFERENCE

["RFC 4271, Section 9.1.1"](#)

::= { bgp4V2NlriEntry 8 }

bgp4V2NlriOrigin 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."](#)

::= { bgp4V2NlriEntry 9 }

bgp4V2NlriNextHopAddrType OBJECT-TYPE

SYNTAX InetAddressType

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The address family of the address for the border router that should be used to access the destination network."

::= { bgp4V2NlriEntry 10 }

bgp4V2NlriNextHopAddr OBJECT-TYPE

SYNTAX InetAddress (SIZE(4..20))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The address of the border router that should be used to access the destination

network. This address is the nexthop address received in the UPDATE packet associated with this prefix.

Note that for [RFC2545](#) style double nexthops, this object will always contain the global scope nexthop. `bgpPathAttrLinkLocalNextHop` will contain the linklocal scope nexthop, if it is present.

In the case a mechanism is developed to use only a link local nexthop, `bgp4V2NlriNextHopAddr` will contain the link local nexthop."

REFERENCE

"[RFC 4271, Section 4.3](#),
[RFC 4271, Section 5.1.3](#),
[RFC 2545, Section 3](#)."

::= { bgp4V2NlriEntry 11 }

bgp4V2NlriLinkLocalNextHopAddrType OBJECT-TYPE

SYNTAX InetAddressType

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The address type for IPv6 link local addresses. This is present only when receiving [RFC 2545](#) style double nexthops.

This object is optionally present in BGP implementations that do not support IPv6.

When no IPv6 link local nexthop is present, the value of this object should be unknown(0)."

REFERENCE

"[RFC 2545, Section 3](#)."

::= { bgp4V2NlriEntry 12 }

bgp4V2NlriLinkLocalNextHopAddr OBJECT-TYPE

SYNTAX InetAddress

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This value contains an IPv6 link local address and is present only when receiving [RFC 2545](#) style double nexthops.

This object is optionally present in BGP implementations that do not support IPv6.

When no IPv6 link local nexthop is present, the length of this object should be zero."

REFERENCE

["RFC 2545, Section 3."](#)

::= { bgp4V2NlriEntry 13 }

bgp4V2NlriLocalPrefPresent OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This value is true when the LOCAL_PREF value was sent in the UPDATE message."

::= { bgp4V2NlriEntry 14 }

bgp4V2NlriLocalPref OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The originating BGP4 speakers degree of preference for an advertised route."

REFERENCE

["RFC 4271, Section 4.3."](#)

[RFC 4271, Section 5.1.5."](#)

::= { bgp4V2NlriEntry 15 }

bgp4V2NlriMedPresent OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This value is true when the MED value was sent in the UPDATE message."

::= { bgp4V2NlriEntry 16 }

bgp4V2NlriMed OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This metric is used to discriminate between multiple exit points to an adjacent autonomous system. When the MED value is absent but has a calculated default value, this object will contain the calculated value."

REFERENCE

["RFC 4271, Section 4.3."](#)

[RFC 4271, Section 5.1.4."](#)

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```
::= { bgp4V2NlriEntry 17 }
```

bgp4V2NlriAtomicAggregate OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This value is true when the ATOMIC_AGGREGATE Path Attribute is present and indicates that the NLRI MUST NOT be made more specific."

REFERENCE

"[RFC 4271](#), Sections [5.1.6](#) and [9.1.4](#)."

```
::= { bgp4V2NlriEntry 18 }
```

bgp4V2NlriAggregatorPresent OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This value is true when the AGGREGATOR path attribute was sent in the UPDATE message."

```
::= { bgp4V2NlriEntry 19 }
```

bgp4V2NlriAggregatorAS OBJECT-TYPE

SYNTAX InetAutonomousSystemNumber

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The AS number of the last BGP4 speaker that performed route aggregation. When bgp4V2NlriAggregatorPresent is false, the value of this object should be zero (0)."

REFERENCE

"[RFC 4271, Section 5.1.7](#).
[RFC 4271, Section 9.2.2.2](#)."

```
::= { bgp4V2NlriEntry 20 }
```

bgp4V2NlriAggregatorAddr OBJECT-TYPE

SYNTAX Bgp4V2IdentifierTC

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The IP address of the last BGP4 speaker that performed route aggregation. When bgp4V2NlriAggregatorPresent is false, the value of this object should be 0.0.0.0"

REFERENCE

"[RFC 4271, Section 5.1.7](#).
[RFC 4271, Section 9.2.2.2](#)."

```
::= { bgp4V2NlriEntry 21 }
```


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bgp4V2NlriAsPathCalcLength OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This value represents the calculated length of the AS Path according to the rules of the BGP specification. This value is used in route selection."

REFERENCE

["RFC 4271, Section 9.1.2.2.a"](#)

::= { bgp4V2NlriEntry 22 }

bgp4V2NlriAsPathString OBJECT-TYPE

SYNTAX SnmpAdminString

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This is a string depicting the autonomous system path to this network which was received from the peer which advertised it. The format of the string is implementation-dependent, and should be designed for operator readability."

Note that SnmpAdminString is only capable of representing a maximum of 255 characters. This may lead to the string being truncated in the presence of a large AS Path. It is RECOMMENDED that when this object's contents will be truncated that the final 3 octets be reserved for the ellipses string, '...'. bgp4V2NlriAsPath may give access to the full AS Path."

::= { bgp4V2NlriEntry 23 }

-- Maximum size of the following is derived as
-- 4096 max message size
-- - 16 BGP message marker bytes
-- - 2 BGP message size
-- - 1 BGP message type (UPDATE with unknown attr)
-- - 2 UPDATE routes length (even assuming no routes)
-- - 2 UPDATE path attributes length
-- - 1 path attribute flag octet
-- -----
-- 4072 bytes maximum per-message attribute value data

bgp4V2NlriAsPath OBJECT-TYPE

SYNTAX OCTET STRING (SIZE(2..4072))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

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"In order to provide a canonicalized form of the BGP-4 AS_PATH along with the human-readable bgp4V2NlriAsPathString, which may be truncated, this object contains the contents of the BGP-4 AS_PATH Path Attribute. This object may be parsed using the rules defined for Four-octet ASes as defined in [RFC 4893](#). [RFC 4271, Section 4.3](#), 'Path Attributes: b) AS_PATH' as amended by [RFC 5065, Section 3](#) defines the general format of the AS_PATH path attribute and its code points.

In brief, the AS_PATH is composed of a sequence of AS Segments. Each AS Segment is represented by a triple:
<path segment type, path segment length,
path segment value>.

The path segment type and path segment length fields are one octet in length each.

The path segment type field may be one of:

- 1 - AS_SET ([RFC 4721, Section 4.3](#))
- 2 - AS_SEQUENCE ([RFC 4721, Section 4.3](#))
- 3 - AS_CONFED_SEQUENCE ([RFC 3065, Section 5](#))
- 4 - AS_CONFED_SET ([RFC 3065, Section 5](#))

The path segment length field contains the number of ASes (not the number of octets) in the path segment value field.

The path segment value field contains one or more AS numbers, each encoded as a 4-octet length field in network byte order.

Note that since an SNMP agent may truncate this object to less than its maximum theoretical length of 4072 octets users of this object should be prepared to deal with a truncated and thus malformed AS_PATH. It is RECOMMENDED that when such truncation would occur on the boundary of an encoded AS that the partial AS be discarded from this object and the object's size be adjusted accordingly. Further, it is also RECOMMENDED that when such truncation, either alone or in conjunction with the truncation of a partially encoded AS described previously, would yield an empty path segment value field that the path segment type and path segment length components of the truncated AS_PATH also be discarded and the object's size be adjusted accordingly."

REFERENCE

"[RFC 4271, Section 4.3](#).
[RFC 5065, Section 5](#)."


```

    RFC 4893."
 ::= { bgp4V2NlriEntry 24 }

bgp4V2NlriPathAttrUnknown OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..4072))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Path Attributes not understood by this implementation
        SHOULD be presented in this object. Those Path
        Attributes use the type, length, value encoding documented
        in RFC 4271, Section 4.3, 'Path Attributes'."

        Note that since an SNMP agent may truncate this object to
        less than its maximum theoretical length of 4072 octets
        users of this object should be prepared to deal with a
        truncated and thus malformed Path Attribute."
    REFERENCE
        "RFC 4271, Section 4.3."
 ::= { bgp4V2NlriEntry 25 }

--
-- Adj-Ribs-Out Table
--

bgp4V2AdjRibsOutTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Bgp4V2AdjRibsOutEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table contains on a per-peer basis one or more
        routes from the bgp4V2NlriTable that have been
        placed in this peer's Adj-Ribs-Out."
    REFERENCE
        "RFC 4271, Section 3.2."
 ::= { bgp4V2Objects 10 }

bgp4V2AdjRibsOutEntry OBJECT-TYPE
    SYNTAX      Bgp4V2AdjRibsOutEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "List of BGP routes that have been placed into a
        peer's Adj-Ribs-Out."
    INDEX {
        bgp4V2PeerInstance,
```



```
        bgp4V2NlriAfi,
        bgp4V2NlriSafi,
        bgp4V2NlriPrefixType,
        bgp4V2NlriPrefix,
        bgp4V2NlriPrefixLen,
        bgp4V2PeerRemoteAddrType,
        bgp4V2PeerRemoteAddr,
        bgp4V2AdjRibsOutIndex
    }
    ::= { bgp4V2AdjRibsOutTable 1 }

Bgp4V2AdjRibsOutEntry ::= SEQUENCE {
    bgp4V2AdjRibsOutIndex
        Unsigned32,
    bgp4V2AdjRibsOutRoute
        RowPointer
}

bgp4V2AdjRibsOutIndex OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Certain extensions to BGP permit multiple instance of
        a per afi, per safi prefix to be advertised to a peer.
        This object allows the enumeration of them."
    ::= { bgp4V2AdjRibsOutEntry 1 }

bgp4V2AdjRibsOutRoute OBJECT-TYPE
    SYNTAX      RowPointer
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object points to the route in the bgp4V2NlriTable
        that corresponds to the entry in the peer's
        Adj-Rib-Out. Outgoing route maps are not
        reflected at this point as those are part of the
        Update-Send process."
    REFERENCE
        "RFC 4271, Section 9.2."
    ::= { bgp4V2AdjRibsOutEntry 2 }

--
-- Notifications
--

bgp4V2EstablishedNotification NOTIFICATION-TYPE
    OBJECTS {
```



```
        bgp4V2PeerState,
        bgp4V2PeerLocalPort,
        bgp4V2PeerRemotePort
    }
    STATUS current
    DESCRIPTION
        "The BGP Established event is generated when
        the BGP FSM enters the established state."
    ::= { bgp4V2Notifications 1 }

bgp4V2BackwardTransitionNotification NOTIFICATION-TYPE
    OBJECTS {
        bgp4V2PeerState,
        bgp4V2PeerLocalPort,
        bgp4V2PeerRemotePort,
        bgp4V2PeerLastErrorCodeReceived,
        bgp4V2PeerLastErrorSubCodeReceived,
        bgp4V2PeerLastErrorReceivedText
    }
    STATUS current
    DESCRIPTION
        "The BGPPBackwardTransition Event is generated
        when the BGP FSM moves from a higher numbered
        state to a lower numbered state.

        Due to the nature of the BGP state machine, an
        implementation MAY rate limit the generation of this event.
        An implementation MAY also generate this notification ONLY
        when the state machine moves out of the established state.
        An implementation should document its specific behavior."
    ::= { bgp4V2Notifications 2 }

--
-- Conformance Information
--

bgp4V2Compliances OBJECT IDENTIFIER ::=
    { bgp4V2Conformance 1 }

bgp4V2Groups OBJECT IDENTIFIER ::=
    { bgp4V2Conformance 2 }

bgp4V2Compliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The compliance statement for entities which
        implement the BGP4 mib."
    MODULE -- this module
```

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MANDATORY-GROUPS {

bgp4V2StdMIBTimersGroup,
bgp4V2StdMIBCountersGroup,
bgp4V2StdMIBErrorsGroup,
bgp4V2StdMIBPeerGroup,
bgp4V2StdMIBNlriGroup,
bgp4V2GlobalsGroup
}

GROUP bgp4V2StdMIBNotificationGroup

DESCRIPTION

"Implementation of BGP Notifications are completely optional in this MIB."

OBJECT bgp4V2PeerLocalAddr

SYNTAX InetAddress (SIZE(4|16|20))

DESCRIPTION

"An implementation is required to support IPv4 peering sessions. An implementation MAY support IPv6 peering sessions. IPv6 link-local peering sessions MAY be supported by this MIB."

OBJECT bgp4V2PeerRemoteAddr

SYNTAX InetAddress (SIZE(4|16|20))

DESCRIPTION

"An implementation is required to support IPv4 peering sessions. An implementation MAY support IPv6 peering sessions. IPv6 link-local peering sessions MAY be supported by this MIB."

OBJECT bgp4V2NlriPrefix

SYNTAX InetAddress (SIZE(0..16))

DESCRIPTION

"An implementation is required to support IPv4 prefixes. An implementation MAY support IPv6 prefixes."

OBJECT bgp4V2NlriLinkLocalNextHopAddrType

SYNTAX InetAddressType

DESCRIPTION

"This object is only present when [RFC 2545](#) extensions for IPv6 are supported by the implementation. When present, this object shall only have a value of ipv6z or none."

OBJECT bgp4V2NlriLinkLocalNextHopAddr

SYNTAX InetAddress (SIZE(0|20))

DESCRIPTION

"This object is only present when [RFC 2545](#) extensions for IPv6 are supported by the implementation. When present, this object shall only have a size of 20 or 0 when no

[RFC 2545](#) double-nexthop is present."

OBJECT bgp4V2PeerInstance

SYNTAX Unsigned32 (1..4294967295)

DESCRIPTION

"This object represents an abstract index which can utilize the full range of acceptable SNMP index values."

::= { bgp4V2Compliances 4 }

bgp4V2GlobalsGroup OBJECT-GROUP

OBJECTS { bgp4V2DiscontinuityTime }

STATUS current

DESCRIPTION

"A collection of objects providing information on global BGP state."

::= { bgp4V2Groups 1 }

bgp4V2StdMIBTimersGroup OBJECT-GROUP

OBJECTS {

bgp4V2PeerFsmEstablishedTime,
bgp4V2PeerInUpdatesElapsedTime,
bgp4V2PeerConnectRetryInterval,
bgp4V2PeerHoldTimeConfigured,
bgp4V2PeerKeepAliveConfigured,
bgp4V2PeerMinASOrigInterval,
bgp4V2PeerMinRouteAdverInterval,
bgp4V2PeerHoldTime,
bgp4V2PeerKeepAlive

}

STATUS current

DESCRIPTION

"Objects associated with BGP peering timers."

::= { bgp4V2Groups 2 }

bgp4V2StdMIBCountersGroup OBJECT-GROUP

OBJECTS {

bgp4V2PeerInUpdates,
bgp4V2PeerOutUpdates,
bgp4V2PeerInTotalMessages,
bgp4V2PeerOutTotalMessages,
bgp4V2PeerFsmEstablishedTransitions,
bgp4V2PrefixInPrefixes,
bgp4V2PrefixInPrefixesAccepted,
bgp4V2PrefixOutPrefixes

}

STATUS current

DESCRIPTION

"Objects to count discrete events and exchanges on BGP sessions."

::= { bgp4V2Groups 3 }

bgp4V2StdMIBErrorsGroup OBJECT-GROUP

OBJECTS {

bgp4V2PeerLastErrorCodeReceived,
bgp4V2PeerLastErrorSubCodeReceived,
bgp4V2PeerLastErrorReceivedData,
bgp4V2PeerLastErrorReceivedTime,
bgp4V2PeerLastErrorReceivedText,
bgp4V2PeerLastErrorCodeSent,
bgp4V2PeerLastErrorSubCodeSent,
bgp4V2PeerLastErrorSentData,
bgp4V2PeerLastErrorSentTime,
bgp4V2PeerLastErrorSentText

}

STATUS current

DESCRIPTION

"Errors received on BGP peering sessions."

::= { bgp4V2Groups 5 }

bgp4V2StdMIBPeerGroup OBJECT-GROUP

OBJECTS {

bgp4V2PeerState,
bgp4V2PeerAdminStatus,
bgp4V2PeerLocalPort,
bgp4V2PeerLocalAs,
bgp4V2PeerRemotePort,
bgp4V2PeerRemoteAs,
bgp4V2PeerLocalIdentifier,
bgp4V2PeerRemoteIdentifier,
bgp4V2PeerDescription

}

STATUS current

DESCRIPTION

"Core object types on BGP peering sessions."

::= { bgp4V2Groups 6 }

bgp4V2StdMIBNlriGroup OBJECT-GROUP

OBJECTS {

bgp4V2NlriAsPathCalcLength,
bgp4V2NlriAsPathString,
bgp4V2NlriBest,
bgp4V2NlriCalcLocalPref,
bgp4V2NlriPrefixType,
bgp4V2AdjRibsOutRoute,
bgp4V2NlriAggregatorPresent,

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```
    bgp4V2NlriAggregatorAS,
    bgp4V2NlriAggregatorAddr,
    bgp4V2NlriAtomicAggregate,
    bgp4V2NlriLocalPref,
    bgp4V2NlriLocalPrefPresent,
    bgp4V2NlriMed,
    bgp4V2NlriMedPresent,
    bgp4V2NlriNextHopAddr,
    bgp4V2NlriNextHopAddrType,
    bgp4V2NlriLinkLocalNextHopAddrType,
    bgp4V2NlriLinkLocalNextHopAddr,
    bgp4V2NlriOrigin,
    bgp4V2NlriAsPath,
    bgp4V2NlriPathAttrUnknown
}
STATUS current
DESCRIPTION
    "Attributes received on BGP peering sessions."
::= { bgp4V2Groups 7 }
```

```
bgp4V2StdMIBNotificationGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
        bgp4V2EstablishedNotification,
        bgp4V2BackwardTransitionNotification
    }
STATUS current
DESCRIPTION
    "Notifications in this modules are completely optional."
::= { bgp4V2Groups 8 }
```

END

8. 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. These are the tables and objects and their sensitivity/vulnerability:

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- o `bgp4V2PeerLocalAddrType`, `bgp4V2PeerLocalAddr`, `bgp4V2PeerLocalPort`, `bgp4V2PeerRemoteAddrType`, `bgp4V2PeerRemoteAddr`, `bgp4V2PeerRemotePort`, `bgp4V2PeerLocalAddr`, `bgp4V2PeerLocalPort`, `bgp4V2PeerRemoteAddr`, `bgp4V2PeerRemotePort` - 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. Note that other tables which share elements of these objects as indexes may similarly expose sensitive information.
- o `bgp4V2NlriTable`, `bgp4V2AdjRibsOutTable` - A BGP peer's routing information may be sensitive for ISPs as the contents of their routing tables may expose details related to business relationships as implemented in Internet routing.

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.

9. IANA Considerations

IANA is requested to assign this MIB module an OID under `mib-2`.

10. Contributors

This document owes significant thanks over the years to Wayne Tackabury, Susan Hares and the members of the IDR and OPS-NM mailing lists. This document represents several years of negotiating operational needs, Internet operational security considerations and the sheer messiness of representing the BGP protocol in SMIV2.

I owe particular thanks to Susan Hares as a mentor who let me dive head-first into the world of Internet standards work by saying, "We

have this MIB that just needs a little cleanup to advance in the standards process."

11. Acknowledgements

We would like to acknowledge the assistance of all the members of the Inter-Domain Routing Working Group and individuals who contributed to RFCs 1269, 1657 and 4273.

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12. References

12.1. 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.
- [RFC3411] Harrington, D., Presuhn, R., and B. Wijnen, "An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks", STD 62, [RFC 3411](#), December 2002.
- [RFC4271] Rekhter, Y., Li, T., and S. Hares, "A Border Gateway Protocol 4 (BGP-4)", [RFC 4271](#), January 2006.
- [RFC4273] Haas, J. and S. Hares, "Definitions of Managed Objects for BGP-4", [RFC 4273](#), January 2006.
- [RFC2545] Marques, P. and F. Dupont, "Use of BGP-4 Multiprotocol Extensions for IPv6 Inter-Domain Routing", [RFC 2545](#), March 1999.

- [RFC4001] Daniele, M., Haberman, B., Routhier, S., and J. Schoenwaelder, "Textual Conventions for Internet Network Addresses", [RFC 4001](#), February 2005.
- [RFC4760] Bates, T., Chandra, R., Katz, D., and Y. Rekhter, "Multiprotocol Extensions for BGP-4", [RFC 4760](#), January 2007.
- [RFC5065] Traina, P., McPherson, D., and J. Scudder, "Autonomous System Confederations for BGP", [RFC 5065](#), August 2007.

[12.2.](#) Informative References

- [RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", [RFC 3410](#), December 2002.
- [RFC1657] Willis, S., Burruss, J., and J. Chu, "Definitions of Managed Objects for the Fourth Version of the Border Gateway Protocol (BGP-4) using SMIV2", [RFC 1657](#), July 1994.
- [RFC3107] Rekhter, Y. and E. Rosen, "Carrying Label Information in BGP-4", [RFC 3107](#), May 2001.
- [RFC4022] Raghunarayan, R., "Management Information Base for the Transmission Control Protocol (TCP)", [RFC 4022](#), March 2005.
- [RFC4456] Bates, T., Chen, E., and R. Chandra, "BGP Route Reflection: An Alternative to Full Mesh Internal BGP (IBGP)", [RFC 4456](#), April 2006.

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