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Intended status: Standards Track	Z. Ali	
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TOC

BFD Management Information Base
draft-ietf-bfd-mib-07

Status of this Memo

Copyright Notice

Abstract

This draft 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 for modeling Bidirectional Forwarding Detection (BFD) protocol.

Table of Contents

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1. Requirements notation

TOC

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 [RFC2119] (Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," March 1997.).

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2. The Internet-Standard Management Framework

TOC

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of [RFC3410] (Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework," December 2002.).
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, [RFC2578] (McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Structure of Management Information Version 2 (SMIv2)," April 1999.), STD 58, [RFC2579] (McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., "Textual Conventions for SMIv2," April 1999.) and STD 58, [RFC2580] (McCloghrie, K., Perkins, D., and J. Schoenwaelder, "Conformance Statements for SMIv2," April 1999.).

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3. Introduction

TOC

This memo defines an portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it describes managed objects to configure and/or monitor Bi-Directional Forwarding Detection for [BFD] (Katz, D. and D. Ward, "Bidirectional Forwarding Detection," March 2008.), [BFD-1HOP] (Katz, D. and D. Ward, "BFD for IPv4 and IPv6 (Single Hop)," March 2008.) and [BFD-MH] (Katz, D. and D. Ward, "BFD for Multihop Paths," January 2008.), BFD versions 0 and/or 1, on devices supporting this feature.
Comments should be made directly to the BFD mailing list at rtg-bfd@ietf.org.

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4. Terminology

TOC

This document adopts the definitions, acronyms and mechanisms described in [BFD] (Katz, D. and D. Ward, "Bidirectional Forwarding Detection," March 2008.), [BFD-1HOP] (Katz, D. and D. Ward, "BFD for IPv4 and IPv6 (Single Hop)," March 2008.) and [BFD-MH] (Katz, D. and D. Ward, "BFD for Multihop Paths," January 2008.). Unless otherwise stated, the mechanisms described therein will not be re-described here.

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5. Brief Description of MIB Objects

TOC

This section describes objects pertaining to BFD. The MIB objects are derived from [BFD] (Katz, D. and D. Ward, "Bidirectional Forwarding Detection," March 2008.) and [BFD-MH] (Katz, D. and D. Ward, "BFD for Multihop Paths," January 2008.).

5.1. General Variables

TOC

The General Variables are used to identify parameters that are global to the BFD process.

5.2. Session Table (bfdSessionTable)

TOC

The session table is used to identify a BFD session between a pair of nodes.

5.3. Session Performance Table (bfdSessionPerfTable)

TOC

The session performance table is used for collecting BFD performance counts on a per session basis. This table is an AUGMENT to the bfdSessionTable.

5.4. BFD Session Discriminator Mapping Table (bfdSessDiscMapTable)

TOC

The BFD Session Discriminator Mapping Table maps a local discriminator value to associated BFD sessions' BfdSessIndexTC used in the bfdSessionTable.

5.5. BFD Session IP Mapping Table (bfdSessIpMapTable)

TOC

The BFD Session IP Mapping Table maps, given bfdSessInterface, bfdSessAddrType, and bfdSessAddr, to an associated BFD sessions' BfdSessIndexTC used in the bfdSessionTable. This table SHOULD contains those BFD sessions are of IP type.

6. BFD MIB Module Definitions

TOC

This MIB module makes references to the following documents. [RFC2579] (McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed.,

“Textual Conventions for SMIv2,” April 1999.), [RFC2580] (McCloghrie, K., Perkins, D., and J. Schoenwaelder, “Conformance Statements for SMIv2,” April 1999.), [RFC2863] (McCloghrie, K. and F. Kastenholz, “The Interfaces Group MIB,” June 2000.), [RFC4001] (Daniele, M., Haberman, B., Routhier, S., and J. Schoenwaelder, “Textual Conventions for Internet Network Addresses,” February 2005.), and [RFC3413] (Levi, D., Meyer, P., and B. Stewart, “Simple Network Management Protocol (SNMP) Applications,” December 2002.).

```
   BFD-STD-MIB DEFINITIONS ::= BEGIN

   IMPORTS
       MODULE-IDENTITY, OBJECT-TYPE, NOTIFICATION-TYPE,
           mib-2, Integer32, Unsigned32, Counter32, Counter64
           FROM SNMPv2-SMI

       TEXTUAL-CONVENTION, TruthValue, RowStatus,
           StorageType, TimeStamp
           FROM SNMPv2-TC

       MODULE-COMPLIANCE, OBJECT-GROUP, NOTIFICATION-GROUP
           FROM SNMPv2-CONF

       InterfaceIndexOrZero
           FROM IF-MIB

       InetAddress, InetAddressType, InetPortNumber
           FROM INET-ADDRESS-MIB;

   bfdMib MODULE-IDENTITY
       LAST-UPDATED "200904261200Z" -- 26 April 2009 12:00:00 EST
       ORGANIZATION "IETF Bidirectional Forwarding Detection
                     Working Group"
       CONTACT-INFO
           "Thomas D. Nadeau
            BT
            Email:  tom.nadeau@bt.com

            Zafar Ali
            Cisco Systems, Inc.
            Email:  zali@cisco.com

            Nobo Akiya
            Cisco Systems, G.K.
            Email:  nobo@cisco.com"
       DESCRIPTION
           "Bidirectional Forwarding Management Information Base."
       REVISION "200904261200Z" -- 26 April 2009 12:00:00 EST
       DESCRIPTION
           "Initial version. Published as RFC xxxx."
-- RFC Ed.: RFC-editor pls fill in xxxx
       ::= { mib-2 XXX }
-- RFC Ed.: assigned by IANA, see section 7.1 for details

-- Top level components of this MIB module.

   bfdNotifications OBJECT IDENTIFIER ::= { bfdMIB 0 }
```

```
   bfdObjects       OBJECT IDENTIFIER ::= { bfdMIB 1 }

   bfdConformance   OBJECT IDENTIFIER ::= { bfdMIB 2 }

   bfdScalarObjects OBJECT IDENTIFIER ::= { bfdObjects 1 }

-- Textual Conventions

   BfdSessIndexTC ::= TEXTUAL-CONVENTION
   DISPLAY-HINT   "d"
   STATUS         current
   DESCRIPTION
       "An index used to uniquely identify BFD sessions."
   SYNTAX Unsigned32 (1..4294967295)

   BfdInterval ::= TEXTUAL-CONVENTION
   DISPLAY-HINT   "d"
   STATUS         current
   DESCRIPTION
       "The BFD interval delay in microseconds."
   SYNTAX Unsigned32 (0..4294967295)

   BfdMultiplier ::= TEXTUAL-CONVENTION
   DISPLAY-HINT   "d"
   STATUS         current
   DESCRIPTION
       "The BFD failure detection multiplier."
   SYNTAX Unsigned32 (1..255)

   BfdDiag ::= TEXTUAL-CONVENTION
   STATUS         current
   DESCRIPTION
       "A common BFD diagnostic code."
   SYNTAX INTEGER {
       noDiagnostic(0),
       controlDetectionTimeExpired(1),
       echoFunctionFailed(2),
       neighborSignaledSessionDown(3),
       forwardingPlaneReset(4),
       pathDown(5),
       concatenatedPathDown(6),
       administrativelyDown(7),
       reverseConcatenatedPathDown(8)
   }

-- BFD General Variables

-- These parameters apply globally to the Systems'
-- BFD Process.
```

```
   bfdAdminStatus OBJECT-TYPE
       SYNTAX     INTEGER {
           enabled(1),
           disabled(2)
       }
       MAX-ACCESS read-write
       STATUS     current
       DESCRIPTION
           "The global administrative status of BFD in this router.
            The value 'enabled' denotes that the BFD Process is
            active on at least one interface; 'disabled' disables
            it on all interfaces."
       DEFVAL { enabled }
       ::= { bfdScalarObjects 1 }

   bfdSessNotificationsEnable OBJECT-TYPE
       SYNTAX     TruthValue
       MAX-ACCESS read-write
       STATUS     current
       DESCRIPTION
           "If this object is set to true(1), then it enables
            the emission of bfdSessUp and bfdSessDown
            notifications; otherwise these notifications are not
            emitted."
       REFERENCE
           "See also RFC3413 for explanation that
            notifications are under the ultimate control of the
            MIB modules in this document."
       DEFVAL { false }
       ::= { bfdScalarObjects 2 }

-- BFD Session Table
-- The BFD Session Table specifies BFD session specific
-- information.

   bfdSessTable OBJECT-TYPE
       SYNTAX     SEQUENCE OF BfdSessEntry
       MAX-ACCESS not-accessible
       STATUS     current
       DESCRIPTION
           "The BFD Session Table describes the BFD sessions."
       REFERENCE
           "BFD Version 0 (draft-katz-ward-bfd-02.txt) and
            BFD Version 1 (draft-ietf-bfd-base-08.txt)"
       ::= { bfdObjects 2 }

   bfdSessEntry OBJECT-TYPE
       SYNTAX     BfdSessEntry
       MAX-ACCESS not-accessible
```

```
    STATUS     current
    DESCRIPTION
        "The BFD Session Entry describes BFD session."
    INDEX { bfdSessIndex }
    ::= { bfdSessTable 1 }

BfdSessEntry ::= SEQUENCE {
    bfdSessIndex                    BfdSessIndexTC,
    bfdSessVersionNumber            Unsigned32,
    bfdSessType                     INTEGER,
    bfdSessMultiHopUniLinkMode      INTEGER,
    bfdSessDiscriminator            Unsigned32,
    bfdSessRemoteDiscr              Unsigned32,
    bfdSessDestinationUdpPort       InetPortNumber,
    bfdSessSourceUdpPort            InetPortNumber,
    bfdSessEchoSourceUdpPort        InetPortNumber,
    bfdSessAdminStatus              INTEGER,
    bfdSessState                    INTEGER,
    bfdSessRemoteHeardFlag          TruthValue,
    bfdSessDiag                     BfdDiag,
    bfdSessOperMode                 INTEGER,
    bfdSessDemandModeDesiredFlag    TruthValue,
    bfdSessControlPlaneIndepFlag    TruthValue,
    bfdSessInterface                InterfaceIndexOrZero,
    bfdSessAddrType                 InetAddressType,
    bfdSessAddr                     InetAddress,
    bfdSessGTSM                     TruthValue,
    bfdSessGTSMTTL                  Unsigned32,
    bfdSessDesiredMinTxInterval     BfdInterval,
    bfdSessReqMinRxInterval         BfdInterval,
    bfdSessReqMinEchoRxInterval     BfdInterval,
    bfdSessDetectMult               BfdMultiplier,
    bfdSessNegotiatedInterval       BfdInterval,
    bfdSessNegotiatedEchoInterval   BfdInterval,
    bfdSessNegotiatedDetectMult     BfdMultiplier,
    bfdSessAuthPresFlag             TruthValue,
    bfdSessAuthenticationType       INTEGER,
    bfdSessAuthenticationKeyID      Integer32,
    bfdSessAuthenticationKey        OCTET STRING,
    bfdSessStorType                 StorageType,
    bfdSessRowStatus                RowStatus
}

bfdSessIndex OBJECT-TYPE
    SYNTAX     BfdSessIndexTC
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This object contains an index used to represent a
```

```
         unique BFD session on this device."
    ::= { bfdSessEntry 1 }

bfdSessVersionNumber OBJECT-TYPE
    SYNTAX     Unsigned32 (0..7)
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "The version number of the BFD protocol that this session
         is running in. Write access is available for this object
         to provide ability to set desired version for this
         BFD session."
    REFERENCE
        "BFD Version 0 (draft-katz-ward-bfd-02.txt) and
         BFD Version 1 (draft-ietf-bfd-base-08.txt)"
    DEFVAL { 1 }
    ::= { bfdSessEntry 2 }

bfdSessType OBJECT-TYPE
    SYNTAX     INTEGER {
        singleHop(1),
        multiHopTotallyArbitraryPaths(2),
        multiHopOutOfBandSignaling(3),
        multiHopUnidirectionalLinks(4)
    }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies the type of this BFD session."
    REFERENCE
        "draft-ietf-bfd-v4v6-1hop-08 and
         draft-ietf-bfd-multihop-06"
    ::= { bfdSessEntry 3 }

bfdSessMultiHopUniLinkMode OBJECT-TYPE
    SYNTAX     INTEGER {
        none(1),
        active(2),
        passive(3)
    }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "For bfdSessType of multiHopUnidirectionalLinks(4), this
         object specifies whether this BFD session is running in
         active(2) mode or passive(3) mode. For all other BFD
         bfdSessType BFD sessions, none(1) MUST be specified."
    REFERENCE
        "draft-ietf-bfd-multihop-06, Section 3.3"
```

```
    ::= { bfdSessEntry 4 }

bfdSessDiscriminator OBJECT-TYPE
    SYNTAX     Unsigned32 (1..4294967295)
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies the local discriminator for this BFD
         session, used to uniquely identify it."
    ::= { bfdSessEntry 5 }

bfdSessRemoteDiscr OBJECT-TYPE
    SYNTAX     Unsigned32 (0 | 1..4294967295)
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies the session discriminator chosen
         by the remote system for this BFD session.  The value may
         be zero(0) if the remote discriminator is not yet known
         or if the session is in the down or adminDown(1) state."
    REFERENCE
        "draft-ietf-bfd-base-08, Section 6.8.6."
    ::= { bfdSessEntry 6 }

bfdSessDestinationUdpPort OBJECT-TYPE
    SYNTAX     InetPortNumber
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies the destination UDP port used for
         this BFD session. The value maybe zero(0) if the session
         is in adminDown(1) state."
    REFERENCE
        "Port 3784 (draft-ietf-bfd-v4v6-1hop-08),
         Port 3785 (draft-ietf-bfd-v4v6-1hop-08), and
         Port 4784 (draft-ietf-bfd-multihop-06)"
    DEFVAL { 0 }
    ::= { bfdSessEntry 7 }

bfdSessSourceUdpPort OBJECT-TYPE
    SYNTAX     InetPortNumber
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies the source UDP port of BFD control
         packets for this BFD session. The value maybe zero(0) if
         the session is in adminDown(1) state."
    REFERENCE
        "draft-ietf-bfd-v4v6-1hop-08 and
```

```
         draft-ietf-bfd-multihop-06"
    DEFVAL { 0 }
    ::= { bfdSessEntry 8 }

bfdSessEchoSourceUdpPort OBJECT-TYPE
    SYNTAX     InetPortNumber
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies the source UDP port of BFD echo
         packets for this BFD session. The value maybe zero(0) if
         the session is not running in the echo mode, or the
         session is in adminDown(1) state."
    REFERENCE
        "draft-ietf-bfd-v4v6-1hop-08 and
         draft-ietf-bfd-multihop-06"
    DEFVAL { 0 }
    ::= { bfdSessEntry 9 }

bfdSessAdminStatus OBJECT-TYPE
    SYNTAX     INTEGER {
                        stop(1),
                        start(2)
               }
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
            "A transition from 'stop' to 'start' will start
             the BFD state machine for the session. The state
             machine will have an initial state of down.
             A transition from 'start' to 'stop' will cause
             the BFD sesssion to be brought down to
             adminDown(1). Care should be used in providing
             write access to this object without adequate
             authentication."
    DEFVAL { 2 }
    ::= { bfdSessEntry 10 }

bfdSessState OBJECT-TYPE
    SYNTAX     INTEGER {
        adminDown(1),
        down(2),
        init(3),
        up(4),
        failing(5)
    }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
```

```
        "The perceived state of the BFD session.
         BFD State failing(5) is only applicable if this BFD
         session is running version 0.
         Upon creation of a new BFD session via this MIB, the
         suggested initial state is down(2)."
    DEFVAL { 2 }
    ::= { bfdSessEntry 11 }

bfdSessRemoteHeardFlag OBJECT-TYPE
    SYNTAX     TruthValue
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies status of BFD packet reception from
         the remote system. Specifically, it is set to true(1) if
         the local system is actively receiving BFD packets from the
         remote system, and is set to false(2) if the local system
         has not received BFD packets recently (within the detection
         time) or if the local system is attempting to tear down
         the BFD session."
    REFERENCE
        "BFD Version 0 (draft-katz-ward-bfd-02.txt) and
         BFD Version 1 (draft-ietf-bfd-base-08.txt)"
    DEFVAL { false }
    ::= { bfdSessEntry 12 }

bfdSessDiag OBJECT-TYPE
    SYNTAX     BfdDiag
    MAX-ACCESS accessible-for-notify
    STATUS     current
    DESCRIPTION
        "A diagnostic code specifying the local system's reason
         for the last transition of the session from up(4)
         to some other state."
    ::= { bfdSessEntry 13 }

bfdSessOperMode OBJECT-TYPE
    SYNTAX     INTEGER {
        asyncModeWEchoFun(1),
        asynchModeWOEchoFun(2),
        demandModeWEchoFunction(3),
        demandModeWOEchoFunction(4)
    }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies current operating mode that BFD
         session is operating in."
    ::= { bfdSessEntry 14 }
```

```
bfdSessDemandModeDesiredFlag OBJECT-TYPE
    SYNTAX     TruthValue
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object indicates that the local system's
         desire to use Demand mode. Specifically, it is set
         to true(1) if the local system wishes to use
         Demand mode or false(2) if not"
    DEFVAL { false }
    ::= { bfdSessEntry 15 }

bfdSessControlPlaneIndepFlag OBJECT-TYPE
    SYNTAX     TruthValue
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object indicates that the local system's
         ability to continue to function through a disruption of
         the control plane. Specifically, it is set
         to true(1) if the local system BFD implementation is
         independent of the control plane. Otherwise, the
         value is set to false(2)"
    DEFVAL { false }
    ::= { bfdSessEntry 16 }

bfdSessInterface OBJECT-TYPE
    SYNTAX     InterfaceIndexOrZero
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object contains an interface index used to indicate
         the interface which this BFD session is running on. This
         value can be zero if there is no interface associated
         with this BFD session."
    ::= { bfdSessEntry 17 }

bfdSessAddrType OBJECT-TYPE
    SYNTAX     InetAddressType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies IP address type of the neighboring IP
         address which is being monitored with this BFD session.

         Only values unknown(0), ipv4(1), ipv6(2), or ipv6z(4)
         have to be supported.
```

```
          A value of unknown(0) is allowed only when
          the outgoing interface is of type point-to-point, or
          when the BFD session is not associated with a specific
          interface.

          If any other unsupported values are attempted in a set
          operation, the agent MUST return an inconsistentValue
          error."
  ::= { bfdSessEntry 18 }

bfdSessAddr OBJECT-TYPE
    SYNTAX     InetAddress
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies the neighboring IP address which is
         being monitored with this BFD session.
         It can also be used to enabled BFD on a specific
         interface. The value is set to zero when BFD session is not
         associated with a specific interface."
    ::= { bfdSessEntry 19 }

bfdSessGTSM OBJECT-TYPE
    SYNTAX  TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
       "Setting the value of this object to true(1) will enable GTSM
        protection of the BFD session.  GTSM MUST be enabled on a
        singleHop(1) session if no authentication is in use."
    REFERENCE
       "RFC 5082 - The Generalized TTL Security Mechanism (GTSM).
        draft-ietf-bfd-v4v6-1hop-08, Sec. 5"
    DEFVAL { false }
    ::= { bfdSessEntry 20 }

bfdSessGTSMTTL OBJECT-TYPE
    SYNTAX Unsigned32 (0..255)
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "This object is valid only when bfdSessGTSM protection is
         enabled on the system. This object specifies the minimum
         allowed TTL for received BFD control packets. For
         singleHop(1) session, if GTSM protection is enabled,
         this object SHOULD be set to maximum TTL allowed for
         single hop."
    REFERENCE
       "RFC 5082 - The Generalized TTL Security Mechanism (GTSM).
```

```
        draft-ietf-bfd-v4v6-1hop-08, Sec. 5"
    DEFVAL { 0 }
    ::= { bfdSessEntry 21 }

bfdSessDesiredMinTxInterval OBJECT-TYPE
    SYNTAX     BfdInterval
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies the minimum interval, in
         microseconds, that the local system would like to use when
         transmitting BFD Control packets."
    ::= { bfdSessEntry 22 }

bfdSessReqMinRxInterval OBJECT-TYPE
    SYNTAX     BfdInterval
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies the minimum interval, in
         microseconds, between received  BFD Control packets the
         local system is capable of supporting."
    ::= { bfdSessEntry 23 }

bfdSessReqMinEchoRxInterval OBJECT-TYPE
    SYNTAX     BfdInterval
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies the minimum interval, in
         microseconds, between received BFD Echo packets that this
         system is capable of supporting."
    ::= { bfdSessEntry 24 }

bfdSessDetectMult OBJECT-TYPE
    SYNTAX     BfdMultiplier
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This object specifies the Detect time multiplier."
    ::= { bfdSessEntry 25 }

bfdSessNegotiatedInterval OBJECT-TYPE
    SYNTAX     BfdInterval
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies the negotiated interval, in
         microseconds, that the local system is transmitting
```

```
          BFD Control packets."
    ::= { bfdSessEntry 26 }

bfdSessNegotiatedEchoInterval OBJECT-TYPE
    SYNTAX     BfdInterval
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies the negotiated interval, in
         microseconds, that the local system is transmitting
         BFD echo packets. Value is expected to be zero if
         the sessions is not running in echo mode."
    ::= { bfdSessEntry 27 }

bfdSessNegotiatedDetectMult OBJECT-TYPE
    SYNTAX     BfdMultiplier
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object specifies the Detect time multiplier."
    ::= { bfdSessEntry 28 }

bfdSessAuthPresFlag OBJECT-TYPE
    SYNTAX     TruthValue
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This object indicates that the local system's
         desire to use Authentication. Specifically, it is set
         to true(1) if the local system wishes the session
         to be authenticated or false(2) if not."
    REFERENCE
        "draft-ietf-bfd-base-08, Sections 4.2 - 4.4"
    DEFVAL { false }
    ::= { bfdSessEntry 29 }

bfdSessAuthenticationType OBJECT-TYPE
    SYNTAX     INTEGER {
        reserved(0),
        simplePassword(1),
        keyedMD5(2),
        meticulousKeyedMD5(3),
        keyedSHA1(4),
        meticulousKeyedSHA1(5)
    }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "The Authentication Type used for this BFD session.
```

```
            This field is valid only when the Authentication
            Present bit is set."
        REFERENCE
            "draft-ietf-bfd-base-08, Sections 4.2 - 4.4"
        ::= { bfdSessEntry 30 }

    bfdSessAuthenticationKeyID OBJECT-TYPE
        SYNTAX     Integer32 (-1 | 0..255)
        MAX-ACCESS read-only
        STATUS     current
        DESCRIPTION
            "The authentication key ID in use for this session.  This
            object permits multiple keys to be active simultaneously.

            When bfdSessAuthPresFlag is false(2), then the value
            of this object MUST be -1.  The value -1 indicates that
            no Authentication Key ID will be present in the optional
            BFD Authentication Section."
        REFERENCE
            "draft-ietf-bfd-base-08, Sections 4.2 - 4.4"
        DEFVAL { -1 }
        ::= { bfdSessEntry 31 }

    bfdSessAuthenticationKey OBJECT-TYPE
        SYNTAX     OCTET STRING (SIZE (0..252))
        MAX-ACCESS read-only
        STATUS     current
        DESCRIPTION
            "The authentication key.  When the
            bfdSessAuthenticationType is simplePassword(1), the value
            of this object is the password present in the BFD packets.

            When the bfdSessAuthentication type is one of the keyed
            authentication types, this value is used in the
            computation of the key present in the BFD authentication
            packet."
        REFERENCE
            "draft-ietf-bfd-base-08, Sections 4.2 - 4.4"
        ::= { bfdSessEntry 32 }

    bfdSessStorType OBJECT-TYPE
        SYNTAX     StorageType
        MAX-ACCESS read-create
        STATUS     current
        DESCRIPTION
            "This variable indicates the storage type for this
            object. Conceptual rows having the value
            'permanent' need not allow write-access to any
            columnar objects in the row."
```

```
        ::= { bfdSessEntry 33 }

    bfdSessRowStatus OBJECT-TYPE
        SYNTAX     RowStatus
        MAX-ACCESS read-create
        STATUS     current
        DESCRIPTION
            "This variable is used to create, modify, and/or
             delete a row in this table. When a row in this
             table has a row in the active(1) state, no
             objects in this row can be modified except the
             bfdSessRowStatus and bfdSessStorageType."
        ::= { bfdSessEntry 34 }

-- BFD Session Performance Table

    bfdSessPerfTable OBJECT-TYPE
        SYNTAX     SEQUENCE OF BfdSessPerfEntry
        MAX-ACCESS not-accessible
        STATUS     current
        DESCRIPTION
            "This table specifies BFD Session performance counters."
        ::= { bfdObjects 3 }

    bfdSessPerfEntry OBJECT-TYPE
        SYNTAX     BfdSessPerfEntry
        MAX-ACCESS not-accessible
        STATUS     current
        DESCRIPTION
            "An entry in this table is created by a BFD-enabled node for
             every BFD Session. bfdCounterDiscontinuityTime is used to
             indicate potential discontinuity for all counter objects
             in this table."
        AUGMENTS    { bfdSessEntry }
        ::= { bfdSessPerfTable 1 }

    BfdSessPerfEntry ::= SEQUENCE {
       bfdSessPerfPktIn              Counter32,
       bfdSessPerfPktOut             Counter32,
       bfdSessUpTime                 TimeStamp,
       bfdSessPerfLastSessDownTime   TimeStamp,
       bfdSessPerfLastCommLostDiag   BfdDiag,
       bfdSessPerfSessUpCount        Counter32,
       bfdSessPerfDiscTime           TimeStamp,

       -- High Capacity Counters
       bfdSessPerfPktInHC            Counter64,
       bfdSessPerfPktOutHC           Counter64
    }
```

```
-- Ed Note: should we add per-diag code counts here,

   bfdSessPerfPktIn OBJECT-TYPE
       SYNTAX     Counter32
       MAX-ACCESS read-only
       STATUS     current
       DESCRIPTION
           "The total number of BFD messages received for this BFD
            session."
       ::= { bfdSessPerfEntry 1 }

   bfdSessPerfPktOut OBJECT-TYPE
       SYNTAX     Counter32
       MAX-ACCESS read-only
       STATUS     current
       DESCRIPTION
           "The total number of BFD messages sent for this BFD
            session."
       ::= { bfdSessPerfEntry 2 }

   bfdSessUpTime OBJECT-TYPE
       SYNTAX     TimeStamp
       MAX-ACCESS read-only
       STATUS     current
       DESCRIPTION
           "The value of sysUpTime on the most recent occasion at which
            the session came up. If no such up event exists this object
            contains a zero value."
       ::= { bfdSessPerfEntry 3 }

   bfdSessPerfLastSessDownTime OBJECT-TYPE
       SYNTAX     TimeStamp
       MAX-ACCESS read-only
       STATUS     current
       DESCRIPTION
           "The value of sysUpTime on the most recent occasion at
            which the last time communication was lost with the
            neighbor. If no such down event exist this object
            contains a zero value."
       ::= { bfdSessPerfEntry 4 }

   bfdSessPerfLastCommLostDiag OBJECT-TYPE
       SYNTAX     BfdDiag
       MAX-ACCESS read-only
       STATUS     current
       DESCRIPTION
           "The BFD diag code for the last time communication was lost
            with the neighbor. If no such down event exists this object
```

```
          contains a zero value."
    ::= { bfdSessPerfEntry 5 }

bfdSessPerfSessUpCount OBJECT-TYPE
    SYNTAX     Counter32
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "The number of times this session has gone into the Up
         state since the system last rebooted."
    ::= { bfdSessPerfEntry 6 }

bfdSessPerfDiscTime OBJECT-TYPE
    SYNTAX     TimeStamp
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
      "The value of sysUpTime on the most recent occasion at
       which any one or more of the session counters suffered
       a discontinuity.
       The relevant counters are the specific instances associated
       with this BFD session of any Counter32 object contained in
       the BfdSessPerfTable. If no such discontinuities have
       occurred since the last re-initialization of the local
       management subsystem, then this object contains a zero
       value."
    ::= { bfdSessPerfEntry 7 }

bfdSessPerfPktInHC OBJECT-TYPE
    SYNTAX     Counter64
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This value represents the total number of BFD messages
         received for this BFD session. It MUST be equal to the
         least significant 32 bits of bfdSessPerfPktIn
         if bfdSessPerfPktInHC is supported according to
         the rules spelled out in RFC2863."
    ::= { bfdSessPerfEntry 8 }

bfdSessPerfPktOutHC OBJECT-TYPE
    SYNTAX     Counter64
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This value represents the total number of
         total number of BFD messages transmitted for this
         BFD session. It MUST be equal to the
         least significant 32 bits of bfdSessPerfPktIn
```

```
            if bfdSessPerfPktOutHC is supported according to
            the rules spelled out in RFC2863."
        ::= { bfdSessPerfEntry 9 }

-- BFD Session Discriminator Mapping Table

   bfdSessDiscMapTable OBJECT-TYPE
       SYNTAX     SEQUENCE OF BfdSessDiscMapEntry
       MAX-ACCESS not-accessible
       STATUS     current
       DESCRIPTION
           "The BFD Session Discriminator Mapping Table maps a
            local discriminator value to associated BFD sessions'
            BfdSessIndexTC used in the bfdSessionTable."
       ::= { bfdObjects 4 }

   bfdSessDiscMapEntry OBJECT-TYPE
       SYNTAX     BfdSessDiscMapEntry
       MAX-ACCESS not-accessible
       STATUS     current
       DESCRIPTION
           "The BFD Session Discriminator Map Entry describes
            BFD session that is mapped to this BfdSessIndexTC."
       INDEX { bfdSessDiscriminator }
       ::= { bfdSessDiscMapTable 1 }

   BfdSessDiscMapEntry ::= SEQUENCE {
       bfdSessDiscMapIndex            BfdSessIndexTC
   }

   bfdSessDiscMapIndex OBJECT-TYPE
       SYNTAX     BfdSessIndexTC
       MAX-ACCESS read-only
       STATUS     current
       DESCRIPTION
           "This object specifies the BfdIndex referred to by
            the indexes of this row. In essence, a mapping is
            provided between these indexes and the BfdSessTable."
       ::= { bfdSessDiscMapEntry 1 }

-- BFD Session IP Mapping Table

   bfdSessIpMapTable OBJECT-TYPE
       SYNTAX     SEQUENCE OF BfdSessIpMapEntry
       MAX-ACCESS not-accessible
       STATUS     current
       DESCRIPTION
           "The BFD Session IP Mapping Table maps given
            bfdSessInterface, bfdSessAddrType, and bfdSessAddr
```

```
            to an associated BFD sessions' BfdSessIndexTC used in
            the bfdSessionTable. This table SHOULD contains those
            BFD sessions of singleHop(1) type."
        ::= { bfdObjects 5 }

    bfdSessIpMapEntry OBJECT-TYPE
        SYNTAX     BfdSessIpMapEntry
        MAX-ACCESS not-accessible
        STATUS     current
        DESCRIPTION
           "The BFD Session IP Map Entry describes
            BFD session that is mapped to this BfdSessIndexTC."
        INDEX {
            bfdSessInterface,
            bfdSessAddrType,
            bfdSessAddr
        }
        ::= { bfdSessIpMapTable 1 }

    BfdSessIpMapEntry ::= SEQUENCE {
        bfdSessIpMapIndex            BfdSessIndexTC
    }

    bfdSessIpMapIndex OBJECT-TYPE
        SYNTAX     BfdSessIndexTC
        MAX-ACCESS read-only
        STATUS     current
        DESCRIPTION
            "This object specifies the BfdIndex referred to by
             the indexes of this row. In essence, a mapping is
             provided between these indexes and the BfdSessTable."
        ::= { bfdSessIpMapEntry 1 }

-- Notification Configuration

    bfdSessUp NOTIFICATION-TYPE
        OBJECTS {
            bfdSessDiag, -- low range value
            bfdSessDiag  -- high range value
        }
        STATUS     current
        DESCRIPTION
            "This notification is generated when the
             bfdSessState object for one or more contiguous
             entries in bfdSessTable are about to enter the up(4)
             state from some other state. The included values of
             bfdSessDiag MUST both be set equal to this
             new state (i.e: up(4)).  The two instances of
             bfdSessDiag in this notification indicate the range
```

```
                of indexes that are affected.  Note that all the indexes
                of the two ends of the range can be derived from the
                instance identifiers of these two objects.  For the
                cases where a contiguous range of sessions
                have transitioned into the up(4) state at roughly
                the same time, the device SHOULD issue a single
                notification for each range of contiguous indexes in
                an effort to minimize the emission of a large number
                of notifications.  If a notification has to be
                issued for just a single bfdSessEntry, then
                the instance identifier (and values) of the two
                bfdSessDiag objects MUST be the identical."
            ::= { bfdNotifications 1 }

        bfdSessDown NOTIFICATION-TYPE
            OBJECTS {
                bfdSessDiag, -- low range value
                bfdSessDiag  -- high range value
            }
            STATUS     current
            DESCRIPTION
                "This notification is generated when the
                 bfdSessState object for one or more contiguous
                 entries in bfdSessTable are about to enter the down(2)
                 or adminDown(1) states from some other state. The included
                 values of bfdSessDiag MUST both be set equal to this new
                 state (i.e: down(2) or adminDown(1)).  The two instances
                 of bfdSessDiag in this notification indicate the range
                 of indexes that are affected.  Note that all the indexes
                 of the two ends of the range can be derived from the
                 instance identifiers of these two objects.  For
                 cases where a contiguous range of sessions
                 have transitioned into the down(2) or adminDown(1) states
                 at roughly the same time, the device SHOULD issue a single
                 notification for each range of contiguous indexes in
                 an effort to minimize the emission of a large number
                 of notifications.  If a notification has to be
                 issued for just a single bfdSessEntry, then
                 the instance identifier (and values) of the two
                 bfdSessDiag objects MUST be the identical."
            ::= { bfdNotifications 2 }

    -- Ed Note: We need to add notification for changes
    -- when the two ends automatically negotiate to a new detection time
    -- value or when detection multiplier changes.
    -- Similarly, changes in the operating mode (bfdSessOperMode)
    -- also need to be notified.

    -- Module compliance.
```

```
   bfdGroups
       OBJECT IDENTIFIER ::= { bfdConformance 1 }

   bfdCompliances
       OBJECT IDENTIFIER ::= { bfdConformance 2 }

-- Compliance requirement for fully compliant implementations.

   bfdModuleFullCompliance MODULE-COMPLIANCE
       STATUS     current
       DESCRIPTION "Compliance statement for agents that provide full
                    support for BFD-MIB. Such devices can
                    then be monitored and also be configured using
                    this MIB module."
       MODULE -- This module.
       MANDATORY-GROUPS {
           bfdSessionGroup,
           bfdSessionReadOnlyGroup,
           bfdSessionPerfGroup,
           bfdSessionPerfHCGroup,
           bfdNotificationGroup
       }

       GROUP        bfdSessionPerfHCGroup
       DESCRIPTION "This group is mandatory for those bfdPerfTable
                    entries for which any of the objects
                    bfdSessPerfPktInHC or bfdSessPerfPktOutHC
                    wraps around too quickly
                    based on the criteria specified in RFC 2863 for
                    high-capacity counters."

       GROUP        bfdNotificationGroup
       DESCRIPTION "This group is only mandatory for those
                    implementations which can efficiently implement
                    the notifications contained in this group."

       OBJECT       bfdSessAddrType
       SYNTAX       InetAddressType {
                        unknown(0),
                        ipv4(1),
                        ipv6(2),
                        ipv6z(4)
                    }
       DESCRIPTION "Only unknown(0), ipv4(1), ipv6(2) and ipv6z(4)
                    support are required."

       OBJECT       bfdSessAddr
       SYNTAX       InetAddress (SIZE (0|4|16|20))
       DESCRIPTION "An implementation is only required to support
```

```
                    unknown(0), ipv4(1), ipv6(2) and ipv6z(4) sizes."

        ::= { bfdCompliances 1 }

-- Units of conformance.

    bfdSessionGroup OBJECT-GROUP
        OBJECTS {
            bfdSessNotificationsEnable,
            bfdAdminStatus,
            bfdSessVersionNumber,
            bfdSessSourceUdpPort,
            bfdSessEchoSourceUdpPort,
            bfdSessAdminStatus,
            bfdSessDiag,
            bfdSessDemandModeDesiredFlag,
            bfdSessInterface,
            bfdSessAddrType,
            bfdSessAddr,
            bfdSessGTSM,
            bfdSessGTSMTTL,
            bfdSessDesiredMinTxInterval,
            bfdSessReqMinRxInterval,
            bfdSessReqMinEchoRxInterval,
            bfdSessDetectMult,
            bfdSessStorType,
            bfdSessRowStatus
        }
        STATUS     current
        DESCRIPTION
            "Collection of objects needed for BFD sessions."
        ::= { bfdGroups 1 }

    bfdSessionReadOnlyGroup OBJECT-GROUP
        OBJECTS {
            bfdSessType,
            bfdSessMultiHopUniLinkMode,
            bfdSessDiscriminator,
            bfdSessRemoteDiscr,
            bfdSessDestinationUdpPort,
            bfdSessState,
            bfdSessRemoteHeardFlag,
            bfdSessOperMode,
            bfdSessControlPlaneIndepFlag,
            bfdSessNegotiatedInterval,
            bfdSessNegotiatedEchoInterval,
            bfdSessNegotiatedDetectMult,
            bfdSessAuthPresFlag,
            bfdSessAuthenticationType,
```

```
        bfdSessAuthenticationKeyID,
        bfdSessAuthenticationKey,
        bfdSessDiscMapIndex,
        bfdSessIpMapIndex
    }
    STATUS     current
    DESCRIPTION
        "Collection of read-only objects needed for BFD sessions."
    ::= { bfdGroups 2 }

bfdSessionPerfGroup OBJECT-GROUP
    OBJECTS {
        bfdSessPerfPktIn,
        bfdSessPerfPktOut,
        bfdSessUpTime,
        bfdSessPerfLastSessDownTime,
        bfdSessPerfLastCommLostDiag,
        bfdSessPerfSessUpCount,
        bfdSessPerfDiscTime
    }
    STATUS     current
    DESCRIPTION
        "Collection of objects needed to monitor the
         performance of BFD sessions."
    ::= { bfdGroups 3 }

bfdSessionPerfHCGroup OBJECT-GROUP
    OBJECTS {
        bfdSessPerfPktInHC,
        bfdSessPerfPktOutHC
    }
    STATUS     current
    DESCRIPTION
        "Collection of objects needed to monitor the
         performance of BFD sessions for which the
         values of bfdSessPerfPktIn, bfdSessPerfPktOut
         wrap around too quickly."
    ::= { bfdGroups 4 }

bfdNotificationGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
        bfdSessUp,
        bfdSessDown
    }
    STATUS     current
    DESCRIPTION
        "Set of notifications implemented in this
         module."
    ::= { bfdGroups 5 }
```

```
END
```

---

7. Security Considerations

TOC

As BFD may be tied into the stability of the network infrastructure (such as routing protocols), the effects of an attack on a BFD session may be very serious. This ultimately has denial-of-service effects, as links may be declared to be down (or falsely declared to be up.) 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 a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These are the tables and objects and their sensitivity/vulnerability:

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

- bfdSessDesiredMinTxInterval, bfdSessReqMinRxInterval, bfdSessReqMinEchoRxInterval, bfdSessDetectMult - 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.

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

- The bfdSessTable may be used to directly configure BFD sessions. The bfdSessMapTable can be used indirectly in the same way. Unauthorized access to objects in this table could result in disruption of traffic on the network. This is especially true if an unauthorized user configures enough tables to invoke a denial of service attack on the device where they are configured, or on a remote device where the sessions terminate.

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:

*The bfdSessPerfTable both allows access to the performance characteristics of BFD sessions. Network administrators not wishing to show this information should consider this table sensitive.

The bfdSessAuthenticationType, bfdSessAuthenticationKeyID, and bfdSessAuthenticationKey objects hold security methods and associated security keys of BFD sessions. These objects SHOULD be considered highly sensitive objects. In order for these sensitive information from being improperly accessed, implementors MAY wish to disallow read access to these objects.
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 these MIB modules.
It is RECOMMENDED that implementers consider the security features as provided by the SNMPv3 framework "see [RFC3410] (Case, J., Mundy, R., Partain, D., and B. Stewart, “Introduction and Applicability Statements for Internet-Standard Management Framework,” December 2002.), 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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8. IANA Considerations

TOC

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

Descriptor	OBJECT IDENTIFIER value
bfdMib	{ mib-2 XXX }

[Editor's Note (to be removed prior to publication): the IANA is requested to assign a value for "XXX" under the 'mib-2' subtree and to record the assignment in the SMI Numbers registry. When the assignment has been made, the RFC Editor is asked to replace "XXX" (here and in the MIB module) with the assigned value and to remove this note.]
This document also requests IANA to manage the registry for the BfdDiag object.

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9. References

TOC

9.1. Normative References

TOC

[BFD]	Katz, D. and D. Ward, “Bidirectional Forwarding Detection,” ID Document: draft-ietf-bfd-base-08.txt, March 2008.
[BFD-1HOP]	Katz, D. and D. Ward, “BFD for IPv4 and IPv6 (Single Hop),” ID Document: draft-ietf-bfd-v4v6-1hop-08.txt, March 2008.
[BFD-MH]	Katz, D. and D. Ward, “BFD for Multihop Paths,” ID Document: draft-ietf-bfd-multihop-06.txt, January 2008.
[RFC2578]	McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., “Structure of Management Information Version 2 (SMIv2),” STD 58, RFC 2578, April 1999 (TXT).
[RFC2579]	McCloghrie, K., Ed., Perkins, D., Ed., and J. Schoenwaelder, Ed., “Textual Conventions for SMIv2,” STD 58, RFC 2579, April 1999 (TXT).
[RFC2580]	McCloghrie, K., Perkins, D., and J. Schoenwaelder, “Conformance Statements for SMIv2,” STD 58, RFC 2580, April 1999 (TXT).

9.2. Informative References

TOC

[RFC2119]	Bradner, S., “Key words for use in RFCs to Indicate Requirement Levels,” BCP 14, RFC 2119, March 1997 (TXT, HTML, XML).

[RFC2434]	Narten, T. and H. Alvestrand, “Guidelines for Writing an IANA Considerations Section in RFCs,” BCP 26, RFC 2434, October 1998 (TXT, HTML, XML).
[RFC2863]	McCloghrie, K. and F. Kastenholz, “The Interfaces Group MIB,” RFC 2863, June 2000 (TXT).
[RFC3410]	Case, J., Mundy, R., Partain, D., and B. Stewart, “Introduction and Applicability Statements for Internet-Standard Management Framework,” RFC 3410, December 2002 (TXT).
[RFC3413]	Levi, D., Meyer, P., and B. Stewart, “Simple Network Management Protocol (SNMP) Applications,” STD 62, RFC 3413, December 2002 (TXT).
[RFC4001]	Daniele, M., Haberman, B., Routhier, S., and J. Schoenwaelder, “Textual Conventions for Internet Network Addresses,” RFC 4001, February 2005 (TXT).

Appendix A. Acknowledgments

TOC

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