                        Definitions of Managed Objects
                              for Bridges

Status of this Memo

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

Abstract

   This memo defines a portion of the Management Information Base (MIB)
   for use with network management protocols in TCP/IP based internets.
   In particular it defines objects for managing MAC bridges based on
   the IEEE 802.1D-1990 standard between Local Area Network (LAN)
   segments. Provisions are made for support of transparent bridging.
   Provisions are also made so that these objects apply to bridges
   connected by subnetworks other than LAN segments.

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1. The Network Management Framework

   The Internet-standard Network Management Framework consists of three
   components. They are:

      STD16/RFC 1155 which defines the SMI, the mechanisms used for
      describing and naming objects for the purpose of management.
      STD16/RFC 1212 defines a more concise description mechanism, which
      is wholly consistent with the SMI.

      RFC 1156 which defines MIB-I, the core set of managed objects for
      the Internet suite of protocols. STD17/RFC 1213, defines MIB-II,
      an evolution of MIB-I based on implementation experience and new
      operational requirements.

      STD15/RFC 1157 which defines the SNMP, the protocol used for
      network access to managed objects.

   The Framework permits new objects to be defined for the purpose of
   experimentation and evaluation.

2. Objects

   Managed objects are accessed via a virtual information store, termed
   the Management Information Base or MIB. Objects in the MIB are
   defined using the subset of Abstract Syntax Notation One (ASN.1) [7]
   defined in the SMI. In particular, each object is named by an OBJECT
   IDENTIFIER, an administratively assigned name, which specifies an
   object type. The object type together with an object instance serves
   to uniquely identify a specific instantiation of the object. For
   human convenience, we often use a textual string, termed the
   descriptor, to also refer to the object type.

2.1. Format of Definitions

   Section 5 contains the specification of all object types contained in
   this MIB module. The object types are defined using the conventions
   defined in the SMI, as amended by the extensions specified in [9,10].

3. Overview

   A common device present in many networks is the Bridge. This device
   is used to connect Local Area Network segments below the network
   layer.

   There are two major modes defined for this bridging; transparent and
   source route. The transparent method of bridging is defined in the
   draft IEEE 802.1d specification [11]. This memo defines those
   objects needed for the management of a bridging entity operating in
   the transparent mode, as well as some objects applicable to all types
   of bridges.

   To be consistent with IAB directives and good engineering practice,
   an explicit attempt was made to keep this MIB as simple as possible.
   This was accomplished by applying the following criteria to objects
   proposed for inclusion:

           (1) Start with a small set of essential objects and add only
                as further objects are needed.

           (2) Require objects be essential for either fault or
                configuration management.

           (3) Consider evidence of current use and/or utility.

           (4) Limit the total of objects.

           (5) Exclude objects which are simply derivable from others in
                this or other MIBs.

           (6) Avoid causing critical sections to be heavily
                instrumented. The guideline that was followed is one
                counter per critical section per layer.

3.1. Structure of MIB

   Objects in this MIB are arranged into groups. Each group is
   organized as a set of related objects. The overall structure and
   assignment of objects to their groups is shown below. Where
   appropriate the corresponding IEEE 802.1d [11] management object name
   is also included.

```
        Bridge MIB Name                     IEEE 802.1d Name

        dot1dBridge
          dot1dBase
            BridgeAddress                   Bridge.BridgeAddress
            NumPorts                        Bridge.NumberOfPorts
            Type
            PortTable
              Port                          BridgePort.PortNumber
              IfIndex
              Circuit
              DelayExceededDiscards            .DiscardTransitDelay
              MtuExceededDiscards              .DiscardOnError
          dot1dStp
            ProtocolSpecification
            Priority                        SpanningTreeProtocol
                                               .BridgePriority
            TimeSinceTopologyChange            .TimeSinceTopologyChange
            TopChanges                         .TopologyChangeCount
            DesignatedRoot                     .DesignatedRoot
            RootCost                           .RootCost
            RootPort                           .RootPort
            MaxAge                             .MaxAge
            HelloTime                          .HelloTime
            HoldTime                           .HoldTime
            ForwardDelay                       .ForwardDelay
            BridgeMaxAge                       .BridgeMaxAge
            BridgeHelloTime                    .BridgeHelloTime
            BridgeForwardDelay                 .BridgeForwardDelay
            PortTable
              Port                          SpanningTreeProtocolPort
                                               .PortNumber
              Priority                         .PortPriority
              State                            .SpanningTreeState
              Enable
              PathCost                         .PortPathCost
              DesignatedRoot                   .DesignatedRoot
              DesignatedCost                   .DesignatedCost
              DesignatedBridge                 .DesignatedBridge
              DesignatedPort                   .DesignatedPort
              ForwardTransitions
          dot1dTp
            LearnedEntryDiscards            BridgeFilter.DatabaseSize
                                               .NumDynamic,NumStatic
            AgingTime                       BridgeFilter.AgingTime
            FdbTable
              Address
              Port
```

```
                  Status
               PortTable
                  Port
                  MaxInfo
                  InFrames                 BridgePort.FramesReceived
                  OutFrames                     .ForwardOutbound
                  InDiscards                    .DiscardInbound
            dot1dStatic
               StaticTable
                  Address
                  ReceivePort
                  AllowedToGoTo
                  Status
```

The following IEEE 802.1d management objects have not been included in the Bridge MIB for the indicated reasons.

```
        IEEE 802.1d Object               Disposition

        Bridge.BridgeName                Same as sysDescr (MIB II)
        Bridge.BridgeUpTime              Same as sysUpTime (MIB II)
        Bridge.PortAddresses             Same as ifPhysAddress (MIB II)
        BridgePort.PortName              Same as ifDescr (MIB II)
        BridgePort.PortType              Same as ifType (MIB II)
        BridgePort.RoutingType           Derivable from the implemented
                                         groups


        SpanningTreeProtocol
            .BridgeIdentifier            Combination of dot1dStpPriority
                                         and dot1dBaseBridgeAddress
            .TopologyChange              Since this is transitory, it
                                         is not considered useful.

        SpanningTreeProtocolPort
            .Uptime                      Same as ifLastChange (MIB II)
            .PortIdentifier              Combination of dot1dStpPort
                                         and dot1dStpPortPriority
            .TopologyChangeAcknowledged  Since this is transitory, it
                                         is not considered useful.
            .DiscardLackOfBuffers        Redundant


        Transmission Priority            These objects are not required
                                         as per the Pics Proforma and
                                         not considered useful.

            .TransmissionPriorityName
            .OutboundUserPriority
            .OutboundAccessPriority
```

3.1.1. The dot1dBase Group

   This mandatory group contains the objects which are applicable to all
   types of bridges.

3.1.2. The dot1dStp Group

   This group contains the objects that denote the bridge's state with
   respect to the Spanning Tree Protocol. If a node does not
   implemented the Spanning Tree Protocol, this group will not be
   implemented.

3.1.3. The dot1dSr Group

   This group contains the objects that describe the entity's state with
   respect to source route bridging. If source routing is not supported
   this group will not be implemented. This group is applicable to
   source route only, and SRT bridges. This group will be described in
   a separate document applicable only to source route bridging.

3.1.4. The dot1dTp Group

   This group contains objects that describe the entity's state with
   respect to transparent bridging. If transparent bridging is not
   supported this group will not be implemented. This group is
   applicable to transparent only and SRT bridges.

3.1.5. The dot1dStatic Group

   This group contains objects that describe the entity's state with
   respect to destination-address filtering. If destination-address
   filtering is not supported this group will not be implemented. This
   group is applicable to any type of bridge which performs
   destination-address filtering.

3.2. Relationship to Other MIBs

   As described above, some IEEE 802.1d management objects have not been
   included in this MIB because they overlap with objects in other MIBs
   applicable to a bridge implementing this MIB. In particular, it is
   assumed that a bridge implementing this MIB will also implement (at
   least) the 'system' group and the 'interfaces' group defined in MIB-
   II [6].

3.2.1. Relationship to the 'system' group

   In MIB-II, the 'system' group is defined as being mandatory for all
   systems such that each managed entity contains one instance of each

object in the 'system' group. Thus, those objects apply to the
entity as a whole irrespective of whether the entity's sole
functionality is bridging, or whether bridging is only a subset of
the entity's functionality.

3.2.2. Relationship to the 'interfaces' group

In MIB-II, the 'interfaces' group is defined as being mandatory for
all systems and contains information on an entity's interfaces, where
each interface is thought of as being attached to a 'subnetwork'.
(Note that this term is not to be confused with 'subnet' which refers
to an addressing partitioning scheme used in the Internet suite of
protocols.) The term 'segment' is used in this memo to refer to such
a subnetwork, whether it be an Ethernet segment, a 'ring', a WAN
link, or even an X.25 virtual circuit.

Implicit in this Bridge MIB is the notion of ports on a bridge. Each
of these ports is associated with one interface of the 'interfaces'
group, and in most situations, each port is associated with a
different interface. However, there are situations in which multiple
ports are associated with the same interface. An example of such a
situation would be several ports each corresponding one-to-one with
several X.25 virtual circuits but all on the same interface.

Each port is uniquely identified by a port number. A port number has
no mandatory relationship to an interface number, but in the simple
case a port number will have the same value as the corresponding
interface's interface number. Port numbers are in the range
(1..dot1dBaseNumPorts).

Some entities perform other functionality as well as bridging through
the sending and receiving of data on their interfaces. In such
situations, only a subset of the data sent/received on an interface
is within the domain of the entity's bridging functionality. This
subset is considered to be delineated according to a set of
protocols, with some protocols being bridged, and other protocols not
being bridged. For example, in an entity which exclusively performed
bridging, all protocols would be considered as being bridged, whereas
in an entity which performed IP routing on IP datagrams and only
bridged other protocols, only the non-IP data would be considered as
being bridged.

Thus, this Bridge MIB (and in particular, its counters) are
applicable only to that subset of the data on an entity's interfaces
which is sent/received for a protocol being bridged. All such data
is sent/received via the ports of the bridge.

3.3. Textual Conventions

   The datatypes, MacAddress, BridgeId and Timeout, are used as textual
   conventions in this document. These textual conventions have NO
   effect on either the syntax nor the semantics of any managed object.
   Objects defined using these conventions are always encoded by means
   of the rules that define their primitive type. Hence, no changes to
   the SMI or the SNMP are necessary to accommodate these textual
   conventions which are adopted merely for the convenience of readers.

4. Changes from RFC 1286

            (1) Updated all text to remove references to source route
                 bridging where not applicable. SR MIB will be a separate
                 document.

            (2) Removed dot1dSrPortTable. Retained OID definition of
                 dot1dSr.

            (3) Updated all references of "draft P802.1d/D9" to "IEEE
                 802.1D-1990".

            (4) Updated bibliography.

            (5) Added clarification to description of dot1dPortPathCost.

            (6) Put recommended default in description of
                 dot1dStaticAllowedToGoTo.

            (7) Put recommended default in description of
                 dot1dStaticStatus.

            (8) Put recommended default in description of
                 dot1dTpAgingTime. Specified range of (10..1000000).

            (9) Updated all port number syntaxes, when used as index, to
                 use the range (1..65535).

            (10) Updated definition of dot1dTpPortInFrames and
                 dot1dTpPortOutFrames.

            (11) Added text to the traps indicating that they are
                 optional.

            (12) Clarified definition of dot1dStpForwardDelay.

5. Definitions

          BRIDGE-MIB DEFINITIONS ::= BEGIN

          IMPORTS
                  Counter, TimeTicks
                          FROM RFC1155-SMI
                  mib-2
                          FROM RFC1213-MIB
                  OBJECT-TYPE
                          FROM RFC-1212
                  TRAP-TYPE
                          FROM RFC-1215;

          -- All representations of MAC addresses in this MIB Module
          -- use, as a textual convention (i.e. this convention does
          -- not affect their encoding), the data type:

          MacAddress ::= OCTET STRING (SIZE (6))   -- a 6 octet address
                                                    -- in the
                                                    -- "canonical"
                                                    -- order
          -- defined by IEEE 802.1a, i.e., as if it were transmitted
          -- least significant bit first, even though 802.5 (in
          -- contrast to other n802.x protocols) requires MAC
          -- addresses to be transmitted most significant bit first.
          --
          -- 16-bit addresses, if needed, are represented by setting
          -- their upper 4 octets to all 0's, i.e., AAFF would be
          -- represented as 00000000AAFF.

          -- Similarly, all representations of Bridge-Id in this MIB
          -- Module use, as a textual convention (i.e. this
          -- convention does not affect their encoding), the data
          -- type:

          BridgeId ::= OCTET STRING (SIZE (8))   -- the
                                                 -- Bridge-Identifier
                                                 -- as used in the
                                                 -- Spanning Tree
          -- Protocol to uniquely identify a bridge. Its first two
          -- octets (in network byte order) contain a priority
          -- value and its last 6 octets contain the MAC address
          -- used to refer to a bridge in a unique fashion
          -- (typically, the numerically smallest MAC address
          -- of all ports on the bridge).

```
       -- Several objects in this MIB module represent values of
       -- timers used by the Spanning Tree Protocol.  In this
       -- MIB, these timers have values in units of hundreths of
       -- a second (i.e. 1/100 secs).
       -- These timers, when stored in a Spanning Tree Protocol's
       -- BPDU, are in units of 1/256 seconds.  Note, however,
       -- that 802.1D-1990 specifies a settable granularity of
       -- no more than 1 second for these timers.  To avoid
       -- ambiguity, a data type is defined here as a textual
       -- convention and all representation of these timers
       -- in this MIB module are defined using this data type.  An
       -- algorithm is also defined for converting between the
       -- different units, to ensure a timer's value is not
       -- distorted by multiple conversions.
       -- The data type is:

       Timeout ::= INTEGER -- a STP timer in units of 1/100 seconds

       -- To convert a Timeout value into a value in units of
       -- 1/256 seconds, the following algorithm should be used:
       --
       --      b  = floor( (n * 256) / 100)
       --
       -- where:
       --      floor   =  quotient [ignore remainder]
       --      n is the value in 1/100 second units
       --      b is the value in 1/256 second units
       --
       -- To convert the value from 1/256 second units back to
       -- 1/100 seconds, the following algorithm should be used:
       --
       --      n = ceiling( (b * 100) / 256)
       --
       -- where:
       --      ceiling =  quotient [if remainder is 0], or
       --                 quotient + 1 [if remainder is non-zero]
       --      n is the value in 1/100 second units
       --      b is the value in 1/256 second units
       --
       -- Note: it is important that the arithmetic operations are
       -- done in the order specified (i.e., multiply first, divide
       -- second).


       dot1dBridge    OBJECT IDENTIFIER ::= { mib-2 17 }
```

          -- groups in the Bridge MIB

          dot1dBase   OBJECT IDENTIFIER ::= { dot1dBridge 1 }

          dot1dStp   OBJECT IDENTIFIER ::= { dot1dBridge 2 }

          dot1dSr   OBJECT IDENTIFIER ::= { dot1dBridge 3 }
          -- separately documented

          dot1dTp   OBJECT IDENTIFIER ::= { dot1dBridge 4 }

          dot1dStatic   OBJECT IDENTIFIER ::= { dot1dBridge 5 }

          -- the dot1dBase group

          -- Implementation of the dot1dBase group is mandatory for all
          -- bridges.

          dot1dBaseBridgeAddress OBJECT-TYPE
              SYNTAX MacAddress
              ACCESS read-only
              STATUS mandatory
              DESCRIPTION
                      "The MAC address used by this bridge when it must
                      be referred to in a unique fashion.   It is
                      recommended that this be the numerically smallest
                      MAC address of all ports that belong to this
                      bridge. However it is only required to be unique.
                      When concatenated with dot1dStpPriority a unique
                      BridgeIdentifier is formed which is used in the
                      Spanning Tree Protocol."
              REFERENCE
                      "IEEE 802.1D-1990: Sections 6.4.1.1.3 and 3.12.5"
              ::= { dot1dBase 1 }

          dot1dBaseNumPorts OBJECT-TYPE
              SYNTAX INTEGER
              ACCESS read-only
              STATUS mandatory
              DESCRIPTION
                      "The number of ports controlled by this bridging
                      entity."
              REFERENCE
                      "IEEE 802.1D-1990: Section 6.4.1.1.3"
              ::= { dot1dBase 2 }

          dot1dBaseType OBJECT-TYPE

```
            SYNTAX  INTEGER {
                        unknown(1),
                        transparent-only(2),
                        sourceroute-only(3),
                        srt(4)
                    }
            ACCESS  read-only
            STATUS  mandatory
            DESCRIPTION
                    "Indicates what type of bridging this bridge can
                    perform.  If a bridge is actually performing a
                    certain type of bridging this will be indicated by
                    entries in the port table for the given type."
            ::= { dot1dBase 3 }

        -- The Generic Bridge Port Table

        dot1dBasePortTable OBJECT-TYPE
            SYNTAX  SEQUENCE OF Dot1dBasePortEntry
            ACCESS  not-accessible
            STATUS  mandatory
            DESCRIPTION
                    "A table that contains generic information about
                    every port that is associated with this bridge.
                    Transparent, source-route, and srt ports are
                    included."
            ::= { dot1dBase 4 }

        dot1dBasePortEntry OBJECT-TYPE
            SYNTAX  Dot1dBasePortEntry
            ACCESS  not-accessible
            STATUS  mandatory
            DESCRIPTION
                    "A list of information for each port of the
                    bridge."
            REFERENCE
                    "IEEE 802.1D-1990: Section 6.4.2, 6.6.1"
            INDEX  { dot1dBasePort }
            ::= { dot1dBasePortTable 1 }


        Dot1dBasePortEntry ::=
            SEQUENCE {
                dot1dBasePort
                    INTEGER,
                dot1dBasePortIfIndex
                    INTEGER,
                dot1dBasePortCircuit
```

```
                        OBJECT IDENTIFIER,
                dot1dBasePortDelayExceededDiscards
                    Counter,
                dot1dBasePortMtuExceededDiscards
                    Counter
            }

        dot1dBasePort OBJECT-TYPE
            SYNTAX   INTEGER (1..65535)
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                    "The port number of the port for which this entry
                    contains bridge management information."
            ::= { dot1dBasePortEntry 1 }

        dot1dBasePortIfIndex OBJECT-TYPE
            SYNTAX   INTEGER
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                    "The value of the instance of the ifIndex object,
                    defined in MIB-II, for the interface corresponding
                    to this port."
            ::= { dot1dBasePortEntry 2 }

        dot1dBasePortCircuit OBJECT-TYPE
            SYNTAX   OBJECT IDENTIFIER
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                    "For a port which (potentially) has the same value
                    of dot1dBasePortIfIndex as another port on the
                    same bridge, this object contains the name of an
                    object instance unique to this port.  For example,
                    in the case where multiple ports correspond one-
                    to-one with multiple X.25 virtual circuits, this
                    value might identify an (e.g., the first) object
                    instance associated with the X.25 virtual circuit
                    corresponding to this port.

                    For a port which has a unique value of
                    dot1dBasePortIfIndex, this object can have the
                    value { 0 0 }."
            ::= { dot1dBasePortEntry 3 }

        dot1dBasePortDelayExceededDiscards OBJECT-TYPE
            SYNTAX   Counter
```

```
        ACCESS  read-only
        STATUS  mandatory
        DESCRIPTION
                "The number of frames discarded by this port due
                to excessive transit delay through the bridge.  It
                is incremented by both transparent and source
                route bridges."
        REFERENCE
                "IEEE 802.1D-1990: Section 6.6.1.1.3"
        ::= { dot1dBasePortEntry 4 }

    dot1dBasePortMtuExceededDiscards OBJECT-TYPE
        SYNTAX  Counter
        ACCESS  read-only
        STATUS  mandatory
        DESCRIPTION
                "The number of frames discarded by this port due
                to an excessive size.  It is incremented by both
                transparent and source route bridges."
        REFERENCE
                "IEEE 802.1D-1990: Section 6.6.1.1.3"
        ::= { dot1dBasePortEntry 5 }


    -- the dot1dStp group

    -- Implementation of the dot1dStp group is optional.  It is
    -- implemented by those bridges that support the Spanning Tree
    -- Protocol.


    dot1dStpProtocolSpecification OBJECT-TYPE
        SYNTAX   INTEGER {
                    unknown(1),
                    decLb100(2),
                    ieee8021d(3)
                }
        ACCESS  read-only
        STATUS  mandatory
        DESCRIPTION
                "An indication of what version of the Spanning
                Tree Protocol is being run.  The value
                'decLb100(2)' indicates the DEC LANbridge 100
                Spanning Tree protocol.  IEEE 802.1d
                implementations will return 'ieee8021d(3)'.  If
                future versions of the IEEE Spanning Tree Protocol
                are released that are incompatible with the
                current version a new value will be defined."
```

```
                    ::= { dot1dStp 1 }

            dot1dStpPriority OBJECT-TYPE
                SYNTAX  INTEGER (0..65535)
                ACCESS  read-write
                STATUS  mandatory
                DESCRIPTION
                        "The value of the write-able portion of the Bridge
                        ID, i.e., the first two octets of the (8 octet
                        long) Bridge ID.  The other (last) 6 octets of the
                        Bridge ID are given by the value of
                        dot1dBaseBridgeAddress."
                REFERENCE
                        "IEEE 802.1D-1990: Section 4.5.3.7"
                ::= { dot1dStp 2 }

            dot1dStpTimeSinceTopologyChange OBJECT-TYPE
                SYNTAX  TimeTicks
                ACCESS  read-only
                STATUS  mandatory
                DESCRIPTION
                        "The time (in hundredths of a second) since the
                        last time a topology change was detected by the
                        bridge entity."
                REFERENCE
                        "IEEE 802.1D-1990: Section 6.8.1.1.3"
                ::= { dot1dStp 3 }

            dot1dStpTopChanges OBJECT-TYPE
                SYNTAX  Counter
                ACCESS  read-only
                STATUS  mandatory
                DESCRIPTION
                        "The total number of topology changes detected by
                        this bridge since the management entity was last
                        reset or initialized."
                REFERENCE
                        "IEEE 802.1D-1990: Section 6.8.1.1.3"
                ::= { dot1dStp 4 }

            dot1dStpDesignatedRoot OBJECT-TYPE
                SYNTAX  BridgeId
                ACCESS  read-only
                STATUS  mandatory
                DESCRIPTION
                        "The bridge identifier of the root of the spanning
                        tree as determined by the Spanning Tree Protocol
                        as executed by this node.  This value is used as
```

```
                    the Root Identifier parameter in all Configuration
                    Bridge PDUs originated by this node."
             REFERENCE
                    "IEEE 802.1D-1990: Section 4.5.3.1"
             ::= { dot1dStp 5 }

        dot1dStpRootCost OBJECT-TYPE
             SYNTAX  INTEGER
             ACCESS  read-only
             STATUS  mandatory
             DESCRIPTION
                    "The cost of the path to the root as seen from
                    this bridge."
             REFERENCE
                    "IEEE 802.1D-1990: Section 4.5.3.2"
             ::= { dot1dStp 6 }

        dot1dStpRootPort OBJECT-TYPE
             SYNTAX  INTEGER
             ACCESS  read-only
             STATUS  mandatory
             DESCRIPTION
                    "The port number of the port which offers the
                    lowest cost path from this bridge to the root
                    bridge."
             REFERENCE
                    "IEEE 802.1D-1990: Section 4.5.3.3"
             ::= { dot1dStp 7 }

        dot1dStpMaxAge OBJECT-TYPE
             SYNTAX  Timeout
             ACCESS  read-only
             STATUS  mandatory
             DESCRIPTION
                    "The maximum age of Spanning Tree Protocol
                    information learned from the network on any port
                    before it is discarded, in units of hundredths of
                    a second.  This is the actual value that this
                    bridge is currently using."
             REFERENCE
                    "IEEE 802.1D-1990: Section 4.5.3.4"
             ::= { dot1dStp 8 }

        dot1dStpHelloTime OBJECT-TYPE
             SYNTAX  Timeout
             ACCESS  read-only
             STATUS  mandatory
             DESCRIPTION
```

                        "The amount of time between the transmission of
                        Configuration bridge PDUs by this node on any port
                        when it is the root of the spanning tree or trying
                        to become so, in units of hundredths of a second.
                        This is the actual value that this bridge is
                        currently using."
                REFERENCE
                        "IEEE 802.1D-1990: Section 4.5.3.5"
                ::= { dot1dStp 9 }

        dot1dStpHoldTime OBJECT-TYPE
            SYNTAX   INTEGER
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                        "This time value determines the interval length
                        during which no more than two Configuration bridge
                        PDUs shall be transmitted by this node, in units
                        of hundredths of a second."
                REFERENCE
                        "IEEE 802.1D-1990: Section 4.5.3.14"
                ::= { dot1dStp 10 }

        dot1dStpForwardDelay OBJECT-TYPE
            SYNTAX   Timeout
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                        "This time value, measured in units of hundredths
                        of a second, controls how fast a port changes its
                        spanning state when moving towards the Forwarding
                        state. The value determines how long the port
                        stays in each of the Listening and Learning
                        states, which precede the Forwarding state. This
                        value is also used, when a topology change has
                        been detected and is underway, to age all dynamic
                        entries in the Forwarding Database. [Note that
                        this value is the one that this bridge is
                        currently using, in contrast to
                        dot1dStpBridgeForwardDelay which is the value that
                        this bridge and all others would start using
                        if/when this bridge were to become the root.]"
                REFERENCE
                        "IEEE 802.1D-1990: Section 4.5.3.6"
                ::= { dot1dStp 11 }

        dot1dStpBridgeMaxAge OBJECT-TYPE
            SYNTAX   Timeout (600..4000)

```
                ACCESS   read-write
                STATUS   mandatory
                DESCRIPTION
                        "The value that all bridges use for MaxAge when
                        this bridge is acting as the root.  Note that
                        802.1D-1990 specifies that the range for this
                        parameter is related to the value of
                        dot1dStpBridgeHelloTime. The granularity of this
                        timer is specified by 802.1D-1990 to be 1 second.
                        An agent may return a badValue error if a set is
                        attempted to a value which is not a whole number
                        of seconds."
                REFERENCE
                        "IEEE 802.1D-1990: Section 4.5.3.8"
                ::= { dot1dStp 12 }

        dot1dStpBridgeHelloTime OBJECT-TYPE
                SYNTAX   Timeout (100..1000)
                ACCESS   read-write
                STATUS   mandatory
                DESCRIPTION
                        "The value that all bridges use for HelloTime when
                        this bridge is acting as the root.  The
                        granularity of this timer is specified by 802.1D-
                        1990 to be 1 second.  An agent may return a
                        badValue error if a set is attempted to a value
                        which is not a whole number of seconds."
                REFERENCE
                        "IEEE 802.1D-1990: Section 4.5.3.9"
                ::= { dot1dStp 13 }

        dot1dStpBridgeForwardDelay OBJECT-TYPE
                SYNTAX   Timeout (400..3000)
                ACCESS   read-write
                STATUS   mandatory
                DESCRIPTION
                        "The value that all bridges use for ForwardDelay
                        when this bridge is acting as the root.  Note that
                        802.1D-1990 specifies that the range for this
                        parameter is related to the value of
                        dot1dStpBridgeMaxAge.  The granularity of this
                        timer is specified by 802.1D-1990 to be 1 second.
                        An agent may return a badValue error if a set is
                        attempted to a value which is not a whole number
                        of seconds."
                REFERENCE
                        "IEEE 802.1D-1990: Section 4.5.3.10"
                ::= { dot1dStp 14 }
```

```
          -- The Spanning Tree Port Table

          dot1dStpPortTable OBJECT-TYPE
              SYNTAX   SEQUENCE OF Dot1dStpPortEntry
              ACCESS   not-accessible
              STATUS   mandatory
              DESCRIPTION
                      "A table that contains port-specific information
                      for the Spanning Tree Protocol."
              ::= { dot1dStp 15 }

          dot1dStpPortEntry OBJECT-TYPE
              SYNTAX   Dot1dStpPortEntry
              ACCESS   not-accessible
              STATUS   mandatory
              DESCRIPTION
                      "A list of information maintained by every port
                      about the Spanning Tree Protocol state for that
                      port."
              INDEX    { dot1dStpPort }
              ::= { dot1dStpPortTable 1 }

          Dot1dStpPortEntry ::=
              SEQUENCE {
                  dot1dStpPort
                      INTEGER,
                  dot1dStpPortPriority
                      INTEGER,
                  dot1dStpPortState
                      INTEGER,
                  dot1dStpPortEnable
                      INTEGER,
                  dot1dStpPortPathCost
                      INTEGER,
                  dot1dStpPortDesignatedRoot
                      BridgeId,
                  dot1dStpPortDesignatedCost
                      INTEGER,
                  dot1dStpPortDesignatedBridge
                      BridgeId,
                  dot1dStpPortDesignatedPort
                      OCTET STRING,
                  dot1dStpPortForwardTransitions
                      Counter
              }

          dot1dStpPort OBJECT-TYPE
              SYNTAX   INTEGER (1..65535)
```

```
        ACCESS  read-only
        STATUS  mandatory
        DESCRIPTION
                "The port number of the port for which this entry
                contains Spanning Tree Protocol management
                information."
        REFERENCE
                "IEEE 802.1D-1990: Section 6.8.2.1.2"
        ::= { dot1dStpPortEntry 1 }

    dot1dStpPortPriority OBJECT-TYPE
        SYNTAX  INTEGER (0..255)
        ACCESS  read-write
        STATUS  mandatory
        DESCRIPTION
                "The value of the priority field which is
                contained in the first (in network byte order)
                octet of the (2 octet long) Port ID.  The other
                octet of the Port ID is given by the value of
                dot1dStpPort."
        REFERENCE
                "IEEE 802.1D-1990: Section 4.5.5.1"
        ::= { dot1dStpPortEntry 2 }

    dot1dStpPortState OBJECT-TYPE
        SYNTAX  INTEGER {
                    disabled(1),
                    blocking(2),
                    listening(3),
                    learning(4),
                    forwarding(5),
                    broken(6)
                }
        ACCESS  read-only
        STATUS  mandatory
        DESCRIPTION
                "The port's current state as defined by
                application of the Spanning Tree Protocol.  This
                state controls what action a port takes on
                reception of a frame.  If the bridge has detected
                a port that is malfunctioning it will place that
                port into the broken(6) state.  For ports which
                are disabled (see dot1dStpPortEnable), this object
                will have a value of disabled(1)."
        REFERENCE
                "IEEE 802.1D-1990: Section 4.5.5.2"
        ::= { dot1dStpPortEntry 3 }
```

```
        dot1dStpPortEnable OBJECT-TYPE
            SYNTAX  INTEGER {
                    enabled(1),
                    disabled(2)
                }
            ACCESS  read-write
            STATUS  mandatory
            DESCRIPTION
                    "The enabled/disabled status of the port."
            REFERENCE
                    "IEEE 802.1D-1990: Section 4.5.5.2"
            ::= { dot1dStpPortEntry 4 }

        dot1dStpPortPathCost OBJECT-TYPE
            SYNTAX  INTEGER (1..65535)
            ACCESS  read-write
            STATUS  mandatory
            DESCRIPTION
                    "The contribution of this port to the path cost of
                    paths towards the spanning tree root which include
                    this port.  802.1D-1990 recommends that the
                    default value of this parameter be in inverse
                    proportion to the speed of the attached LAN."
            REFERENCE
                    "IEEE 802.1D-1990: Section 4.5.5.3"
            ::= { dot1dStpPortEntry 5 }

        dot1dStpPortDesignatedRoot OBJECT-TYPE
            SYNTAX  BridgeId
            ACCESS  read-only
            STATUS  mandatory
            DESCRIPTION
                    "The unique Bridge Identifier of the Bridge
                    recorded as the Root in the Configuration BPDUs
                    transmitted by the Designated Bridge for the
                    segment to which the port is attached."
            REFERENCE
                    "IEEE 802.1D-1990: Section 4.5.5.4"
            ::= { dot1dStpPortEntry 6 }

        dot1dStpPortDesignatedCost OBJECT-TYPE
            SYNTAX  INTEGER
            ACCESS  read-only
            STATUS  mandatory
            DESCRIPTION
                    "The path cost of the Designated Port of the
                    segment connected to this port.  This value is
                    compared to the Root Path Cost field in received
```

                   bridge PDUs."
            REFERENCE
                   "IEEE 802.1D-1990: Section 4.5.5.5"
            ::= { dot1dStpPortEntry 7 }

        dot1dStpPortDesignatedBridge OBJECT-TYPE
            SYNTAX   BridgeId
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                   "The Bridge Identifier of the bridge which this
                   port considers to be the Designated Bridge for
                   this port's segment."
            REFERENCE
                   "IEEE 802.1D-1990: Section 4.5.5.6"
            ::= { dot1dStpPortEntry 8 }

        dot1dStpPortDesignatedPort OBJECT-TYPE
            SYNTAX   OCTET STRING (SIZE (2))
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                   "The Port Identifier of the port on the Designated
                   Bridge for this port's segment."
            REFERENCE
                   "IEEE 802.1D-1990: Section 4.5.5.7"
            ::= { dot1dStpPortEntry 9 }

        dot1dStpPortForwardTransitions OBJECT-TYPE
            SYNTAX   Counter
            ACCESS   read-only
            STATUS   mandatory
            DESCRIPTION
                   "The number of times this port has transitioned
                   from the Learning state to the Forwarding state."
            ::= { dot1dStpPortEntry 10 }

        -- the dot1dTp group

        -- Implementation of the dot1dTp group is optional. It is
        -- implemented by those bridges that support the transparent
        -- bridging mode. A transparent or SRT bridge will implement
        -- this group.

        dot1dTpLearnedEntryDiscards OBJECT-TYPE
            SYNTAX   Counter

```
                    ACCESS  read-only
                    STATUS  mandatory
                    DESCRIPTION
                            "The total number of Forwarding Database entries,
                            which have been or would have been learnt, but
                            have been discarded due to a lack of space to
                            store them in the Forwarding Database.  If this
                            counter is increasing, it indicates that the
                            Forwarding Database is regularly becoming full (a
                            condition which has unpleasant performance effects
                            on the subnetwork).  If this counter has a
                            significant value but is not presently increasing,
                            it indicates that the problem has been occurring
                            but is not persistent."
                    REFERENCE
                            "IEEE 802.1D-1990: Section 6.7.1.1.3"
                    ::= { dot1dTp 1 }

            dot1dTpAgingTime OBJECT-TYPE
                    SYNTAX   INTEGER (10..1000000)
                    ACCESS   read-write
                    STATUS   mandatory
                    DESCRIPTION
                            "The timeout period in seconds for aging out
                            dynamically learned forwarding information.
                            802.1D-1990 recommends a default of 300 seconds."
                    REFERENCE
                            "IEEE 802.1D-1990: Section 6.7.1.1.3"
                    ::= { dot1dTp 2 }


            --   The Forwarding Database for Transparent Bridges

            dot1dTpFdbTable OBJECT-TYPE
                    SYNTAX  SEQUENCE OF Dot1dTpFdbEntry
                    ACCESS  not-accessible
                    STATUS  mandatory
                    DESCRIPTION
                            "A table that contains information about unicast
                            entries for which the bridge has forwarding and/or
                            filtering information.  This information is used
                            by the transparent bridging function in
                            determining how to propagate a received frame."
                    ::= { dot1dTp 3 }

            dot1dTpFdbEntry OBJECT-TYPE
                    SYNTAX  Dot1dTpFdbEntry
                    ACCESS  not-accessible
```

```
                    STATUS  mandatory
                    DESCRIPTION
                            "Information about a specific unicast MAC address
                            for which the bridge has some forwarding and/or
                            filtering information."
                    INDEX   { dot1dTpFdbAddress }
                    ::= { dot1dTpFdbTable 1 }

            Dot1dTpFdbEntry ::=
                    SEQUENCE {
                        dot1dTpFdbAddress
                            MacAddress,
                        dot1dTpFdbPort
                            INTEGER,
                        dot1dTpFdbStatus
                            INTEGER
                    }

            dot1dTpFdbAddress OBJECT-TYPE
                    SYNTAX  MacAddress
                    ACCESS  read-only
                    STATUS  mandatory
                    DESCRIPTION
                            "A unicast MAC address for which the bridge has
                            forwarding and/or filtering information."
                    REFERENCE
                            "IEEE 802.1D-1990: Section 3.9.1, 3.9.2"
                    ::= { dot1dTpFdbEntry 1 }

            dot1dTpFdbPort OBJECT-TYPE
                    SYNTAX  INTEGER
                    ACCESS  read-only
                    STATUS  mandatory
                    DESCRIPTION
                            "Either the value '0', or the port number of the
                            port on which a frame having a source address
                            equal to the value of the corresponding instance
                            of dot1dTpFdbAddress has been seen.  A value of
                            '0' indicates that the port number has not been
                            learned but that the bridge does have some
                            forwarding/filtering information about this
                            address (e.g. in the dot1dStaticTable).
                            Implementors are encouraged to assign the port
                            value to this object whenever it is learned even
                            for addresses for which the corresponding value of
                            dot1dTpFdbStatus is not learned(3)."
                    ::= { dot1dTpFdbEntry 2 }
```

```
         dot1dTpFdbStatus OBJECT-TYPE
             SYNTAX  INTEGER {
                         other(1),
                         invalid(2),
                         learned(3),
                         self(4),
                         mgmt(5)
                     }
             ACCESS  read-only
             STATUS  mandatory
             DESCRIPTION
                     "The status of this entry.  The meanings of the
                     values are:

                         other(1)   : none of the following.  This would
                                      include the case where some other
                                      MIB object (not the corresponding
                                      instance of dot1dTpFdbPort, nor an
                                      entry in the dot1dStaticTable) is
                                      being used to determine if and how
                                      frames addressed to the value of
                                      the corresponding instance of
                                      dot1dTpFdbAddress are being
                                      forwarded.

                         invalid(2) : this entry is not longer valid
                                      (e.g., it was learned but has since
                                      aged-out), but has not yet been
                                      flushed from the table.

                         learned(3) : the value of the corresponding
                                      instance of dot1dTpFdbPort was
                                      learned, and is being used.

                         self(4)    : the value of the corresponding
                                      instance of dot1dTpFdbAddress
                                      represents one of the bridge's
                                      addresses.  The corresponding
                                      instance of dot1dTpFdbPort
                                      indicates which of the bridge's
                                      ports has this address.

                         mgmt(5)    : the value of the corresponding
                                      instance of dot1dTpFdbAddress is
                                      also the value of an existing
                                      instance of dot1dStaticAddress."
             ::= { dot1dTpFdbEntry 3 }
```

          -- Port Table for Transparent Bridges

          dot1dTpPortTable OBJECT-TYPE
              SYNTAX   SEQUENCE OF Dot1dTpPortEntry
              ACCESS   not-accessible
              STATUS   mandatory
              DESCRIPTION
                      "A table that contains information about every
                      port that is associated with this transparent
                      bridge."
              ::= { dot1dTp 4 }

          dot1dTpPortEntry OBJECT-TYPE
              SYNTAX   Dot1dTpPortEntry
              ACCESS   not-accessible
              STATUS   mandatory
              DESCRIPTION
                      "A list of information for each port of a
                      transparent bridge."
              INDEX   { dot1dTpPort }
              ::= { dot1dTpPortTable 1 }

          Dot1dTpPortEntry ::=
              SEQUENCE {
                  dot1dTpPort
                      INTEGER,
                  dot1dTpPortMaxInfo
                      INTEGER,
                  dot1dTpPortInFrames
                      Counter,
                  dot1dTpPortOutFrames
                      Counter,
                  dot1dTpPortInDiscards
                      Counter
              }

          dot1dTpPort OBJECT-TYPE
              SYNTAX   INTEGER (1..65535)
              ACCESS   read-only
              STATUS   mandatory
              DESCRIPTION
                      "The port number of the port for which this entry
                      contains Transparent bridging management
                      information."
              ::= { dot1dTpPortEntry 1 }

      -- It would be nice if we could use ifMtu as the size of the
      -- largest INFO field, but we can't because ifMtu is defined

```
            -- to be the size that the (inter-)network layer can use which
            -- can differ from the MAC layer (especially if several layers
            -- of encapsulation are used).

            dot1dTpPortMaxInfo OBJECT-TYPE
                SYNTAX   INTEGER
                ACCESS   read-only
                STATUS   mandatory
                DESCRIPTION
                        "The maximum size of the INFO (non-MAC) field that
                        this port will receive or transmit."
                ::= { dot1dTpPortEntry 2 }

            dot1dTpPortInFrames OBJECT-TYPE
                SYNTAX   Counter
                ACCESS   read-only
                STATUS   mandatory
                DESCRIPTION
                        "The number of frames that have been received by
                        this port from its segment. Note that a frame
                        received on the interface corresponding to this
                        port is only counted by this object if and only if
                        it is for a protocol being processed by the local
                        bridging function, including bridge management
                        frames."
                REFERENCE
                        "IEEE 802.1D-1990: Section 6.6.1.1.3"
                ::= { dot1dTpPortEntry 3 }

            dot1dTpPortOutFrames OBJECT-TYPE
                SYNTAX   Counter
                ACCESS   read-only
                STATUS   mandatory
                DESCRIPTION
                        "The number of frames that have been transmitted
                        by this port to its segment.  Note that a frame
                        transmitted on the interface corresponding to this
                        port is only counted by this object if and only if
                        it is for a protocol being processed by the local
                        bridging function, including bridge management
                        frames."
                REFERENCE
                        "IEEE 802.1D-1990: Section 6.6.1.1.3"
                ::= { dot1dTpPortEntry 4 }

            dot1dTpPortInDiscards OBJECT-TYPE
                SYNTAX    Counter
                ACCESS    read-only
```

```
            STATUS    mandatory
            DESCRIPTION
                    "Count of valid frames received which were
                    discarded (i.e., filtered) by the Forwarding
                    Process."
            REFERENCE
                    "IEEE 802.1D-1990: Section 6.6.1.1.3"
            ::= { dot1dTpPortEntry 5 }


        -- The Static (Destination-Address Filtering) Database

        -- Implementation of this group is optional.


        dot1dStaticTable OBJECT-TYPE
            SYNTAX    SEQUENCE OF Dot1dStaticEntry
            ACCESS    not-accessible
            STATUS    mandatory
            DESCRIPTION
                    "A table containing filtering information
                    configured into the bridge by (local or network)
                    management specifying the set of ports to which
                    frames received from specific ports and containing
                    specific destination addresses are allowed to be
                    forwarded.  The value of zero in this table as the
                    port number from which frames with a specific
                    destination address are received, is used to
                    specify all ports for which there is no specific
                    entry in this table for that particular
                    destination address.  Entries are valid for
                    unicast and for group/broadcast addresses."
            REFERENCE
                    "IEEE 802.1D-1990: Section 6.7.2"
            ::= { dot1dStatic 1 }

        dot1dStaticEntry OBJECT-TYPE
            SYNTAX    Dot1dStaticEntry
            ACCESS    not-accessible
            STATUS    mandatory
            DESCRIPTION
                    "Filtering information configured into the bridge
                    by (local or network) management specifying the
                    set of ports to which frames received from a
                    specific port and containing a specific
                    destination address are allowed to be forwarded."
            REFERENCE
                    "IEEE 802.1D-1990: Section 6.7.2"
```

```
        INDEX   { dot1dStaticAddress, dot1dStaticReceivePort }
        ::= { dot1dStaticTable 1 }

    Dot1dStaticEntry ::=
        SEQUENCE {
            dot1dStaticAddress
                MacAddress,
            dot1dStaticReceivePort
                INTEGER,
            dot1dStaticAllowedToGoTo
                OCTET STRING,
            dot1dStaticStatus
                INTEGER
        }

    dot1dStaticAddress OBJECT-TYPE
        SYNTAX  MacAddress
        ACCESS  read-write
        STATUS  mandatory
        DESCRIPTION
                "The destination MAC address in a frame to which
                this entry's filtering information applies.  This
                object can take the value of a unicast address, a
                group address or the broadcast address."
        REFERENCE
                "IEEE 802.1D-1990: Section 3.9.1, 3.9.2"
        ::= { dot1dStaticEntry 1 }

    dot1dStaticReceivePort OBJECT-TYPE
        SYNTAX  INTEGER
        ACCESS  read-write
        STATUS  mandatory
        DESCRIPTION
                "Either the value '0', or the port number of the
                port from which a frame must be received in order
                for this entry's filtering information to apply.
                A value of zero indicates that this entry applies
                on all ports of the bridge for which there is no
                other applicable entry."
        ::= { dot1dStaticEntry 2 }

    dot1dStaticAllowedToGoTo OBJECT-TYPE
        SYNTAX  OCTET STRING
        ACCESS  read-write
        STATUS  mandatory
        DESCRIPTION
                "The set of ports to which frames received from a
                specific port and destined for a specific MAC
```

                        address, are allowed to be forwarded. Each octet
                        within the value of this object specifies a set of
                        eight ports, with the first octet specifying ports
                        1 through 8, the second octet specifying ports 9
                        through 16, etc. Within each octet, the most
                        significant bit represents the lowest numbered
                        port, and the least significant bit represents the
                        highest numbered port. Thus, each port of the
                        bridge is represented by a single bit within the
                        value of this object. If that bit has a value of
                        '1' then that port is included in the set of
                        ports; the port is not included if its bit has a
                        value of '0'. (Note that the setting of the bit
                        corresponding to the port from which a frame is
                        received is irrelevant.) The default value of
                        this object is a string of ones of appropriate
                        length."
                ::= { dot1dStaticEntry 3 }

        dot1dStaticStatus OBJECT-TYPE
            SYNTAX   INTEGER {
                        other(1),
                        invalid(2),
                        permanent(3),
                        deleteOnReset(4),
                        deleteOnTimeout(5)
                    }
            ACCESS   read-write
            STATUS   mandatory
            DESCRIPTION
                    "This object indicates the status of this entry.
                    The default value is permanent(3).

                        other(1) - this entry is currently in use but
                            the conditions under which it will
                            remain so are different from each of the
                            following values.
                        invalid(2) - writing this value to the object
                            removes the corresponding entry.
                        permanent(3) - this entry is currently in use
                            and will remain so after the next reset
                            of the bridge.
                        deleteOnReset(4) - this entry is currently in
                            use and will remain so until the next
                            reset of the bridge.
                        deleteOnTimeout(5) - this entry is currently
                            in use and will remain so until it is
                            aged out."

```
        ::= { dot1dStaticEntry 4 }


    -- Traps for use by Bridges

    -- Traps for the Spanning Tree Protocol

    newRoot TRAP-TYPE
        ENTERPRISE  dot1dBridge
        DESCRIPTION
                "The newRoot trap indicates that the sending agent
                has become the new root of the Spanning Tree; the
                trap is sent by a bridge soon after its election
                as the new root, e.g., upon expiration of the
                Topology Change Timer immediately subsequent to
                its election.  Implementation of this trap is
                optional."
        ::= 1


    topologyChange TRAP-TYPE
        ENTERPRISE  dot1dBridge
        DESCRIPTION
                "A topologyChange trap is sent by a bridge when
                any of its configured ports transitions from the
                Learning state to the Forwarding state, or from
                the Forwarding state to the Blocking state.  The
                trap is not sent if a newRoot trap is sent for the
                same transition.  Implementation of this trap is
                optional."
        ::= 2


    END
```

6. Acknowledgments

   This document was produced on behalf of the Bridge Sub-Working Group
   of the SNMP Working Group of the Internet Engineering Task Force.
   Over the course of its deliberations, the working group received four
   separate documents for consideration as the basis for its work. The
   first was submitted by Stan Froyd of Advanced Computer
   Communications; the second by Richard Fox of SynOptics; the third by
   Eric Decker of cisco Inc. and Keith McCloghrie of Hughes LAN Systems;
   and the fourth by Paul Langille and Anil Rijsinghani of Digital
   Equipment Corp. After considering the submissions, the working group
   chose to proceed with a document formed as a conjunction of the
   latter two submissions. This document is the result.

7. References

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   [4] Case, J., Fedor, M., Schoffstall, M., and J. Davin, "Simple
       Network Management Protocol", STD 15, RFC 1157, SNMP Research,
       Performance Systems International, Performance Systems
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   [7] Information processing systems - Open Systems Interconnection -
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       International Standard 8825, December 1987.

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       STD 16, RFC 1212, Performance Systems International, Hughes LAN
       Systems, March 1991.

   [9] Rose, M., Editor, "A Convention for Defining Traps for use with
       the SNMP", RFC 1215, Performance Systems International, March
       1991.

  [10] ANSI/IEEE Standard 802.1D-1990 MAC Bridges, IEEE Project 802
       Local and Metropolitan Area Networks, (March 8, 1991).

  [11] ISO DIS 10038 MAC Bridges.

8. Security Considerations

   Security issues are not discussed in this memo.

9. Authors' Addresses

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