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**Management Information Base for Virtual Machines Controlled by a
Hypervisor
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Abstract

This document defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, this specifies objects for managing virtual machines controlled by a hypervisor (a.k.a. virtual machine manager).

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1. Introduction

This document defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, this specifies objects for managing virtual machines controlled by a hypervisor (a.k.a. virtual machine managers). A hypervisor controls multiple virtual machines on a single physical machine by allocating resources to each virtual machine using virtualization technologies. Therefore, this MIB module contains information on virtual machines and their resources controlled by a hypervisor as well as hypervisor's hardware and software information.

The design of this MIB module has been derived from enterprise specific MIB modules, namely a MIB module for managing guests of the Xen hypervisor, a MIB module for managing virtual machines controlled by the VMware hypervisor, and a MIB module using the libvirt programming interface to access different hypervisors.

1.1. Requirements Language

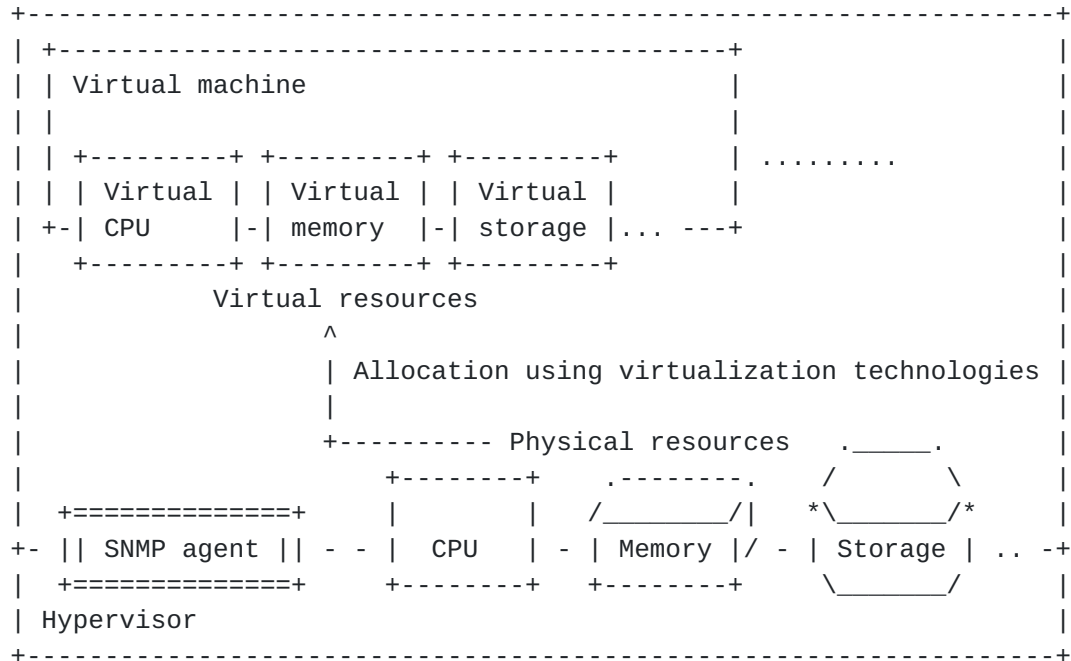
The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [[RFC2119](#)].

2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to [section 7 of RFC 3410](#) [[RFC3410](#)]. Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies a MIB module that is compliant to the SMIV2, which is described in STD 58, [RFC 2578](#) [[RFC2578](#)], STD 58, [RFC 2579](#) [[RFC2579](#)] and STD 58, [RFC 2580](#) [[RFC2580](#)].

3. Managed Objects for Virtual Machines Controlled by a Hypervisor

3.1. Managed Objects on Virtualization Environment



A hypervisor allocates resources as virtual devices such as virtual CPU, virtual memory, virtual storage, and virtual network interface to multiple virtual machines controlled by the hypervisor from physical resources.

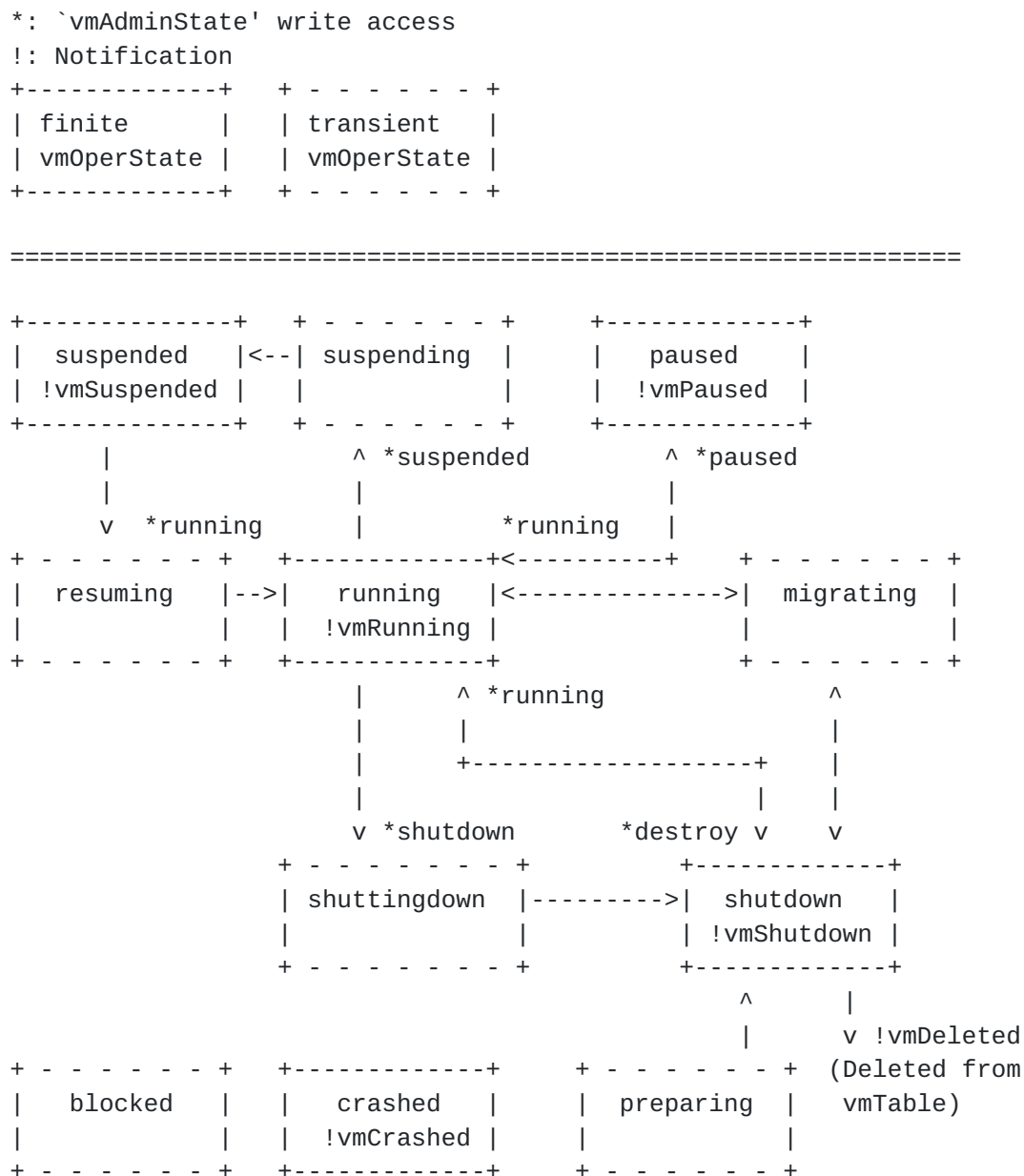
Figure 1: An example of a virtualization environment

On the common implementations of hypervisor softwares, a hypervisor allocates resources as virtual devices such as virtual CPUs, virtual memory, virtual storage, and virtual network interface to multiple virtual machines controlled by the hypervisor from physical resources. This document defines objects related to system and software information of a hypervisor, the list of virtual machines controlled by the hypervisor, and virtual resources allocated by the hypervisor to virtual machines. As shown in Figure 1, the virtual resource objects are defined as virtual devices. Consequently, this document specifies four specific types of virtual devices; CPUs (processors), memory, network interfaces, and storage devices. Note that physical resources are managed in HOST-RESOURCES-MIB [RFC2790]. In case that each virtual resource device object has a corresponding parent physical device managed in HOST-RESOURCES-MIB, the object of the virtual resource device contains a pointer to the physical device. The objects related to virtual network interfaces are mapped to the objects managed in IF-MIB [RFC2863].

The objects defined in this document are managed at a hypervisor and an SNMP agent is launched at the hypervisor to provide access to the objects. The objects are managed from the viewpoint of the operators of hypervisors, but not the operators of virtual machines; i.e., the objects do not take into account the actual resource utilization on each virtual machine but the resource allocation from the physical resources. For example, `vmNetworIfIndex` indicates the virtual interface associated with an interface of a virtual machine at the hypervisor, and consequently, the ``in'` and ``out'` directions denote ``from a virtual machine to the hypervisor'` and ``from the hypervisor to a virtual machine'`, respectively. Moreover, `vmStorageAllocatedSize` denotes the size allocated by the hypervisor, but not the size actually used by the operating system on the virtual machine. This means that `vmStorageDefinedSize` and `vmStorageAllocatedSize` must not take different values when the `vmStorageSourceType` is ``block'` or ``raw'`.

3.2. Overview of the MIB Module

The MIB module is organized into a group of scalars and tables. The scalars below ``hypervisor'` provide basic information about the hypervisor. The ``vmTable'` lists the virtual machines (guests) that are known to the hypervisor. The ``vmCpuTable'` and ``vmCpuAffinityTable'` provide the mapping of virtual CPUs and their affinity to virtual machines. The ``vmStorageTable'` and the ``vmNetworkTable'` provide the mapping of logical storage areas and network interfaces to virtual machines.



The state transition of a virtual machine

Figure 2: State transition of a virtual machine

The `vmAdminState'` and `vmOperState'` textual conventions define an administrative state and an operational state model for virtual machines. Events causing transitions between major operational states will cause the generation of notifications. Per-VM notifications (`vmRunning`, `vmShutdown`, `vmPaused`, `vmSuspended`, `vmCrashed`, `vmDeleted`) are generated if `vmPerVMNotificationsEnabled` is `true(1)`. Bulk notifications (`vmBulkRunning`, `vmBulkShutdown`, `vmBulkPaused`, `vmBulkSuspended`, `vmBulkCrashed`, `vmBulkDeleted`) are

generated if `vmBulkNotificationsEnabled` is `true(1)`. The transition of ``vmOperState'` by the write access to ``vmAdminState'` and the notifications generated by the operational state changes are summarized in Figure 2. Note that the notifications shown in this figure are per-VM notifications. In the case of Bulk notifications, the prefix ``vm'` is replaced with `'vmBulk'`.

The bulk notification mechanism is designed to reduce the number of notifications that are trapped by an SNMP manager. This is because the number of virtual machines managed by a bunch of hypervisors in a datacenter possibly becomes several thousands or more, and consequently, many notifications could be trapped if these virtual machines frequently change their administrative state. The per-VM notifications carry more detailed information, but the scalability shall be a problem. An implementation shall support both, either of, or none of per-VM notifications and bulk notifications. The notification filtering mechanism described in [section 6 of RFC 3413 \[RFC3413\]](#) is used by the management applications to control the notifications.

The MIB module provides a few writable objects that can be used to make non-persistent changes, e.g., changing the memory allocation or the CPU allocation. It is not the goal of this MIB module to provide a configuration interface for virtual machines since other protocols and data modeling languages are more suitable for this task.

The OID tree structure of the MIB module is shown below.

```
--vmMIB (1.3.6.1.2.1.yyy)
+-vmNotifications(0)
| +-vmRunning(1) [vmName, vmUUID, vmOperState]
| +-vmShutdown(2) [vmName, vmUUID, vmOperState]
| +-vmPaused(3) [vmName, vmUUID, vmOperState]
| +-vmSuspended(4) [vmName, vmUUID, vmOperState]
| +-vmCrashed(5) [vmName, vmUUID, vmOperState]
| +-vmDeleted(6) [vmName, vmUUID, vmOperState, vmPersistent]
| +-vmBulkRunning(7) [vmAffectedVMs]
| +-vmBulkShutdown(8) [vmAffectedVMs]
| +-vmBulkPaused(9) [vmAffectedVMs]
| +-vmBulkSuspended(10) [vmAffectedVMs]
| +-vmBulkCrashed(11) [vmAffectedVMs]
| +-vmBulkDeleted(12) [vmAffectedVMs]
+-vmObjects(1)
| +-vmHypervisor(1)
| | +-- r-n SnmpAdminString    vmHvSoftware(1)
| | +-- r-n SnmpAdminString    vmHvVersion(2)
| | +-- r-n OBJECT IDENTIFIER  vmHvObjectID(3)
| | +-- r-n TimeTicks          vmHvUpTime(4)
```



```

| +-- r-n Integer32    vmNumber(2)
| +-- r-n TimeTicks    vmTableLastChange(3)
| +--vmTable(4)
| |   +--vmEntry(1) [vmIndex]
| |       +-- --- VirtualMachineIndex    vmIndex(1)
| |       +-- r-n SnmpAdminString         vmName(2)
| |       +-- r-n UUIDorZero              vmUUID(3)
| |       +-- r-n SnmpAdminString         vmOSType(4)
| |       +-- rwn VirtualMachineAdminState
| |           |
| |           vmAdminState(5)
| |       +-- r-n VirtualMachineOperState
| |           |
| |           vmOperState(6)
| |       +-- rwn VirtualMachineAutoStart
| |           |
| |           vmAutoStart(7)
| |       +-- r-n VirtualMachinePersistent
| |           |
| |           vmPersistent(8)
| |       +-- r-n Integer32                vmCurCpuNumber(9)
| |       +-- rwn Integer32                vmMinCpuNumber(10)
| |       +-- rwn Integer32                vmMaxCpuNumber(11)
| |       +-- r-n Integer32                vmMemUnit(12)
| |       +-- r-n Integer32                vmCurMem(13)
| |       +-- rwn Integer32                vmMinMem(14)
| |       +-- rwn Integer32                vmMaxMem(15)
| |       +-- r-n TimeTicks                vmUpTime(16)
| |       +-- r-n Counter64                vmCpuTime(17)
| +--vmCpuTable(5)
| |   +--vmCpuEntry(1) [vmIndex, vmCpuIndex]
| |       +-- --- VirtualMachineCpuIndex
| |           |
| |           vmCpuIndex(1)
| |       +-- r-n Counter64                vmCpuCoreTime(2)
| +--vmCpuAffinityTable(6)
| |   +--vmCpuAffinityEntry(1) [vmIndex,
| |       |
| |       vmCpuIndex,
| |       |
| |       vmCpuPhysIndex]
| |       +-- --- Integer32                vmCpuPhysIndex(1)
| |       +-- rwn Integer32                vmCpuAffinity(2)
| +--vmStorageTable(7)
| |   +--vmStorageEntry(1) [vmStorageVmIndex, vmStorageIndex]
| |       +-- --- VirtualMachineIndexOrZero
| |           |
| |           vmStorageVmIndex(1)
| |       +-- --- VirtualMachineStorageIndex
| |           |
| |           vmStorageIndex(2)
| |       +-- r-n Integer32                vmStorageParent(3)
| |       +-- r-n VirtualMachineStorageSourceType
| |           |
| |           vmStorageSourceType(4)
| |       +-- r-n SnmpAdminString         vmStorageSourceTypeString(5)
| |       +-- r-n SnmpAdminString         vmStorageResourceID(6)
| |       +-- r-n VirtualMachineStorageAccess

```



```

| | | vmStorageAccess(7)
| | +-- r-n VirtualMachineStorageMediaType
| | | vmStorageMediaType(8)
| | +-- r-n SnmpAdminString vmStorageMediaTypeString(9)
| | +-- r-n Integer32 vmStorageSizeUnit(10)
| | +-- r-n Integer32 vmStorageDefinedSize(11)
| | +-- r-n Integer32 vmStorageAllocatedSize(12)
| | +-- r-n Counter64 vmStorageReadIOs(13)
| | +-- r-n Counter64 vmStorageWriteIOs(14)
| +--vmNetworkTable(8)
| | +--vmNetworkEntry(1) [vmIndex, vmNetworkIndex]
| | | +-- --- VirtualMachineNetworkIndex
| | | | vmNetworkIndex(1)
| | | +-- r-n InterfaceIndexOrZero vmNetworkIfIndex(2)
| | | +-- r-n InterfaceIndexOrZero vmNetworkParent(3)
| | | +-- r-n SnmpAdminString vmNetworkModel(4)
| | | +-- r-n PhysAddress vmNetworkPhysAddress(5)
| +-- rwn TruthValue vmPerVMNotificationsEnabled(9)
| +-- rwn TruthValue vmBulkNotificationsEnabled(10)
| +-- --n VirtualMachineList vmAffectedVMs(11)
+--vmConformance(2)
+--vmCompliances(1)
| +--vmFullCompliances(1)
| +--vmReadOnlyCompliances(2)
+--vmGroups(2)
+--vmHypervisorGroup(1)
+--vmVirtualMachineGroup(2)
+--vmCpuGroup(3)
+--vmCpuAffinityGroup(4)
+--vmStorageGroup(5)
+--vmNetworkGroup(6)
+--vmPerVMNotificationOptionalGroup(7)
+--vmBulkNotificationsVariablesGroup(8)
+--vmBulkNotificationOptionalGroup(9)

```

3.3. Definitions

VM-MIB DEFINITIONS ::= BEGIN

IMPORTS

```

    MODULE-IDENTITY, OBJECT-TYPE, NOTIFICATION-TYPE, TimeTicks,
    Counter64, Integer32, mib-2
    FROM SNMPv2-SMI
    OBJECT-GROUP, MODULE-COMPLIANCE, NOTIFICATION-GROUP
    FROM SNMPv2-CONF
    TEXTUAL-CONVENTION, PhysAddress, TruthValue
    FROM SNMPv2-TC
    SnmpAdminString

```


FROM SNMP-FRAMEWORK-MIB
UUIDorZero
FROM UUID-TC-MIB
InterfaceIndexOrZero
FROM IF-MIB;

vmMIB MODULE-IDENTITY

LAST-UPDATED "201307020000Z" -- 2 July 2013
ORGANIZATION "IETF Operations and Management Area Working Group"
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"

DESCRIPTION

"This MIB module is for use in managing a hypervisor and virtual machines controlled by the hypervisor. The OID `yyy' is temporary one, and it must be assigned by IANA when this becomes an official document.

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REVISION "201307020000Z" -- 2 July 2013

DESCRIPTION

"The original version of this MIB, published as RFCXXXX."

::= { mib-2 yyy }

vmNotifications OBJECT IDENTIFIER ::= { vmMIB 0 }
vmObjects OBJECT IDENTIFIER ::= { vmMIB 1 }
vmConformance OBJECT IDENTIFIER ::= { vmMIB 2 }


```
-- Textual conversion definitions
```

```
--
```

```
VirtualMachineIndex ::= TEXTUAL-CONVENTION
```

```
    DISPLAY-HINT "d"
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "A unique value, greater than zero, identifying a
        virtual machine. The value for each virtual machine
        must remain constant at least from one re-initialization
        of the hypervisor to the next re-initialization."
```

```
    SYNTAX      Integer32 (1..2147483647)
```

```
VirtualMachineIndexOrZero ::= TEXTUAL-CONVENTION
```

```
    DISPLAY-HINT "d"
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "This textual convention is an extension of the
        VirtualMachineIndex convention. This extension permits
        the additional value of zero. The meaning of the value
        zero is object-specific and must therefore be defined as
        part of the description of any object which uses this
        syntax. Examples of the usage of zero might include
        situations where a virtual machine is unknown, or when
        none or all virtual machines need to be referenced."
```

```
    SYNTAX      Integer32 (0..2147483647)
```

```
VirtualMachineAdminState ::= TEXTUAL-CONVENTION
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "The administrative state of a virtual machine:
```

```
        running(1)    The administrative state of the virtual
                        machine indicating the virtual machine
                        should be brought online.
```

```
        suspended(2)  The administrative state of the virtual
                        machine where its memory and CPU execution
                        state has been saved to persistent store
                        and will be restored at next running(1).
```

```
        paused(3)     The administrative state indicating the
                        virtual machine is resident in memory but
                        is no longer scheduled to execute by the
                        hypervisor.
```

```
        shutdown(4)   The administrative state of the virtual
                        machine indicating the virtual machine
                        should be taken shuttingdown.
```


destroy(5) The administrative state of the virtual machine indicating the virtual machine should be forcibly shutdown. After the destroy operation, the administrative state should be automatically changed to shutdown."

SYNTAX INTEGER {
 running(1),
 suspend(2),
 pause(3),
 shutdown(4),
 destroy(5)
 }

VirtualMachineOperState ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"The operational state of a virtual machine:

unknown(1) The state is unknown, e.g., because the implementation failed to obtain the state from the hypervisor.

other(2) The state has been obtained but it is not a known state.

preparing(3) The virtual machine is currently in the process of preparation, e.g., allocating and initializing virtual storage are after creating (defining) virtual machine.

running(4) The virtual machine is currently running.

blocked(5) The virtual machine is currently blocked.

suspending(6) The virtual machine is currently in the process of suspending.

suspended(7) The virtual machine is currently suspended.

resuming(8) The virtual machine is currently in the process of resuming. This is a transient state from suspended state to running state.

paused(9) The virtual machine is currently paused.

migrating(10) The virtual machine is currently migrating.

shuttingdown(11)
The virtual machine is currently in the process of shutting down.

shutdown(12) The virtual machine is down.

crashed(13) The virtual machine has crashed."

SYNTAX INTEGER {
 unknown(1),
 other(2),
 preparing(3),
 running(4),
 blocked(5),
 suspending(6),
 suspended(7),
 resuming(8),
 paused(9),
 migrating(10),
 shuttingdown(11),
 shutdown(12),
 crashed(13)
}

VirtualMachineAutoStart ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"The autostart configuration of a virtual machine:

unknown(1) The autostart configuration is unknown, e.g., because the implementation failed to obtain the autostart configuration from the hypervisor. (read-only)

enable(2) The autostart configuration of the virtual machine is enabled.

disable(3) The autostart configuration of the virtual machine is disabled."

SYNTAX INTEGER {
 unknown(1),
 enable(2),
 disable(3)
}

VirtualMachinePersistent ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"This value indicates whether a virtual machine has a persistent configuration which means the virtual machine will still exist after shutting down:

unknown(1) The persistent configuration is unknown, e.g., because the implementation failed to obtain the persistent configuration from the hypervisor. (read-only)

persistent(2) The virtual machine is persistent.

transient(3) The virtual machine is transient, i.e., the virtual machine does not exist after its power-off."

SYNTAX INTEGER {
 unknown(1),
 persistent(2),
 transient(3)
}

VirtualMachineCpuIndex ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"A unique value, greater than zero, identifying a virtual CPU assigned to a virtual machine. The value for each virtual CPU must remain constant at least from one re-initialization of the virtual machine to the next re-initialization."

SYNTAX Integer32 (1..2147483647)

VirtualMachineStorageIndex ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"A unique value, greater than zero, identifying a virtual storage device allocated to a virtual machine. The value for each virtual storage device must remain constant at least from one re-initialization of the virtual machine to the next re-initialization."

SYNTAX Integer32 (1..2147483647)

VirtualMachineStorageSourceType ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"The source type of a virtual storage device:

unknown(1) The source type is unknown, e.g., because
 the implementation failed to obtain the
 media type from the hypervisor.

other(2) The source type is other than those
 defined in this conversion.

block(3) The source type is a block device.

raw(4) The source type is a raw-formatted file.

sparse(5) The source type is a sparse file.

network(6) The source type is a network device."

SYNTAX INTEGER {
 unknown(1),
 other(2),
 block(3),
 raw(4),
 sparse(5),
 network(6)
 }

VirtualMachineStorageAccess ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"The access permission of a virtual storage:

readwrite(1) The virtual storage is a read-write
 device.

readonly(2) The virtual storage is a read-only
 device."

SYNTAX INTEGER {
 readwrite(1),
 readonly(2)
 }

VirtualMachineStorageMediaType ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"The media type of a virtual storage device:

unknown(1) The media type is unknown, e.g., because
 the implementation failed to obtain the
 media type from the hypervisor.

other(2) The media type is other than those

defined in this conversion.

hardDisk(3) The media type is hard disk.

opticalDisk(4) The media type is optical disk."

```
SYNTAX          INTEGER {
                    other(1),
                    unknown(2),
                    hardDisk(3),
                    opticalDisk(4)
                }
```

VirtualMachineNetworkIndex ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"A unique value, greater than zero, identifying a virtual network interface allocated to a virtual machine. The value for each virtual network interface must remain constant at least from one re-initialization of the virtual machine to the next re-initialization."

SYNTAX Integer32 (1..2147483647)

VirtualMachineList ::= TEXTUAL-CONVENTION

DISPLAY-HINT "1x"

STATUS current

DESCRIPTION

"Each octet within this value specifies a set of eight Virtual Machine vmIndex, with the first octet specifying Virtual Machine 1 through 8, the second octet specifying Virtual Machine 9 through 16, etc. Within each octet, the most significant bit represents the lowest numbered vmIndex, and the least significant bit represents the highest numbered vmIndex. Thus, each Virtual Machine of the host is represented by a single bit within the value of this object. If that bit has a value of '1', then that Virtual Machine is included in the set of Virtual Machines; the Virtual Machine is not included if its bit has a value of '0'."

SYNTAX OCTET STRING

-- The hypervisor group

--

-- A collection of objects common to all hypervisors.

--

vmHypervisor OBJECT IDENTIFIER ::= { vmObjects 1 }

vmHvSoftware OBJECT-TYPE

SYNTAX SnmpAdminString (SIZE (0..255))
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "A textual description of the hypervisor software. This
 value should not include its version, and it should be
 included in `vmHvVersion`."
::= { vmHypervisor 1 }

vmHvVersion OBJECT-TYPE

SYNTAX SnmpAdminString (SIZE (0..255))
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "A textual description of the version of the hypervisor
 software."
::= { vmHypervisor 2 }

vmHvObjectID OBJECT-TYPE

SYNTAX OBJECT IDENTIFIER
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The vendor's authoritative identification of the
 hypervisor software contained in the entity. This value
 is allocated within the SMI enterprises
 subtree (1.3.6.1.4.1). Note that this is different from
 sysObjectID in the SNMPv2-MIB [[RFC3418](#)] because
 sysObjectID is not the identification of the hypervisor
 software but the device, firmware, or management
 operating system."
::= { vmHypervisor 3 }

vmHvUpTime OBJECT-TYPE

SYNTAX TimeTicks
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The time (in centi-seconds) since the hypervisor was
 last re-initialized. Note that this is different from
 sysUpTime in the SNMPv2-MIB [[RFC3418](#)] and hrSystemUptime
 in the HOST-RESOURCES-MIB [[RFC2790](#)] because sysUpTime is
 the uptime of the network management portion of the
 system, and hrSystemUptime is the uptime of the
 management operating system but not the hypervisor
 software."
::= { vmHypervisor 4 }


```
-- The virtual machine information
--
-- A collection of objects common to all virtual machines.
--
vmNumber OBJECT-TYPE
    SYNTAX      Integer32 (0..2147483647)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of virtual machines (regardless of their
        current state) present on this hypervisor."
    ::= { vmObjects 2 }

vmTableLastChange OBJECT-TYPE
    SYNTAX      TimeTicks
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of vmHvUpTime at the time of the last creation
        or deletion of an entry in the vmTable."
    ::= { vmObjects 3 }

vmTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF VmEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of virtual machine entries. The number of
        entries is given by the value of vmNumber."
    ::= { vmObjects 4 }

vmEntry OBJECT-TYPE
    SYNTAX      VmEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry containing management information applicable
        to a particular virtual machine."
    INDEX      { vmIndex }
    ::= { vmTable 1 }

VmEntry ::=
    SEQUENCE {
        vmIndex          VirtualMachineIndex,
        vmName           SnmpAdminString,
        vmUUID           UUIDorZero,
        vmOSType         SnmpAdminString,
        vmAdminState     VirtualMachineAdminState,
```



```
    vmOperState          VirtualMachineOperState,
    vmAutoStart          VirtualMachineAutoStart,
    vmPersistent         VirtualMachinePersistent,
    vmCurCpuNumber      Integer32,
    vmMinCpuNumber       Integer32,
    vmMaxCpuNumber       Integer32,
    vmMemUnit            Integer32,
    vmCurMem            Integer32,
    vmMinMem             Integer32,
    vmMaxMem             Integer32,
    vmUpTime             TimeTicks,
    vmCpuTime            Counter64
}
```

vmIndex OBJECT-TYPE

```
SYNTAX          VirtualMachineIndex
MAX-ACCESS      not-accessible
STATUS          current
DESCRIPTION
    "A unique value, greater than zero, identifying the
    virtual machine. The value assigned to a given Virtual
    machine may not persist across a reboot. A command
    generator must use the vmUUID to identify a given
    Virtual Machine of interest."
::= { vmEntry 1 }
```

vmName OBJECT-TYPE

```
SYNTAX          SnmpAdminString (SIZE (0..255))
MAX-ACCESS      read-only
STATUS          current
DESCRIPTION
    "A textual name of the virtual machine."
::= { vmEntry 2 }
```

vmUUID OBJECT-TYPE

```
SYNTAX          UUIDorZero
MAX-ACCESS      read-only
STATUS          current
DESCRIPTION
    "The virtual machine's 128-bit UUID or the zero-length
    string when a UUID is not available. The UUID if set
    must uniquely identify a VM from all other Virtual
    Machines in an administrative region. (*mrm -note-
    explain case when this value may be empty."
::= { vmEntry 3 }
```

vmOSType OBJECT-TYPE

```
SYNTAX          SnmpAdminString (SIZE (0..255))
```


MAX-ACCESS read-only

STATUS current

DESCRIPTION

"A textual description containing operating system information installed on the virtual machine. This value corresponds to the operating system the hypervisor assumes to be running when the virtual machine is started. This may differ from the actual operating system in case the virtual machine boots into a different operating system."

::= { vmEntry 4 }

vmAdminState OBJECT-TYPE

SYNTAX VirtualMachineAdminState

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The administrative power state of the virtual machine. Note that a virtual machine is supposed to be resumed when vmAdminState of the virtual machine is changed from pause(3) to on(1)."

::= { vmEntry 5 }

vmOperState OBJECT-TYPE

SYNTAX VirtualMachineOperState

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The current operational state of the virtual machine."

::= { vmEntry 6 }

vmAutoStart OBJECT-TYPE

SYNTAX VirtualMachineAutoStart

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The autostart configuration of the virtual machine."

::= { vmEntry 7 }

vmPersistent OBJECT-TYPE

SYNTAX VirtualMachinePersistent

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This value indicates whether the virtual machine has a persistent configuration which means the virtual machine will still exist after shutting down."

::= { vmEntry 8 }

vmCurCpuNumber OBJECT-TYPE

SYNTAX Integer32 (0..2147483647)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The number of virtual CPUs currently assigned to the virtual machine."

::= { vmEntry 9 }

vmMinCpuNumber OBJECT-TYPE

SYNTAX Integer32 (-1|0..2147483647)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The minimum number of virtual CPUs that are assigned to the virtual machine when it is in a power-on state. The value -1 indicates that there is no hard boundary for the minimum number of virtual CPUs. Changes to this object may not persist across restarts of the hypervisor."

::= { vmEntry 10 }

vmMaxCpuNumber OBJECT-TYPE

SYNTAX Integer32 (-1|0..2147483647)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The maximum number of virtual CPUs that are assigned to the virtual machine when it is in a power-on state. The value -1 indicates that there is no limit. Changes to this object may not persist across restarts of the hypervisor."

::= { vmEntry 11 }

vmMemUnit OBJECT-TYPE

SYNTAX Integer32 (1..2147483647)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The multiplication unit for vmCurMem, vmMinMem, and vmMaxMem. For example, when this value is 1024, the memory size unit for vmCurMem, vmMinMem, and vmMaxMem is KiB."

::= { vmEntry 12 }

vmCurMem OBJECT-TYPE

SYNTAX Integer32 (0..2147483647)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The current memory size currently allocated to the virtual memory module in the unit designated by vmMemUnit."

::= { vmEntry 13 }

vmMinMem OBJECT-TYPE

SYNTAX Integer32 (-1|0..2147483647)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The minimum memory size defined to the virtual machine in the unit designated by vmMemUnit. The value -1 indicates that there is no hard boundary for the minimum memory size. Changes to this object may not persist across the restart of the hypervisor."

::= { vmEntry 14 }

vmMaxMem OBJECT-TYPE

SYNTAX Integer32 (-1|0..2147483647)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The maximum memory size defined to the virtual machine in the unit designated by vmMemUnit. The value -1 indicates that there is no limit. Changes to this object may not persist across the restart of the hypervisor."

::= { vmEntry 15 }

vmUpTime OBJECT-TYPE

SYNTAX TimeTicks

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The time (in centi-seconds) since the administrative state of the virtual machine was last changed to power on."

::= { vmEntry 16 }

vmCpuTime OBJECT-TYPE

SYNTAX Counter64

UNITS "microsecond"

MAX-ACCESS read-only

STATUS current

DESCRIPTION


```

        "The total CPU time used in microsecond.  If the number
        of virtual CPUs is larger than 1, vmCpuTime may exceed
        real time."
 ::= { vmEntry 17 }

-- The virtual CPU on each virtual machines
vmCpuTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF VmCpuEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The table of virtual CPUs provided by the hypervisor."
    ::= { vmObjects 5 }

vmCpuEntry OBJECT-TYPE
    SYNTAX      VmCpuEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry for one virtual processor assigned to a
        virtual machine."
    INDEX { vmIndex, vmCpuIndex }
    ::= { vmCpuTable 1 }

VmCpuEntry ::=
    SEQUENCE {
        vmCpuIndex          VirtualMachineCpuIndex,
        vmCpuCoreTime       Counter64
    }

vmCpuIndex OBJECT-TYPE
    SYNTAX      VirtualMachineCpuIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A unique value identifying a virtual CPU assigned to
        the virtual machine."
    ::= { vmCpuEntry 1 }

vmCpuCoreTime OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "microsecond"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The total CPU time used by this virtual CPU in
        microsecond."
    ::= { vmCpuEntry 2 }

```


-- The virtual CPU affinity on each virtual machines

vmCpuAffinityTable OBJECT-TYPE

SYNTAX SEQUENCE OF VmCpuAffinityEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"A list of CPU affinity entries of a virtual CPU."

::= { vmObjects 6 }

vmCpuAffinityEntry OBJECT-TYPE

SYNTAX VmCpuAffinityEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"An entry containing CPU affinity associated with a particular virtual machine."

INDEX { vmIndex, vmCpuIndex, vmCpuPhysIndex }

::= { vmCpuAffinityTable 1 }

VmCpuAffinityEntry ::=

SEQUENCE {

vmCpuPhysIndex Integer32,

vmCpuAffinity Integer32

}

vmCpuPhysIndex OBJECT-TYPE

SYNTAX Integer32 (1..2147483647)

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"A value identifying a physical CPU on the hypervisor. On systems implementing the HOST-RESOURCES-MIB, the value must be the same value that is used as the index in the hrProcessorTable (hrDeviceIndex)."

::= { vmCpuAffinityEntry 2 }

vmCpuAffinity OBJECT-TYPE

SYNTAX INTEGER {

unknown(0), -- unknown

enable(1), -- enabled

disable(2) -- disabled

}

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The CPU affinity of this virtual CPU to the physical CPU represented by `vmCpuPhysIndex'."

::= { vmCpuAffinityEntry 3 }


```
-- The virtual storage devices on each virtual machine. This
-- document defines some overlapped objects with hrStorage in
-- HOST-RESOURCES-MIB [RFC2790], because virtual resources shall be
-- allocated from the hypervisor's resources, which is the `host
-- resources'
```

```
vmStorageTable OBJECT-TYPE
```

```
    SYNTAX          SEQUENCE OF VmStorageEntry
```

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

```
    STATUS          current
```

```
    DESCRIPTION
```

```
        "The conceptual table of virtual storage devices
        attached to the virtual machine."
```

```
    ::= { vmObjects 7 }
```

```
vmStorageEntry OBJECT-TYPE
```

```
    SYNTAX          VmStorageEntry
```

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

```
    STATUS          current
```

```
    DESCRIPTION
```

```
        "An entry for one virtual storage device attached to the
        virtual machine."
```

```
    INDEX { vmStorageVmIndex, vmStorageIndex }
```

```
    ::= { vmStorageTable 1 }
```

```
VmStorageEntry ::=
```

```
    SEQUENCE {
```

```
        vmStorageVmIndex      VirtualMachineIndexOrZero,
        vmStorageIndex        VirtualMachineStorageIndex,
        vmStorageParent        Integer32,
        vmStorageSourceType    VirtualMachineStorageSourceType,
        vmStorageSourceTypeString
                                SnmpAdminString,
        vmStorageResourceID    SnmpAdminString,
        vmStorageAccess        VirtualMachineStorageAccess,
        vmStorageMediaType     VirtualMachineStorageMediaType,
        vmStorageMediaTypeString
                                SnmpAdminString,
        vmStorageSizeUnit      Integer32,
        vmStorageDefinedSize    Integer32,
        vmStorageAllocatedSize  Integer32,
        vmStorageReadIOs        Counter64,
        vmStorageWriteIOs       Counter64
```

```
    }
```

```
vmStorageVmIndex OBJECT-TYPE
```

```
    SYNTAX          VirtualMachineIndexOrZero
```

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

```
    STATUS          current
```


DESCRIPTION

"This value identifies the virtual machine (guest) this storage device has been allocated to. The value zero indicates that the storage device is currently not allocated to any virtual machines."

::= { vmStorageEntry 1 }

vmStorageIndex OBJECT-TYPE

SYNTAX VirtualMachineStorageIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"A unique value identifying a virtual storage device allocated to the virtual machine."

::= { vmStorageEntry 2 }

vmStorageParent OBJECT-TYPE

SYNTAX Integer32 (0..2147483647)

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The value of hrStorageIndex which is the parent (i.e., physical) device of this virtual device on systems implementing the HOST-RESOURCES-MIB. The value zero denotes this virtual device is not any child represented in the hrStorageTable."

::= { vmStorageEntry 3 }

vmStorageSourceType OBJECT-TYPE

SYNTAX VirtualMachineStorageSourceType

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The source type of the virtual storage device."

::= { vmStorageEntry 4 }

vmStorageSourceTypeString OBJECT-TYPE

SYNTAX SnmpAdminString (SIZE (0..255))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"A (detailed) textual string of the source type of the virtual storage device. For example, this represents the specific format name of the sparse file."

::= { vmStorageEntry 5 }

vmStorageResourceID OBJECT-TYPE

SYNTAX SnmpAdminString (SIZE (0..255))

MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "A textual string that represents the resource
 identifier of the virtual storage. For example, this
 contains the path to the disk image file that
 corresponds to the virtual storage."
::= { vmStorageEntry 6 }

vmStorageAccess OBJECT-TYPE
SYNTAX VirtualMachineStorageAccess
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The access permission of the virtual storage device."
::= { vmStorageEntry 7 }

vmStorageMediaType OBJECT-TYPE
SYNTAX VirtualMachineStorageMediaType
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The media type of the virtual storage device."
::= { vmStorageEntry 8 }

vmStorageMediaTypeString OBJECT-TYPE
SYNTAX SnmpAdminString (SIZE (0..255))
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "A (detailed) textual string of the virtual storage
 media. For example, this represents the specific driver
 name of the emulated media such as `IDE' and `SCSI'.
::= { vmStorageEntry 9 }

vmStorageSizeUnit OBJECT-TYPE
SYNTAX Integer32 (1..2147483647)
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The multiplication unit for vmStorageDefinedSize and
 vmStorageAllocatedSize. For example, when this value is
 1048576, the storage size unit for vmStorageDefinedSize
 and vmStorageAllocatedSize is MiB."
::= { vmStorageEntry 10 }

vmStorageDefinedSize OBJECT-TYPE
SYNTAX Integer32 (-1|0..2147483647)

MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The defined virtual storage size defined in the unit
 designated by vmStorageSizeUnit. If this information is
 not available, this value shall be -1."
 ::= { vmStorageEntry 11 }

vmStorageAllocatedSize OBJECT-TYPE

SYNTAX Integer32 (-1|0..2147483647)
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The storage size allocated to the virtual storage from
 a physical storage in the unit designated by
 vmStorageSizeUnit. When the virtual storage is block
 device or raw file, this value and vmStorageDefinedSize
 are supposed to equal. This value must not be different
 from vmStorageDefinedSize when vmStorageSourceType is
 `block' or `raw'. If this information is not available,
 this value shall be -1."
 ::= { vmStorageEntry 12 }

vmStorageReadIOs OBJECT-TYPE

SYNTAX Counter64
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The number of read I/O requests."
 ::= { vmStorageEntry 13 }

vmStorageWriteIOs OBJECT-TYPE

SYNTAX Counter64
MAX-ACCESS read-only
STATUS current
DESCRIPTION
 "The number of write I/O requests."
 ::= { vmStorageEntry 14 }

-- The virtual network interfaces on each virtual machine.

vmNetworkTable OBJECT-TYPE

SYNTAX SEQUENCE OF VmNetworkEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION
 "The conceptual table of virtual network interfaces
 attached to the virtual machine."
 ::= { vmObjects 8 }

vmNetworkEntry OBJECT-TYPE

SYNTAX VmNetworkEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"An entry for one virtual storage device attached to the virtual machine."

INDEX { vmIndex, vmNetworkIndex }

::= { vmNetworkTable 1 }

VmNetworkEntry ::=

SEQUENCE {

vmNetworkIndex VirtualMachineNetworkIndex,

vmNetworkIfIndex InterfaceIndexOrZero,

vmNetworkParent InterfaceIndexOrZero,

vmNetworkModel SnmpAdminString,

vmNetworkPhysAddress PhysAddress

}

vmNetworkIndex OBJECT-TYPE

SYNTAX VirtualMachineNetworkIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"A unique value identifying a virtual network interface allocated to the virtual machine."

::= { vmNetworkEntry 1 }

vmNetworkIfIndex OBJECT-TYPE

SYNTAX InterfaceIndexOrZero

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The value of ifIndex which corresponds to this virtual network interface. If this device is not represented in the ifTable, then this value shall be zero."

::= { vmNetworkEntry 2 }

vmNetworkParent OBJECT-TYPE

SYNTAX InterfaceIndexOrZero

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The value of ifIndex which corresponds to the parent (i.e., physical) device of this virtual device on. The value zero denotes this virtual device is not any child represented in the ifTable."

::= { vmNetworkEntry 3 }

vmNetworkModel OBJECT-TYPE

SYNTAX SnmpAdminString (SIZE (0..255))

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"A textual string containing the (emulated) model of virtual network interface. For example, this value is 'virtio' when the emulation driver model is virtio."

::= { vmNetworkEntry 4 }

vmNetworkPhysAddress OBJECT-TYPE

SYNTAX PhysAddress

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The MAC address of the virtual network interface."

::= { vmNetworkEntry 5 }

-- Notification definitions:**vmPerVMNotificationsEnabled OBJECT-TYPE**

SYNTAX TruthValue

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"Indicates if notification generator will send notifications per VM."

::= { vmObjects 9 }

vmBulkNotificationsEnabled OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"Indicates if notification generator will send notifications per set of VMs."

::= { vmObjects 10 }

vmAffectedVMs OBJECT-TYPE

SYNTAX VirtualMachineList

MAX-ACCESS accessible-for-notify

STATUS current

DESCRIPTION

"A complete list of Virtual Machines whose state has changed. This object is the only object sent with bulk notifications."

::= { vmObjects 11 }

vmRunning NOTIFICATION-TYPE

```
OBJECTS      {
                vmName,
                vmUUID,
                vmOperState
            }
```

```
STATUS      current
```

DESCRIPTION

"This notification is generated when the operational state of a virtual machine has been changed to `running' from some other state. The other state is indicated by the included value of vmOperState."

```
::= { vmNotifications 1 }
```

vmShutdown NOTIFICATION-TYPE

```
OBJECTS      {
                vmName,
                vmUUID,
                vmOperState
            }
```

```
STATUS      current
```

DESCRIPTION

"This notification is generated when the operational state of a virtual machine has been changed to `shutdown' from some other state. The other state is indicated by the included value of vmOperState."

```
::= { vmNotifications 2 }
```

vmPaused NOTIFICATION-TYPE

```
OBJECTS      {
                vmName,
                vmUUID,
                vmOperState
            }
```

```
STATUS      current
```

DESCRIPTION

"This notification is generated when the operational state of a virtual machine has been changed to `paused' from some other state. The other state is indicated by the included value of vmOperState."

```
::= { vmNotifications 3 }
```

vmSuspended NOTIFICATION-TYPE

```
OBJECTS      {
                vmName,
                vmUUID,
                vmOperState
            }
```



```
STATUS          current
DESCRIPTION
    "This notification is generated when the operational
    state of a virtual machine has been changed to
    `suspended' from some other state.  The other state is
    indicated by the included value of vmOperState."
::= { vmNotifications 4 }

vmCrashed NOTIFICATION-TYPE
OBJECTS          {
    vmName,
    vmUUID,
    vmOperState
}
STATUS          current
DESCRIPTION
    "This notification is generated when a virtual machine
    has been crashed.  The previos state of the virtual
    machine is indicated by the included value of
    vmOperState."
::= { vmNotifications 5 }

vmDeleted NOTIFICATION-TYPE
OBJECTS          {
    vmName,
    vmUUID,
    vmOperState,
    vmPersistent
}
STATUS          current
DESCRIPTION
    "This notification is generated when a virtual machine
    has been deleted.  The prior state of the virtual
    machine is indicated by the included value of
    vmOperState."
::= { vmNotifications 6 }

vmBulkRunning NOTIFICATION-TYPE
OBJECTS          {
    vmAffectedVMs
}
STATUS          current
DESCRIPTION
    "This notification is generated when the operational
    state of one or more virtual machine has been changed to
    `running' from a all prior states except for 'running.'
    Management stations are encouraged to subsequently
    poll the subset of VMs of interest for vmOperState."
```



```
::= { vmNotifications 7 }
```

vmBulkShutdown NOTIFICATION-TYPE

```
OBJECTS      {  
                vmAffectedVMs  
            }
```

```
STATUS      current
```

DESCRIPTION

"This notification is generated when the operational state of one or more virtual machine has been changed to `shutdown` from a state other than `shutdown`. Management stations are encouraged to subsequently poll the subset of VMs of interest for vmOperState."

```
::= { vmNotifications 8 }
```

vmBulkPaused NOTIFICATION-TYPE

```
OBJECTS      {  
                vmAffectedVMs  
            }
```

```
STATUS      current
```

DESCRIPTION

"This notification is generated when the operational state of one or more virtual machines have been changed to `paused` from a state other than `paused`. Management stations are encouraged to subsequently poll the subset of VMs of interest for vmOperState."

```
::= { vmNotifications 9 }
```

vmBulkSuspended NOTIFICATION-TYPE

```
OBJECTS      {  
                vmAffectedVMs  
            }
```

```
STATUS      current
```

DESCRIPTION

"This notification is generated when the operational state of one or more virtual machines have been changed to `suspended` from a state other than `suspended`. Management stations are encouraged to subsequently poll the subset of VMs of interest for vmOperState."

```
::= { vmNotifications 10 }
```

vmBulkCrashed NOTIFICATION-TYPE

```
OBJECTS      {  
                vmAffectedVMs  
            }
```

```
STATUS      current
```

DESCRIPTION


```
        "This notification is generated when one or more virtual
        machines have been crashed. Management stations are
        encouraged to subsequently poll the subset of VMs of
        interest for vmOperState."
 ::= { vmNotifications 11 }

vmBulkDeleted NOTIFICATION-TYPE
    OBJECTS      {
                    vmAffectedVMs
                }
    STATUS        current
    DESCRIPTION   "This notification is generated when one or more virtual
                  machines have been deleted. Management stations are
                  encouraged to subsequently poll the subset of VMs of
                  interest for vmOperState."
 ::= { vmNotifications 12 }

-- Compliance definitions:
vmGroups      OBJECT IDENTIFIER ::= { vmConformance 1 }
vmCompliances OBJECT IDENTIFIER ::= { vmConformance 2 }

vmFullCompliances MODULE-COMPLIANCE
    STATUS        current
    DESCRIPTION   "Compliance statement for implementations supporting
                  read/write access, according to the object definitions."
    MODULE        -- this module
    MANDATORY-GROUPS {
        vmHypervisorGroup,
        vmVirtualMachineGroup,
        vmCpuGroup,
        vmCpuAffinityGroup,
        vmStorageGroup,
        vmNetworkGroup
    }
    GROUP vmPerVMNotificationOptionalGroup
    DESCRIPTION   "Support for per-VM notifications is optional. If not
                  implemented then vmPerVMNotificationsEnabled must report
                  false(2)."
```

```
    GROUP vmBulkNotificationsVariablesGroup
    DESCRIPTION   "Necessary only if vmPerVMNotificationOptionalGroup is
                  implemented."
```

```
    GROUP vmBulkNotificationOptionalGroup
    DESCRIPTION   "Support for bulk notifications is optional. If not
```



```
    implemented then vmBulkNotificationsEnabled must report  
    false(2)."
```

```
::= { vmCompliances 1 }
```

```
vmReadOnlyCompliances MODULE-COMPLIANCE
```

```
    STATUS          current
```

```
    DESCRIPTION
```

```
        "Compliance statement for implementations supporting  
        only readonly access."
```

```
    MODULE          -- this module
```

```
    MANDATORY-GROUPS {
```

```
        vmHypervisorGroup,  
        vmVirtualMachineGroup,  
        vmCpuGroup,  
        vmCpuAffinityGroup,  
        vmStorageGroup,  
        vmNetworkGroup
```

```
    }
```

```
    OBJECT vmAdminState
```

```
    MIN-ACCESS      read-only
```

```
    DESCRIPTION
```

```
        "Write access is not required."
```

```
    OBJECT vmAutoStart
```

```
    MIN-ACCESS      read-only
```

```
    DESCRIPTION
```

```
        "Write access is not required."
```

```
    OBJECT vmMinCpuNumber
```

```
    MIN-ACCESS      read-only
```

```
    DESCRIPTION
```

```
        "Write access is not required."
```

```
    OBJECT vmMaxCpuNumber
```

```
    MIN-ACCESS      read-only
```

```
    DESCRIPTION
```

```
        "Write access is not required."
```

```
    OBJECT vmMinMem
```

```
    MIN-ACCESS      read-only
```

```
    DESCRIPTION
```

```
        "Write access is not required."
```

```
    OBJECT vmMaxMem
```

```
    MIN-ACCESS      read-only
```

```
    DESCRIPTION
```


"Write access is not required."

OBJECT vmCpuAffinity
MIN-ACCESS read-only
DESCRIPTION

"Write access is not required."

OBJECT vmPerVMNotificationsEnabled
MIN-ACCESS read-only
DESCRIPTION

"Write access is not required."

OBJECT vmBulkNotificationsEnabled
MIN-ACCESS read-only
DESCRIPTION

"Write access is not required."

::= { vmCompliances 2 }

vmHypervisorGroup OBJECT-GROUP

OBJECTS {
 vmHvSoftware,
 vmHvVersion,
 vmHvObjectID,
 vmHvUpTime,
 vmNumber,
 vmTableLastChange,
 vmPerVMNotificationsEnabled,
 vmBulkNotificationsEnabled
}

STATUS current

DESCRIPTION

"A collection of objects providing insight into the
hypervisor itself."

::= { vmGroups 1 }

vmVirtualMachineGroup OBJECT-GROUP

OBJECTS {
 -- vmIndex
 vmName,
 vmUUID,
 vmOSType,
 vmAdminState,
 vmOperState,
 vmAutoStart,
 vmPersistent,
 vmCurCpuNumber,
 vmMinCpuNumber,
 vmMaxCpuNumber,


```
        vmMemUnit,
        vmCurMem,
        vmMinMem,
        vmMaxMem,
        vmUpTime,
        vmCpuTime
    }
    STATUS          current
    DESCRIPTION
        "A collection of objects providing insight into the
        virtual machines) controlled by a hypervisor."
    ::= { vmGroups 2 }

vmCpuGroup OBJECT-GROUP
    OBJECTS {
        -- vmCpuIndex,
        vmCpuCoreTime
    }
    STATUS          current
    DESCRIPTION
        "A collection of objects providing insight into the
        virtual machines) controlled by a hypervisor."
    ::= { vmGroups 3 }

vmCpuAffinityGroup OBJECT-GROUP
    OBJECTS {
        -- vmCpuPhysIndex,
        vmCpuAffinity
    }
    STATUS          current
    DESCRIPTION
        "A collection of objects providing insight into the
        virtual machines) controlled by a hypervisor."
    ::= { vmGroups 4 }

vmStorageGroup OBJECT-GROUP
    OBJECTS {
        -- vmStorageVmIndex,
        -- vmStorageIndex,
        vmStorageParent,
        vmStorageSourceType,
        vmStorageSourceTypeString,
        vmStorageResourceID,
        vmStorageAccess,
        vmStorageMediaType,
        vmStorageMediaTypeString,
        vmStorageSizeUnit,
        vmStorageDefinedSize,
```



```
        vmStorageAllocatedSize,
        vmStorageReadIOs,
        vmStorageWriteIOs
    }
    STATUS          current
    DESCRIPTION
        "A collection of objects providing insight into the
        virtual storage devices controlled by a hypervisor."
    ::= { vmGroups 5 }

vmNetworkGroup OBJECT-GROUP
    OBJECTS {
        -- vmNetworkIndex,
        vmNetworkIfIndex,
        vmNetworkParent,
        vmNetworkModel,
        vmNetworkPhysAddress
    }
    STATUS          current
    DESCRIPTION
        "A collection of objects providing insight into the
        virtual network interfaces controlled by a hypervisor."
    ::= { vmGroups 6 }

vmPerVMNotificationOptionalGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
        vmRunning,
        vmShutdown,
        vmPaused,
        vmSuspended,
        vmCrashed,
        vmDeleted
    }
    STATUS          current
    DESCRIPTION
        "A collection of notifications for per-VM notification
        of changes to virtual machine state (vmOperState) as
        reported by a hypervisor."
    ::= { vmGroups 7 }

vmBulkNotificationsVariablesGroup OBJECT-GROUP
    OBJECTS {
        vmAffectedVMs
    }
    STATUS          current
    DESCRIPTION
        "The variables used in vmBulkNotificationOptionalGroup
        virtual network interfaces controlled by a hypervisor."
```



```
::= { vmGroups 8 }
```

```
vmBulkNotificationOptionalGroup NOTIFICATION-GROUP
```

```
  NOTIFICATIONS {
```

```
    vmBulkRunning,
```

```
    vmBulkShutdown,
```

```
    vmBulkPaused,
```

```
    vmBulkSuspended,
```

```
    vmBulkCrashed,
```

```
    vmBulkDeleted
```

```
  }
```

```
  STATUS          current
```

```
  DESCRIPTION
```

```
    "A collection of notifications for bulk notification of  
    changes to virtual machine state (vmOperState) as  
    reported by a given hypervisor."
```

```
::= { vmGroups 9 }
```

```
END
```


4. IANA Considerations

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

Descriptor -----	OBJECT IDENTIFIER value -----
vmMIB	{ mib-2 TBD }

5. Security Considerations

There are a number of management objects defined in this MIB that have 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 hypervisor and virtual machine operations.

There are a number of managed objects in this MIB that may contain sensitive information. The objects in the vmHvSoftware and vmHvVersion list information about the hypervisor's software and version. Some may wish not to disclose to others which software they are running. Further, an inventory of the running software and versions may be helpful to an attacker who hopes to exploit software bugs in certain applications. Moreover, the objects in the vmTable, vmCpuTable, vmCpuAffinityTable, vmStorageTable and vmNetworkTable list information about the virtual machines and their virtual resource allocation. Some may wish not to disclose to others how many and what virtual machines they are operating.

It is thus important to control even GET access to these objects and possibly to even encrypt the values of these object when sending them over the network via SNMP. Not all versions of SNMP provide features for such a secure environment.

It is recommended that attention be specifically given to implementing the MAX-ACCESS clause in a number of objects, including vmAdminState, vmAutoStart, vmMinCpuNumber, vmMaxCpuNumber, vmMinMem, vmMaxMem, and vmCpuAffinity in scenarios that DO NOT use SNMPv3 strong security (i.e. authentication and encryption). Extreme caution must be used to minimize the risk of cascading security vulnerabilities when SNMPv3 strong security is not used. When SNMPv3 strong security is not used, these objects should have access of read-only, not read-create.

SNMPv1 by itself is not a secure environment. Even if the network itself is secure (for example by using IPsec), even then, there is no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB.

It is recommended that the implementers consider the security features as provided by the SNMPv3 framework. Specifically, the use of the User-based Security Model [[RFC3414](#)] and the View-based Access Control Model [[RFC3415](#)] is recommended.

It is then a customer/user responsibility to ensure that the SNMP entity giving access to an instance of this MIB, 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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The authors like to thank Randy Presuhn and David Black for providing helpful comments during the development of this specification.

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