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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 monitor).

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Internet-Draft

Virtual Machine Monitoring MIB

October 2013

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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 monitor). 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. However, this MIB module attempts to generalize the managed objects to support other 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](#)].

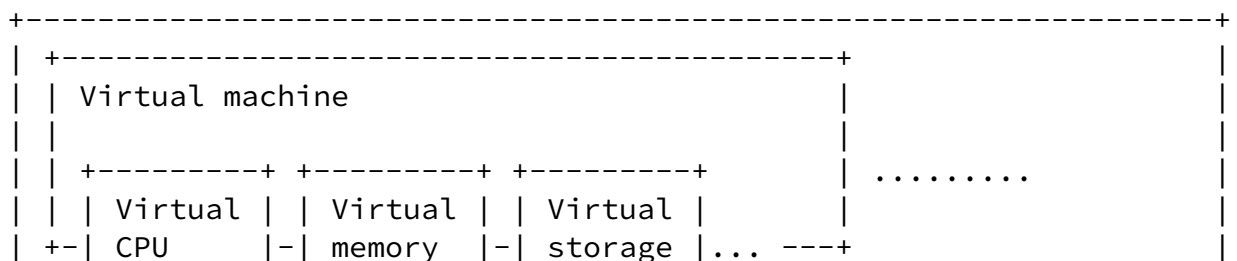
## 2. The Internet-Standard Management Framework

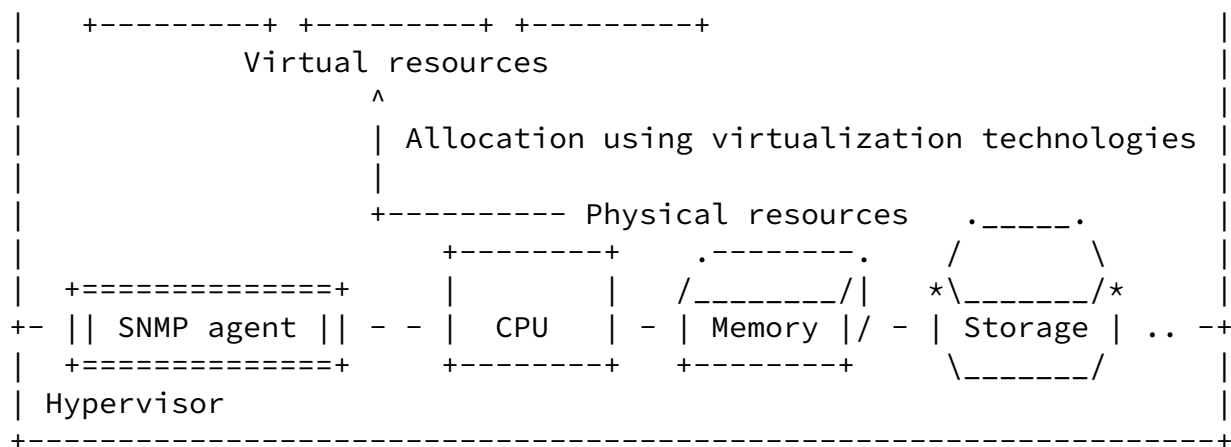
For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to [section 7 of RFC 3410](#) [RFC3410]. Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed 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

On the common implementations of hypervisor softwares, a hypervisor allocates virtual resources such as virtual CPUs, virtual memory, virtual storage devices, and virtual network interfaces to virtual machines 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. This document specifies four specific types of virtual resources that are common to general hypervisors; CPUs (processors), memory, network interfaces, and storage devices.





A hypervisor allocates virtual resources such as virtual CPUs, virtual memory, virtual storage devices, and virtual network interfaces to virtual machines from physical resources.

Figure 1: An example of a virtualization environment

As shown in Figure 1, 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 do not take different values when the vmStorageSourceType is 'block' or 'raw'.

The other objects related to virtual machines such as management IP addresses of a virtual machine are not included in this MIB module because this MIB module defines the objects common to general hypervisors but they are specific to some hypervisors. They may be included in the entLogicalTable of ENTITY-MIB [[RFC4133](#)]. The objects

related to virtual switches are not also included in this MIB module though virtual switches shall be placed on a hypervisor. This is because the virtual network interfaces are the lowest abstraction of network resources allocated to a virtual machine. Instead of including the objects related to virtual switches, for example, BRIDGE-MIB [RFC4188] and Q-BRIDGE-MIB [RFC4363] could be used.

### 3.2. Overview of the MIB Module

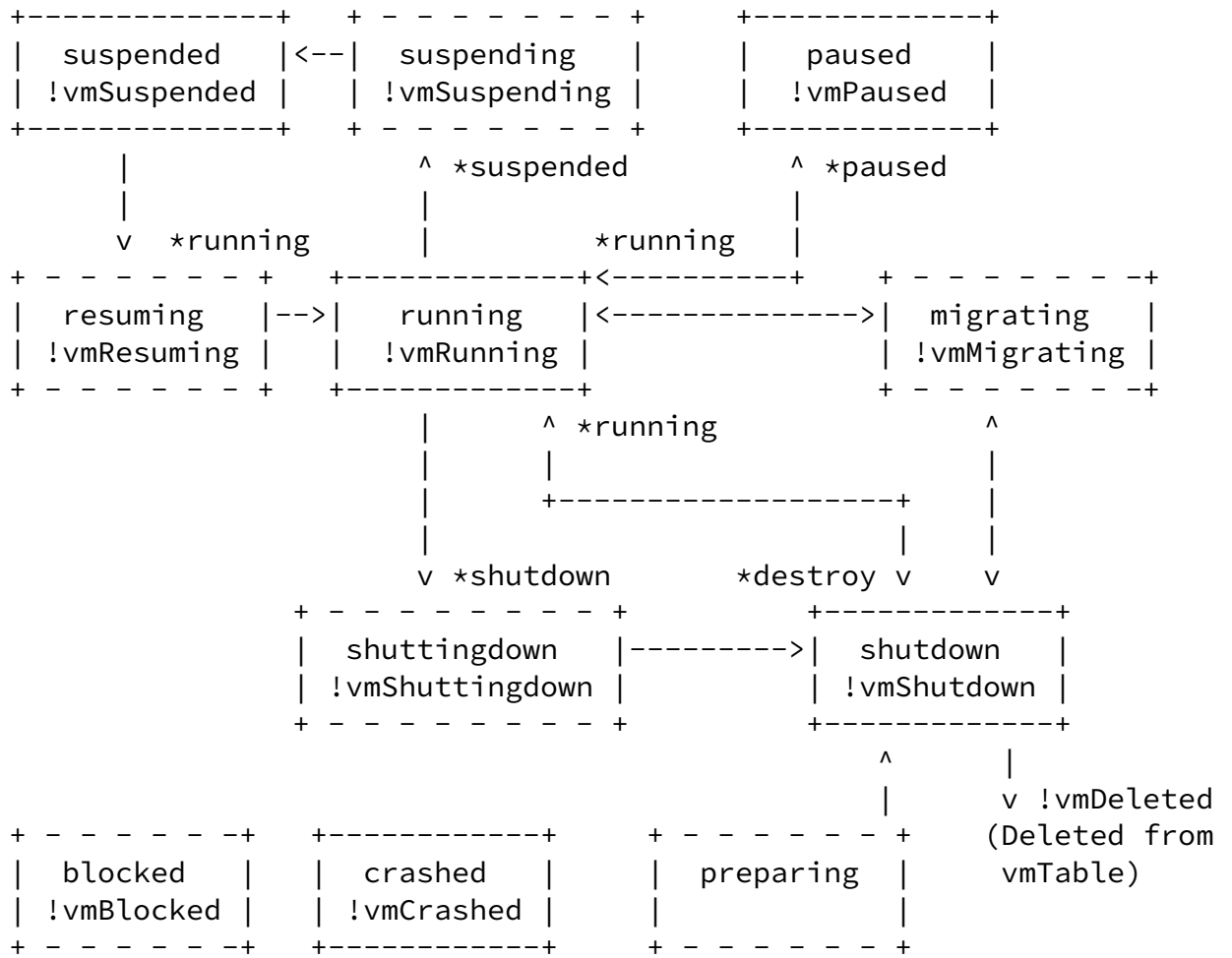
The MIB module is organized into a group of scalars and tables. The scalars below `hypervisor' provide basic information about the hypervisor. The `vmTable' lists the virtual machines (guests) that are known to the hypervisor. The `vmCpuTable' provides the mapping table of virtual CPUs to virtual machines, including CPU time used by each virtual CPU. The `vmCpuAffinityTable' provides the affinity of each virtual CPU to a physical CPU. The `vmStorageTable' provides the list of virtual storage devices and their mapping to virtual machines. In case that an entry in the `vmStorageTable' has a corresponding parent physical storage device managed in `hrStorageTable' of HOST-RESOURCES-MIB [RFC2790], the entry contains a pointer `vmStorageParent' to the physical storage device. The `vmNetworkTable' provides the list of virtual network interfaces and their mapping to virtual machines. Each entry in the `vmNetworkTable' also provides a pointer `vmNetworIfIndex' to the corresponding entry in the `ifTable' of IF-MIB [RFC2863]. In case that an entry in the `vmNetworkTable' has a corresponding parent physical network interface managed in `ifTable' of IF-MIB, the entry contains a pointer `vmNetworkParent' to the physical network interface.

```

*: `vmAdminState' write access
!: Notification
+-----+ + - - - - - +
| finite | | transient |
| vmOperState | | vmOperState |
+-----+ + - - - - - +

```

=====



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 virtual machine (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]
    | +--vmShuttingdown(2) [vmName, vmUUID, vmOperState]
    | +--vmShutdown(3) [vmName, vmUUID, vmOperState]
    | +--vmPaused(4) [vmName, vmUUID, vmOperState]
    | +--vmSuspending(5) [vmName, vmUUID, vmOperState]
    | +--vmSuspended(6) [vmName, vmUUID, vmOperState]
    | +--vmResuming(7) [vmName, vmUUID, vmOperState]
    | +--vmMigrating(8) [vmName, vmUUID, vmOperState]
    | +--vmCrashed(9) [vmName, vmUUID, vmOperState]
    | +--vmBlocked(10) [vmName, vmUUID, vmOperState]
    | +--vmDeleted(11) [vmName, vmUUID, vmOperState, vmPersistent]
    | +--vmBulkRunning(12) [vmAffectedVMs]
    | +--vmBulkShutdown(13) [vmAffectedVMs]
    | +--vmBulkShuttingdown(14) [vmAffectedVMs]
    | +--vmBulkPaused(15) [vmAffectedVMs]
    | +--vmBulkSuspending(16) [vmAffectedVMs]
    | +--vmBulkSuspended(17) [vmAffectedVMs]
```

```

|   +--vmBulkResuming(18) [vmName, vmUUID, vmOperState]
|   +--vmBulkMigrating(19) [vmAffectedVMs]
|   +--vmBulkCrashed(20) [vmAffectedVMs]
|   +--vmBulkBlocked(21) [vmAffectedVMs]
|   +--vmBulkDeleted(22) [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)
|   |   +-- r-n VirtualMachineAutoStart
|   |   |   vmAutoStart(7)
|   |   +-- r-n VirtualMachinePersistent
|   |   |   vmPersistent(8)
|   |   +-- rwn Integer32              vmCurCpuNumber(9)
|   |   +-- rwn Integer32              vmMinCpuNumber(10)
|   |   +-- rwn Integer32              vmMaxCpuNumber(11)
|   |   +-- r-n Integer32              vmMemUnit(12)
|   |   +-- rwn 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 vmNetworIfIndex(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

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```
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 "201310130000Z"           -- 13 October 2013
```

```
  ORGANIZATION "IETF Operations and Management Area Working Group"
```

```
  CONTACT-INFO
```

```
    "
```

```
    WG E-mail: (To be added after approved by WG)
```

```
    Mailing list subscription info:
```

```
      http:// (To be added after approved by WG)
```

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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 "201310130000Z" -- 13 October 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 is currently online or 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 is currently offline or should be taken shutting down.

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(4)."

```
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 operational state of the virtual machine is unknown, e.g., because the implementation failed to obtain the state from the hypervisor.

other(2) The operational state of the virtual machine indicating that an operational state is obtained from the hypervisor but it is not a state defined in this MIB module.

preparing(3) The operational state of the virtual machine indicating the virtual machine is currently in the process of preparation,

e.g., allocating and initializing virtual storage after creating (defining) virtual machine.



- running(4) The operational state of the virtual machine indicating the virtual machine is currently executed but it is not in the process of preparing(3), suspending(6), resuming(8), migrating(10), and shuttingdown(11).
- blocked(5) The operational state of the virtual machine indicating the execution of the virtual machine is currently blocked, e.g., waiting for some action of the hypervisor to finish. This is a transient state from/to other states.
- suspending(6) The operational state of the virtual machine indicating the virtual machine is currently in the process of suspending to save its memory and CPU execution state to persistent store. This is a transient state from running(4) to suspended(7).
- suspended(7) The operational state of the virtual machine indicating the virtual machine is currently suspended, which means the memory and CPU execution state of the virtual machine are saved to persistent store. During this state, the virtual machine is not scheduled to execute by the hypervisor.
- resuming(8) The operational state of the virtual machine indicating the virtual machine is currently in the process of resuming to restore its memory and CPU execution state from persistent store. This is a transient state from suspended(7) to running(4).
- paused(9) The operational state of the virtual machine indicating the virtual machine is resident in memory but no longer scheduled to execute by the hypervisor.

- migrating(10) The operational state of the virtual machine indicating the virtual machine is currently in the process of migration from/to another hypervisor.
- shuttingdown(11) The operational state of the virtual machine indicating the virtual machine is currently in the process of shutting down. This is a transient state from running(4) to shutdown(12).
- shutdown(12) The operational state of the virtual machine indicating the virtual machine is down, and CPU execution is no longer scheduled by the hypervisor and its memory is not resident in the hypervisor.
- crashed(13) The operational state of the virtual machine indicating 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.

enable(2) The autostart configuration of the

virtual machine is enabled. The virtual machine should be automatically brought online at the next re-initialization of the hypervisor.

disable(3) The autostart configuration of the virtual machine is disabled. The virtual machine should not be automatically brought online at the next re-initialization of the hypervisor."

```
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, i.e., the virtual machine will exist after its shutting down.

transient(3) The virtual machine is transient, i.e., the virtual machine will not exist after its shutting down."

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

VirtualMachineCpuIndex ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"A unique value for each virtual machine, greater than zero, identifying a virtual CPU assigned to a virtual machine. The value for each virtual CPU must remain

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constant at least from one re-initialization of the hypervisor to the next re-initialization."

SYNTAX Integer32 (1..2147483647)

VirtualMachineStorageIndex ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"A unique value for each virtual machine, 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 hypervisor 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 for each virtual machine, greater than
        zero, identifying a virtual network interface allocated
        to the virtual machine. The value for each virtual
        network interface must remain constant at least from one
        re-initialization of the hypervisor 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 re-initialization of the hypervisor. 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 virtual machine from all other virtual machines in an administrative region. A zero-length octet string is returned if no UUID information is known."  
 ::= { 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 suspended(2) or paused(3) to running(1)."  
 ::= { vmEntry 5 }

vmOperState OBJECT-TYPE

SYNTAX VirtualMachineOperState

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```
MAX-ACCESS    read-only
STATUS        current
DESCRIPTION
    "The operational state of the virtual machine."
 ::= { vmEntry 6 }
```

vmAutoStart OBJECT-TYPE

```
SYNTAX        VirtualMachineAutoStart
MAX-ACCESS    read-only
STATUS        current
DESCRIPTION
    "The autostart configuration of the virtual machine.  If
     this value is enable(2), the virtual machine
     automatically starts at the next initialization of the
     hypervisor."
 ::= { 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 its shutdown."
 ::= { vmEntry 8 }
```

vmCurCpuNumber OBJECT-TYPE

```
SYNTAX        Integer32 (0..2147483647)
MAX-ACCESS    read-write
STATUS        current
DESCRIPTION
    "The number of virtual CPUs currently assigned to the
     virtual machine.  Changes to this object MUST NOT
     persist across re-initialization of the hypervisor."
 ::= { 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 MUST NOT persist across re-initialization 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 MUST NOT persist across re-initialization 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-write

STATUS current

DESCRIPTION

"The current memory size currently allocated to the virtual memory module in the unit designated by vmMemUnit. Changes to this object MUST NOT persist across re-initialization of the hypervisor."

::= { 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 MUST NOT persist across re-initialization 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 MUST NOT persist across re-initialization 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 from shutdown(4) to running(1)."

::= { 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.

Discontinuities in the value of this counter can occur at re-initialization of the hypervisor, and administrative state (vmAdminState) changes of the virtual machine."

::= { 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.

        Discontinuities in the value of this counter can occur
        at re-initialization of the hypervisor, and
        administrative state (vmAdminState) changes of the
        virtual machine."
 ::= { 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."

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```
::= { 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.

Discontinuities in the value of this counter can occur at re-initialization of the hypervisor, and administrative state (vmAdminState) changes of the virtual machine."

::= { vmStorageEntry 13 }

vmStorageWriteIOs OBJECT-TYPE

SYNTAX Counter64

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The number of write I/O requests.

Discontinuities in the value of this counter can occur

```
        at re-initialization of the hypervisor, and
        administrative state (vmAdminState) changes of the
        virtual machine."
 ::= { 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 network interfaces 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 virtual machine."

::= { vmObjects 9 }

vmBulkNotificationsEnabled OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-write

STATUS current

DESCRIPTION

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

::= { 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(4) 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(12) from some other state. The other state is
indicated by the included value of vmOperState."
```

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

vmShuttingdown 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
shuttingdown(11) from some other state. The other state
is indicated by the included value of vmOperState."
```

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

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(9) from some other state. The other state is indicated by the included value of vmOperState."  
 ::= { vmNotifications 4 }

vmSuspending 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 suspending(6) from some other state. The other state is indicated by the included value of vmOperState."

::= { vmNotifications 5 }

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(7) from some other state. The other state is indicated by the included value of vmOperState."

::= { vmNotifications 6 }

vmResuming NOTIFICATION-TYPE

OBJECTS {  
       vmName,  
       vmUUID,  
       vmOperState  
 }

STATUS current

```

        "This notification is generated when the operational
        state of a virtual machine has been changed to
        resuming(8) from some other state. The other state is
        indicated by the included value of vmOperState."
 ::= { vmNotifications 7 }

vmMigrating 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
    migrating(10) from some other state. The other state is
    indicated by the included value of vmOperState."
 ::= { vmNotifications 8 }

vmCrashed NOTIFICATION-TYPE
OBJECTS      {
                vmName,
                vmUUID,
                vmOperState
            }
STATUS      current
DESCRIPTION
    "This notification is generated when a virtual machine
    has been crashed. The previous state of the virtual
    machine is indicated by the included value of
    vmOperState."
 ::= { vmNotifications 9 }

vmBlocked 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
    blocked(5). The previous state of the virtual machine is
    indicated by the included value of vmOperState."
 ::= { vmNotifications 10 }

```

## 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 11 }
```

## 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(4) from a all prior states except for running(4). Management stations are encouraged to subsequently poll the subset of virtual machines of interest for vmOperState."

```
::= { vmNotifications 12 }
```

## vmBulkShuttingdown 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 shuttingdown(11) from a state other than shuttingdown(11). Management stations are encouraged to subsequently poll the subset of virtual machines of interest for vmOperState."

```
::= { vmNotifications 13 }
```

## 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(12) from a state other than shutdown(12). Management stations are encouraged to subsequently poll the subset of virtual machines of interest for vmOperState."

```
::= { vmNotifications 14 }
```

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(9) from a state other than paused(9). Management stations are encouraged to subsequently poll the subset of virtual machines of interest for vmOperState."

```
::= { vmNotifications 15 }
```

vmBulkSuspending 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 suspending(6) from a state other than suspending(6). Management stations are encouraged to subsequently poll the subset of virtual machines of interest for vmOperState."

```
::= { vmNotifications 16 }
```

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(7) from a state other than suspended(7).
              Management stations are encouraged to subsequently poll
```

```
              the subset of virtual machines of interest for
              vmOperState."
 ::= { vmNotifications 17 }
```

vmBulkResuming 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 resuming(8) from a state other than resuming(8).
              Management stations are encouraged to subsequently poll
              the subset of virtual machines of interest for
              vmOperState."
 ::= { vmNotifications 18 }
```

vmBulkMigrating 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 migrating(10) from a state other than migrating(10).
              Management stations are encouraged to subsequently poll
              the subset of virtual machines of interest for
              vmOperState."
 ::= { vmNotifications 19 }
```

```
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 virtual
    machines of interest for vmOperState."
 ::= { vmNotifications 20 }
```

```
vmBulkBlocked NOTIFICATION-TYPE
OBJECTS      {
                vmAffectedVMs
            }
```

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```
STATUS       current
DESCRIPTION
    "This notification is generated when the operational
    state of one or more virtual machines have been changed
    to blocked(5) from a state other than blocked(5).
    Management stations are encouraged to subsequently poll
    the subset of virtual machines of interest for
    vmOperState."
 ::= { vmNotifications 21 }
```

```
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 virtual
    machines of interest for vmOperState."
 ::= { vmNotifications 22 }
```

-- 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 vmCurCpuNumber
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 vmCurMem
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,
        vmShuttingdown,
        vmShutdown,
        vmPaused,
        vmSuspending,
        vmSuspended,
        vmResuming,
        vmMigrating,
        vmCrashed,
        vmBlocked,
        vmDeleted
    }
    STATUS          current
```

DESCRIPTION

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"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,  
vmBulkShuttingdown,  
vmBulkShutdown,  
vmBulkPaused,  
vmBulkSuspending,  
vmBulkSuspended,  
vmBulkResuming,  
vmBulkMigrating,  
vmBulkCrashed,  
vmBulkBlocked,  
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, 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.

## [6.](#) Acknowledgements

The authors like to thank Joe Marcus Clarke, Randy Presuhn, and David Black for providing helpful comments during the development of this specification.

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[Appendix A](#). State Transition Table

State	Action or (Event)	Next state	Notification
suspended	running	resuming	vmResuming   vmBulkResuming
suspending	(suspend operation completed)	suspended	vmSuspended   vmBulkSuspended
running	suspended	suspending	vmSuspending   vmBulkSuspending
	shutdown	shuttingdown	vmShuttingdown   vmBulkShuttingdown
	destroy	shutdown	vmShutdown   vmBulkShutdown
	(migration to other hypervisor initiated)	migrating	vmMigrating   vmBulkMigrating
resuming	(resume operation completed)	running	vmRunning   vmBulkRunning
paused	running	running	vmRunning   vmBulkRunning
shuttingdown	(shutdown operation completed)	shutdown	vmShutdown   vmBulkShutdown
shutdown	running	running	vmRunning   vmBulkRunning
	(if this state	migrating	vmMigrating

entry is created by a migration operation (\*)

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	(deletion operation completed)	(no state)	vmDeleted   vmBulkDeleted
migrating	(migration from other hypervisor completed)	running	vmRunning   vmBulkRunning
	(migration to other hypervisor completed)	shutdown	vmShutdown   vmBulkShutdown
preparing	(preparation completed)	shutdown	vmShutdown   vmBulkShutdown
blocked	(blocking operation completed)	(previous state)	-
crashed	-	-	-
(any)	(blocking operation initiated)	blocked	vmBlocked   vmBulkBlocked
	(crashed)	crashed	vmCrashed   vmBulkCrashed
(no state)	(preparation initiated)	preparing	-
	(migrate from other	shutdown (*)	vmShutdown   vmBulkShutdown

	hypervisor initiated)		
--	--------------------------	--	--

State transition table

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