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**Information technology —  
Sustainability for and by information  
technology — Smart data centre  
resource monitoring and control**

*Technologies de l'information — Durabilité pour et par les  
technologies de l'information — Surveillance des ressources et  
contrôle des centres de données intelligents*

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## Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

ISO/IEC 19395 was prepared by Ecma International (as ECMA-400) and was adopted, under a special "fast-track procedure", by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

## Introduction

Operation of data centres requires management of storage, computation, communication, electrical energy and temperature to achieve the required quality of service and efficiency parameters. Often, however, the separate management of Information Technology (IT), electrical energy (or power) and cooling Resource islands yields a sub-optimal result.

This International Standard provides Messages that facilitate integrated or “smart” monitoring and control of Resources in those islands. The Messages are exchanged between the Management Function and Resources. The International Standard acknowledges that those Resources may be composed of other Resources (e.g. a rack may contain servers, ventilators, etc.). In addition, e.g. those servers may be viewed from their computing, energy consumption or dissipation aspects which this International Standard models as Resource Components and groups into IT, power and fluid Domains, respectively.

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# Information technology — Sustainability for and by information technology — Smart data centre resource monitoring and control

## 1 Scope

In the Smart Data Centre, Management Functions monitor and control Resources. Resources model IT and facility equipment, systems and components in a data centre. To monitor and control the Resources' Properties, Management Functions exchange command, response or event Messages with Resources, see [Figure 1](#).

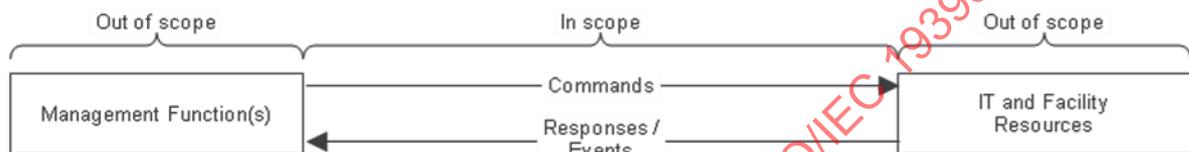


Figure 1 — Scope

Resources are made up out of Resource Components which this second edition shares Properties with classes in Common Information Models (CIM). Messages refer to Resources and their Properties. Messages are encoded in XML and exchanged in HTTP primitives.

[Figure 1](#) illustrates the functionality that this second edition adds as described above.

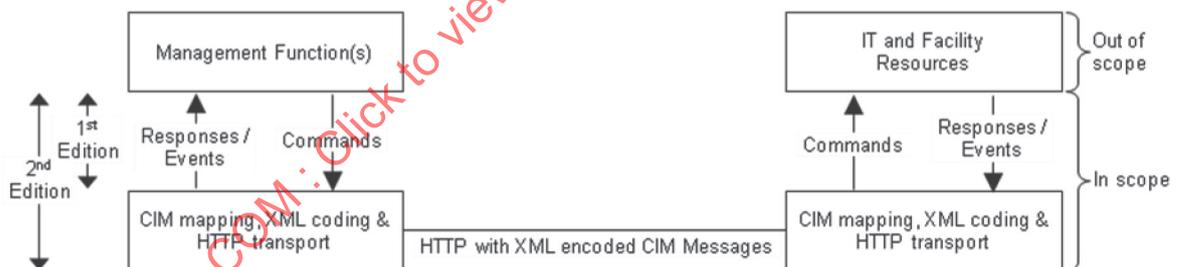


Figure 2 — Functionality that second edition adds

Management Function(s), Resources, IT & facility equipment, systems and components themselves are out of scope as illustrated in [Figure 1](#), [Figure 2](#) and [Figure 3](#). Static information such as location, addressing of Resources and CPU models are out of scope as well.

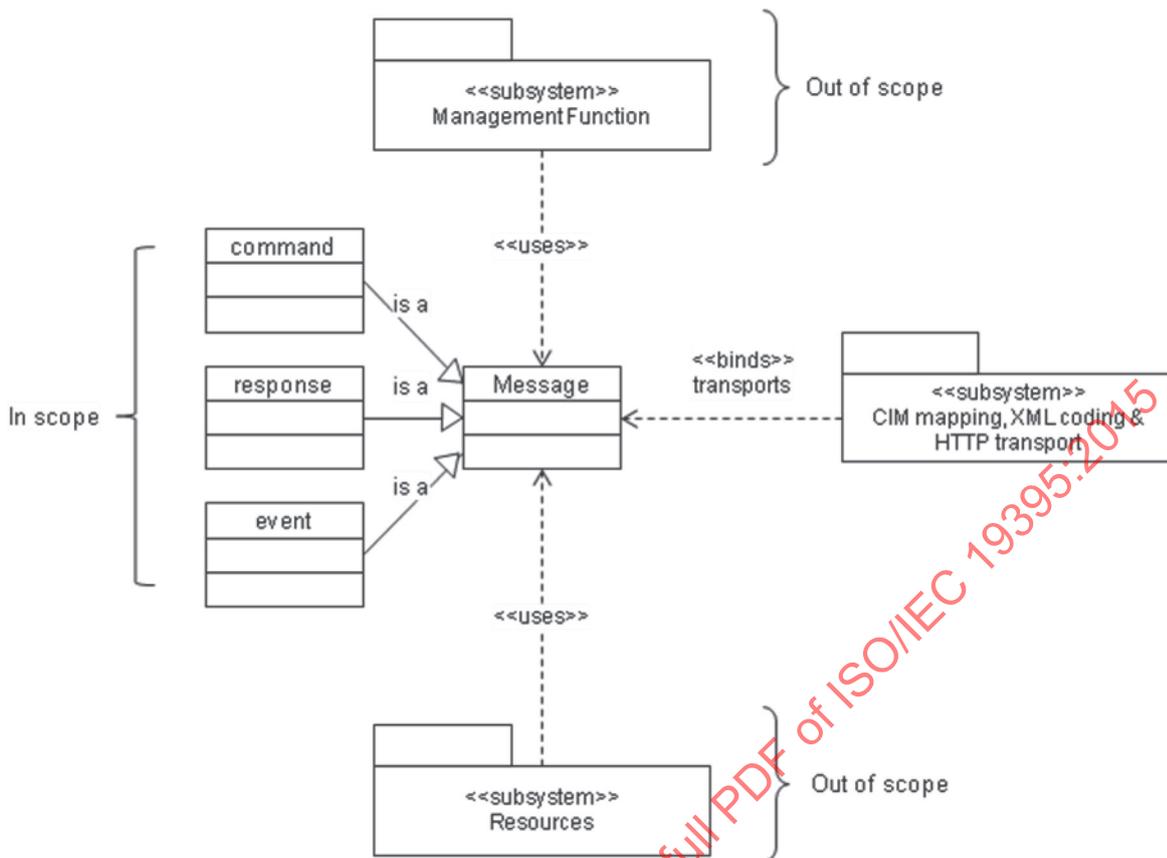


Figure 3 — detailed scope using CIM (UML Notation)

## 2 Conformance

Conformant Management Functions monitor and control Properties (Clause 6) of Resources using Messages as specified in Clause 7.

In response to the commands, conformant responses and events from Resources use the Messages as specified in Clause 7.

Any of the Resource configurations specified in Annex A may optionally be implemented, in addition to any other configuration using any combination of Resources and Resource Components.

## 3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DMTF, “CIM Schema”, <http://dmtof.org/standards/cim>

DMTF DSP0004, “CIM Infrastructure Specification”

DMTF DSP0200, “CIM Operations over HTTP”

DMTF DSP1009, “Sensors Profile”

DMTF DSP1011, “Physical Asset Profile”

DMTF DSP1014, "Ethernet Port Profile"

DMTF DSP1022, "CPU Profile"

DMTF DSP1027, "Power State Management Profile"

DMTF DSP1029, "OS Status Profile"

DMTF DSP1033, "Profile Registration Profile"

DMTF DSP1035, "Host LAN Network Port Profile"

DMTF DSP1042, "System Virtualization Profile"

DMTF DSP1044, "Processor Resource Virtualization Profile"

DMTF DSP1045, "Memory Resource Virtualization Profile"

DMTF DSP1047, "Storage Resource Virtualization Profile"

DMTF DSP1052, "Computer System Profile"

DMTF DSP1053, "Base Metrics Profile"

DMTF DSP1057, "Virtual System Profile"

DMTF DSP1081, "Virtual System Migration Profile"

## 4 Terms, definitions and acronyms

For the purposes of this document, the following terms, definitions and acronyms apply.

### 4.1

#### **Common Information Model**

##### **CIM**

### 4.2

#### **CIM Client**

emitter of CIM message requests and consumer of CIM message responses

### 4.3

#### **CIM Listener**

consumer of events

### 4.4

#### **CIM message request**

command or event request

### 4.5

#### **CIM message response**

response

### 4.6

#### **condition query**

expression on property value

**4.7**  
**Distributed Management Task Force**  
**DMTF**

Note 1 to entry: DMTF's URL is <http://www.dmtf.org/>

**4.8**  
**domain**  
set of resource components

**4.9**  
**event description indication filter**  
set of conditions and associated parameters

**4.10**  
**Information Technology**  
**IT**

**4.11**  
**CIM message**  
command, response or event

**4.12**  
**Management Function**  
**MF**

**4.13**  
**property**  
resource attribute

**4.14**  
**Resource Component**  
**RC**

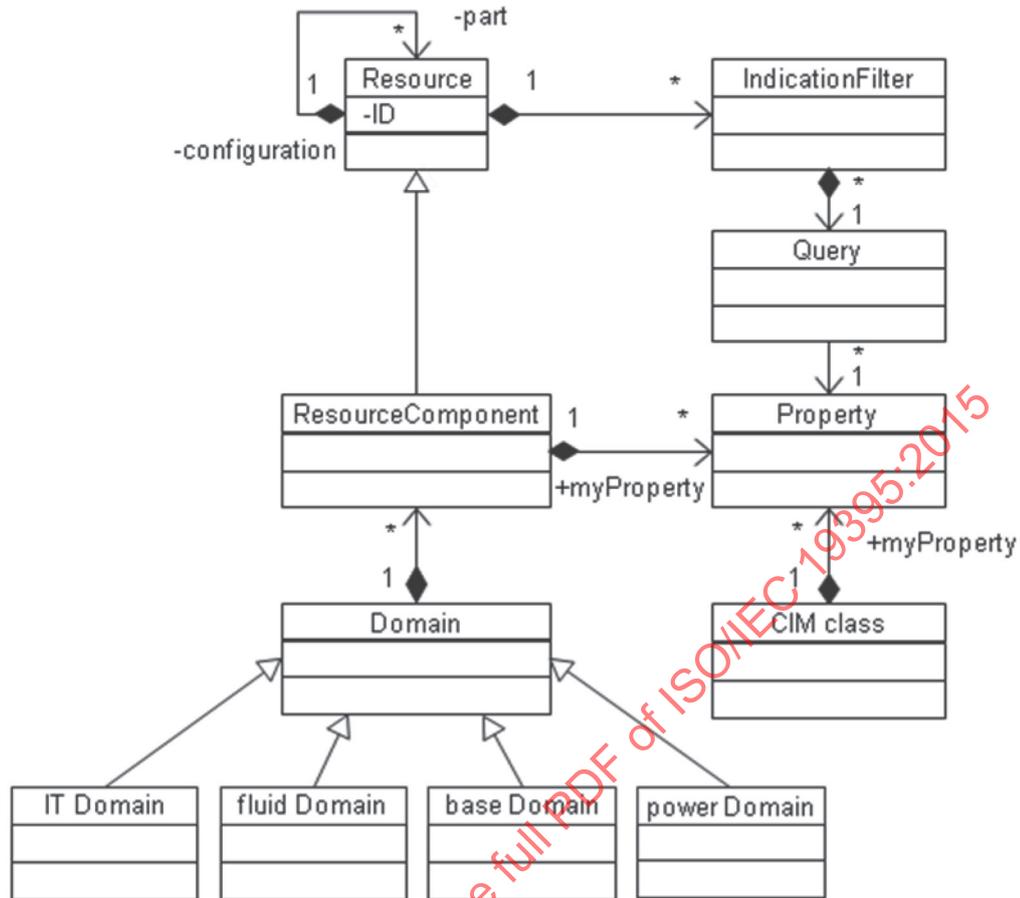
**4.15**  
**CIM Resource**  
representation of IT and facility equipment, systems or components

**4.16**  
**Smart Data Centre**  
**SDC**  
arrangement of all the resources and management function(s)

## **5 Domains**

### **5.1 Introduction**

This International Standard specifies Resource Components (RC) which share Properties with CIM classes, to compose Resource configurations as specified in [Figure 3](#). The Resource Components are grouped into IT, power, fluid and base Domains.



**Figure 4 — Resource and Resource Component**

In tables in this Clause, the Key indicates the identifier which shall be unique in the SDC namespace as specified in *Common Information Model (CIM) Infrastructure Specification* (DSP0004). The Key uniquely identifies each instance.

## 5.2 Base Domain

To construct the foundation of Resources, Resource Components from the base Domain shall be used.

### 5.2.1 CIM System

See *CIM Schema*.

### 5.2.2 CIM\_BaseMetricDefinition

See *Base Metrics Profile* (DSP1053). TimeScope is optional in DSP1053 whereas in this International Standard, TimeScope is mandatory.

### 5.2.3 CIM\_BaseMetricValue

The requirements in *Base Metrics Profile* (DSP1053) and those in [Table 1](#) apply.

**Table 1 — Class: CIM\_BaseMetricValue**

Properties	M/O*1	Requirements on Value
TimeStamp	Mandatory	In case the device generating the metric instances does not have a clock device, the TimeStamp value shall be “99990101000000.000000+000” in case the base metric definition time scope requires that the TimeStamp value is not NULL. “99990101000000.000000+000” is used to indicate that the DateTime property value is not valid.
Volatile	Mandatory	TRUE

\*1 “M/O” indicates “mandatory or optional.”

**5.2.4 CIM\_MetricDefForME**

CIM\_MetricDefForME shall be used to associate CIM\_BaseMetricDefinition to SDC\_FluidMeasurementPoint. The requirements in *Base Metrics Profile* (DSP1053) and those in [Table 2](#) apply.

If the CIM\_BaseMetricDefinition class is implemented, CIM\_MetricDefForME shall be also implemented.

**Table 2 — Class: CIM\_MetricDefForME**

Properties	M/O	Requirements on value
Antecedent	Mandatory	<b>Key:</b> Shall be a reference to SDC_FluidMeasurementPoint with Cardinality 1 indicating one reference
Dependent	Mandatory	<b>Key:</b> Shall be a reference to CIM_BaseMetricDefinition with Cardinality 1..* indicating one or more references
MetricCollectionEnabled	Optional	

**5.2.5 CIM\_MetricInstance**

CIM\_MetricInstance shall be used to associate CIM\_BaseMetricValue instances to CIM\_BaseMetricValue instances. See *Base Metrics Profile* (DSP1053).

If the CIM\_BaseMetricDefinition class is implemented, CIM\_MetricInstance shall be also implemented.

**5.2.6 CIM\_RegisteredProfile**

The requirements in *Profile Registration Profile* (DSP1033) and those in [Table 3](#) apply.

**Table 3 — Class: CIM\_RegisteredProfile**

Properties	M/O	Requirements on value
RegisteredName	Mandatory	“CoolingSystem”
RegisteredVersion	Mandatory	“1.0.0”
RegisteredOrganization	Mandatory	1 (Others)
OtherRegisteredOrganization	Mandatory	“Ecma_TGG”

**5.2.7 CIM\_SystemDevice**

CIM\_SystemDevice association shall be used to associate SDC\_FluidElement with the CIM\_System instance of which it is a member. The requirements in *CIM Schema* and those in [Table 4](#) apply.

**Table 4 — Class: CIM\_SystemDevice**

Properties	M/O	Requirements on value
Antecedent	Mandatory	<b>Key:</b> Shall be a reference to CIM_System with Cardinality 1 indicating one reference
Dependent	Mandatory	<b>Key:</b> Shall be a reference to SDC_FluidElement with Cardinality 1..* indicating one or more references

### 5.2.8 CIM\_Component

CIM\_Component association shall be used to associate SDC\_FluidElement instances of which it is involved. The requirements in *CIM Schema* and those in [Table 5](#) apply.

**Table 5 — Class: CIM\_Component**

Properties	M/O	Requirements on value
Antecedent	Mandatory	<b>Key:</b> Shall be a reference to SDC_FluidElement with Cardinality 1 indicating one reference
Dependent	Mandatory	<b>Key:</b> Shall be a reference to SDC_FluidElement with Cardinality 1..* indicating one or more references

### 5.2.9 Metrics for fluid measurements

The set of fluid metrics supported by an instance of SDC\_FluidMeasurementPoint is implementation dependent. An instance of SDC\_FluidMeasurementPoint may support all, none, or any combination of these metrics. A Management Function may detect the supported metric definitions by traversing the CIM\_MetricDefForME association.

By traversing the CIM\_MetricForME association, a Management Function retrieves all metrics currently available for a given SDC\_FluidMeasurementPoint instance.

The TimeStamp and Duration Properties shall be provided for all metrics where the CIM\_BaseMetricDefinition.TimeScope is equal to "Interval" (3).

#### 5.2.9.1 Interval metrics

Interval metrics shall be used as metrics where the value applies to a time interval, e.g. the average temperature over a given interval. For interval metrics, CIM\_BaseMetricDefinition.TimeScope Property value shall be equal to "Interval" (3). CIM\_BaseMetricValue.TimeStamp and CIM\_BaseMetricValue.Duration allow the Management Function to evaluate over which interval the metric was computed.

##### 5.2.9.1.1 AverageTemperature

AverageTemperature metric shall be used to measure average temperature at the measuring point during a given demand interval. [Table 6](#) specifies the requirements on the CIM\_BaseMetricDefinition instance for AverageTemperature metric.

**Table 6 — CIM\_BaseMetricDefinition instance for AverageTemperature metric**

Properties	M/O	Requirements on value
Id	Mandatory	<b>Key</b>
Name	Mandatory	"SDC:AverageTemperature"
Description	Optional	"SDC standard metric for average temperature at the measuring point during the interval."
DataType	Mandatory	5 (real64)
Units	Optional	"C"
ProgrammaticUnits	Mandatory	"degree Celcius"
IsContinuous	Mandatory	TRUE
ChangeType	Mandatory	4 (Gauge)
TimeScope	Mandatory	3 (Interval)
GatheringType	Mandatory	3 (Periodic)

### 5.2.9.1.2 AverageHumidity

AverageHumidity metric shall be used to measure average temperature at the measuring point during a given demand interval. [Table 7](#) specifies the requirements on the CIM\_BaseMetricDefinition instance for AverageHumidity metric.

**Table 7 — CIM\_BaseMetricDefinition instance for AverageHumidity metric**

Properties	M/O	Requirements on values
Id	Mandatory	<b>Key</b>
Name	Mandatory	"SDC:AverageHumidity"
Description	Optional	"SDC standard metric for average humidity at the measuring point during the interval."
DataType	Mandatory	5 (real64)
Units	Optional	"%"
ProgrammaticUnits	Mandatory	"percent"
IsContinuous	Mandatory	TRUE
ChangeType	Mandatory	4 (Gauge)
TimeScope	Mandatory	3 (Interval)
GatheringType	Mandatory	3 (Periodic)

### 5.2.9.2 Point metrics

#### 5.2.9.2.1 Temperature

Temperature metric shall be used to measure the temperature at a given instant. [Table 8](#) specifies the requirements on the CIM\_BaseMetricDefinition instance for Temperature metric.

**Table 8 — CIM\_BaseMetricDefinition instance for Temperature metric**

Properties	M/O	Requirements on value
Id	Mandatory	<b>Key</b>
Name	Mandatory	“SDC:Temperature”
Description	Optional	“SDC standard metric for temperature at the measuring point at a given point in time.”
DataType	Mandatory	5 (real64)
Units	Optional	“C”
ProgrammaticUnits	Mandatory	“degree Celcius”
IsContinuous	Mandatory	TRUE
ChangeType	Mandatory	3 (Gauge)
TimeScope	Mandatory	2 (Point)
GatheringType	Mandatory	4 (OnRequest)

### 5.2.9.2.2 Humidity

Humidity metric shall be used to measure the humidity at a given instant. [Table 9](#) specifies the requirements on the CIM\_BaseMetricDefinition instance for Humidity metric.

**Table 9 — CIM\_BaseMetricDefinition instance for Humidity metric**

Properties	M/O	Requirements on value
Id	Mandatory	<b>Key</b>
Name	Mandatory	“SDC:Humidity”
Description	Optional	“SDC standard metric for humidity at the measuring point at a given point in time.”
DataType	Mandatory	5 (real64)
Units	Optional	“%”
ProgrammaticUnits	Mandatory	“percent”
IsContinuous	Mandatory	TRUE
ChangeType	Mandatory	3 (Gauge)
TimeScope	Mandatory	2 (Point)
GatheringType	Mandatory	4 (OnRequest)

### 5.2.9.2.3 Flow rate

Flow rate metric shall be used to measure the flow rate at a given instant. [Table 10](#) specifies the requirements on the CIM\_BaseMetricDefinition instance for Flow rate metric.

**Table 10 — CIM\_BaseMetricDefinition instance for Flow rate metric**

Properties	M/O	Requirements on value
Id	Mandatory	<b>Key</b>
Name	Mandatory	“SDC:FlowRate”
Description	Optional	“SDC standard metric for Flow rate at the measuring point at a given point in time.”
DataType	Mandatory	5 (real64)
Units	Optional	“M3/h”
ProgrammaticUnits	Mandatory	“cubic meters per hour”
IsContinuous	Mandatory	TRUE
ChangeType	Mandatory	3 (Gauge)
TimeScope	Mandatory	2 (Point)
GatheringType	Mandatory	4 (OnRequest)

### 5.2.10 CIM\_NumericSensor

CIM\_NumericSensor is specified in *Sensors Profile* (DSP1009) and may be used to measure various values including input power of servers. [Figure 5](#) specifies the class diagram of CIM\_NumericSensor.



**Figure 5 — class: CIM\_NumericSensor**

### 5.2.11 CIM\_EnabledLogicalElementCapabilities

CIM\_EnabledLogicalElementCapabilities class is specified in *Sensors Profile* (DSP1009) and shall be used to indicate support for managing the state of the system.

### 5.2.12 CIM\_ElementCapabilities

CIM\_ElementCapabilities association is specified in *Sensors Profile* (DSP1009) and shall be used to associate CIM\_NumericSensor with an instance of CIM\_EnabledLogicalElementCapabilities that describes the capabilities of CIM\_NumericSensor.

## 5.3 IT Domain

The IT Domain has a set of CIM classes as specified in [Table 11](#), [Figure 6](#), [Figure 7](#) and [Figure 8](#). CIM classes in the IT Domain shall be used to express the IT perspective of Resources.

**Table 11 — CIM classes of IT Domain**

Class/Association	Reference
CIM_ComputerSystem	DSP1052
CIM_HostedDependency	DSP1052
CIM_HostedService	DSP1042, DSP1081
CIM_ServiceAffectsElement	DSP1081

Table 11 (continued)

Class/Association	Reference
CIM_VirtualSystemMigrationService	DSP1081
CIM_VirtualSystemManagementService	DSP1042
CIM_Rack	DSP1011
CIM_Chassis	DSP1011
CIM_ChassisInRack	DSP1011
CIM_ComputerSystemPackage	DSP1011
CIM_SystemDevice	DSP1052
CIM_ElementCapabilities	DSP1057
CIM_Processor	DSP1022
CIM_ProcessorCore	DSP1022
CIM_ConcreteComponent	DSP1022
CIM_Processor(virtual)	DSP1044
CIM_OperatingSystem	DSP1029
CIM_RunningOS	DSP1029
CIM_StorageVolume	DSP1047
CIM_BlockStorageStaticalData	DSP1047
CIM_ElementStatisticalData	DSP1035
CIM_NetworkPort	DSP1035
CIM_NetworkPortStatistics	DSP1035
CIM_VirtualComputerSystem	DSP1057
CIM_VirtualSystemSettingData	DSP1052
CIM_VirtualSystemSettingDataComponent	DSP1052
CIM_ResourceAllocationSettingData	DSP1052
CIM_SettingsDefineState	DSP1052
CIM_ResourcePool	DSP1044, DSP1045, DSP1047
CIM_ElementAllocatedFromPool	DSP1044, DSP1045, DSP1047
CIM_Memory	DSP1045
CIM_LogicalDisk	DSP1047
CIM_StorageAllocationSettingData	DSP1047
CIM_EthernetPort	DSP1014
CIM_EthernetPortAllocationSettingData	DSP1014

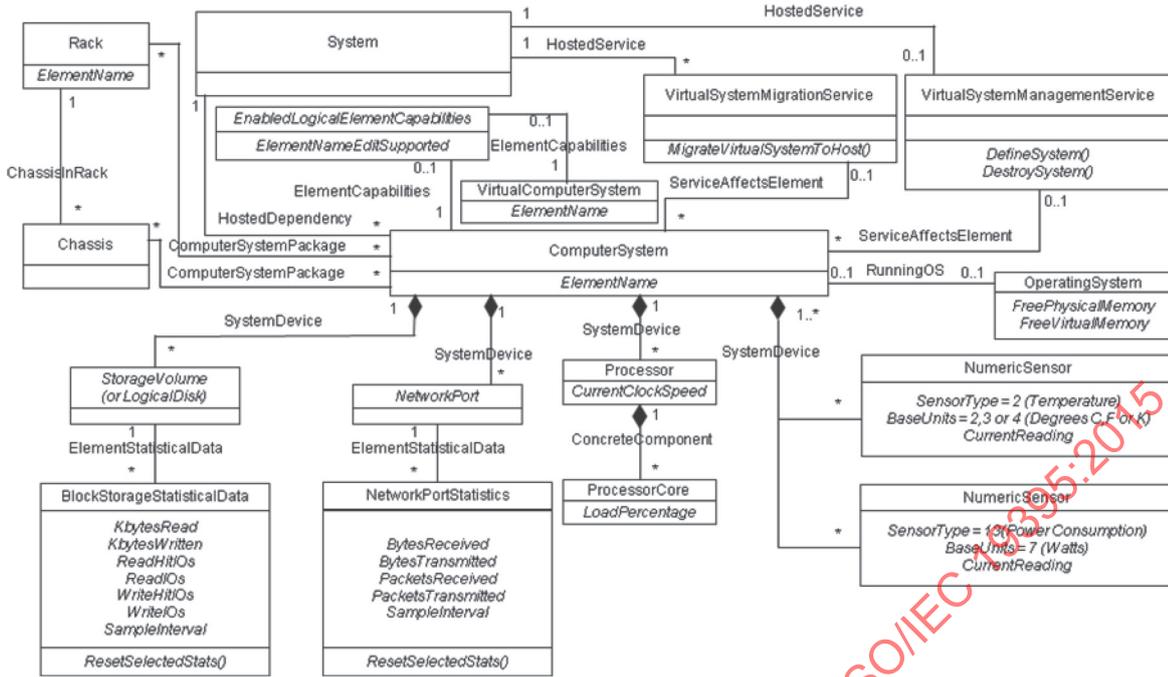


Figure 6 — IT Domain class schema(1)

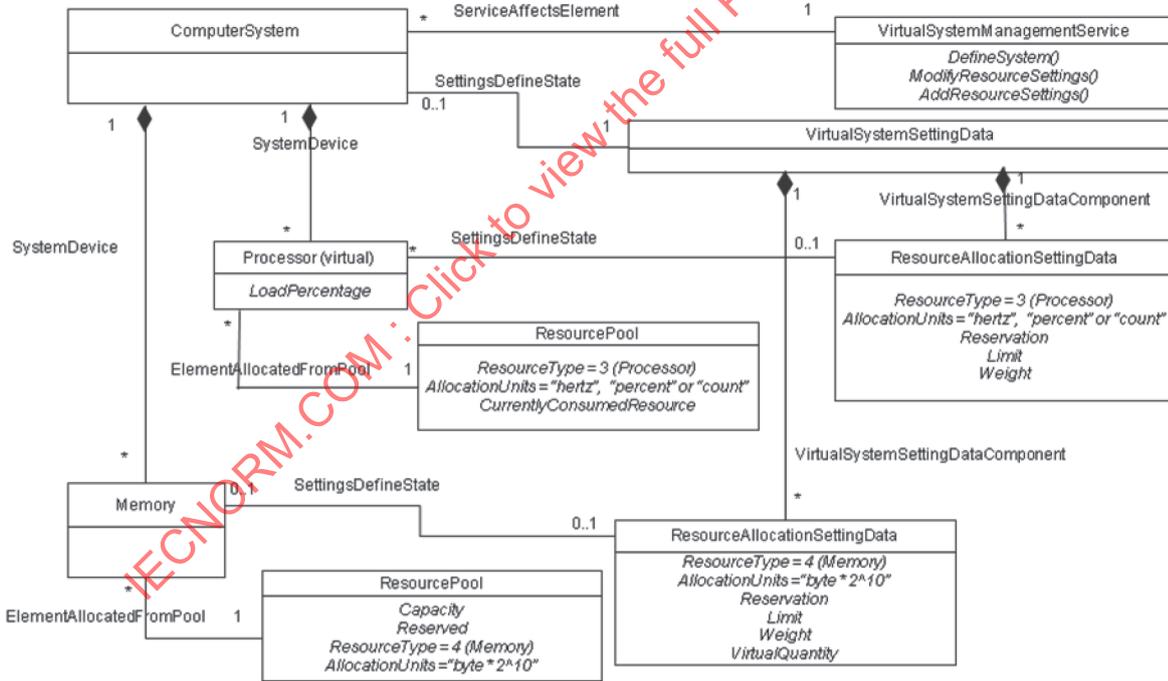


Figure 7 — IT Domain class schema(2)

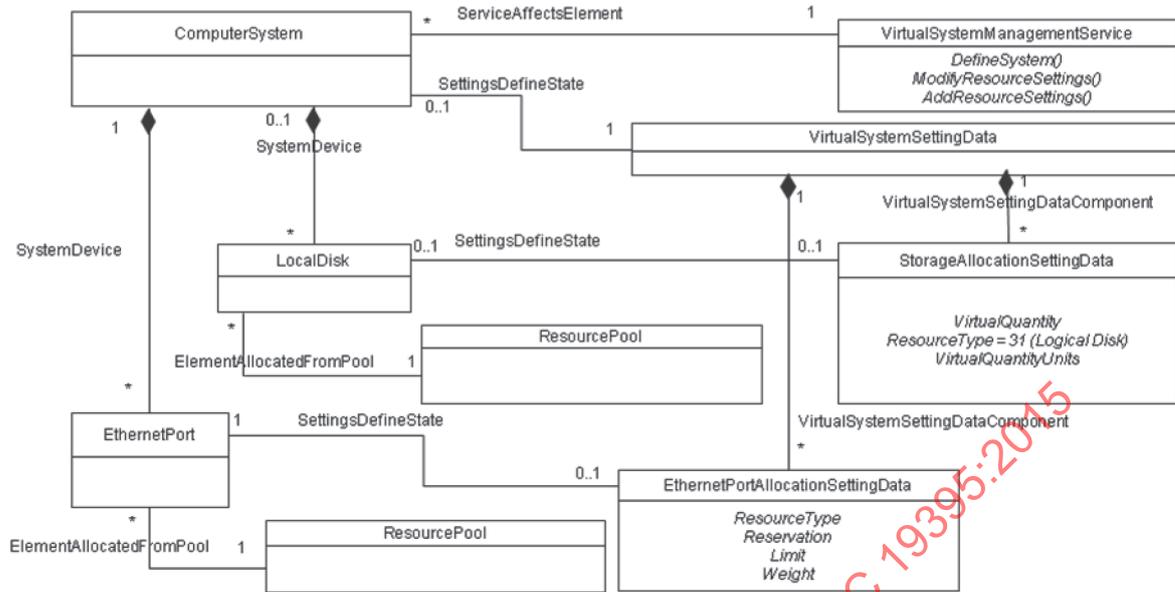


Figure 8 — IT Domain class schema(3)

### 5.4 Power Domain

The power Domain has a set of CIM classes as specified in Table 12 and Figure 9. CIM classes in the power Domain shall be used to express the power perspective of Resources.

Table 12 — CIM classes of power Domain

Class/Association	Reference
CIM_PowerManagementService	DSP1027
CIM_AssosatedPowerManagementService:PowerState	DSP1027

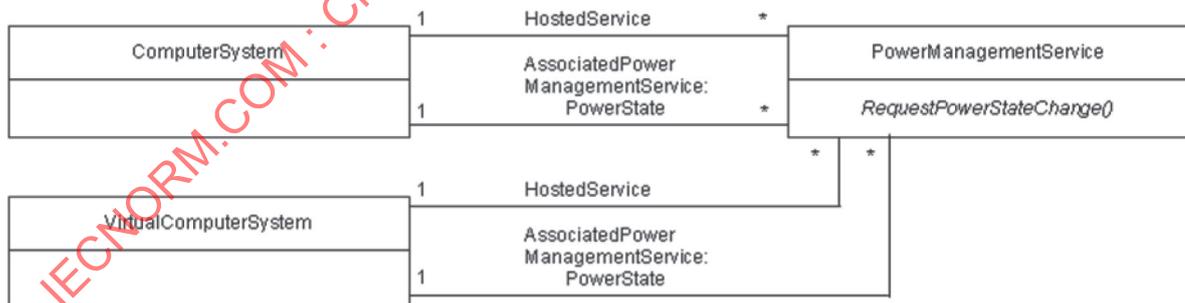


Figure 9 — Power Domain class schema

### 5.5 Fluid Domain

The fluid Domain has a set of CIM classes to express the fluid perspective of Resources.

The fluid Domain classes shall be used to construct a topology of SDC\_FluidElements concerned with thermal energy flows. Annex B shows examples of such topologies.

Figure 10 represents the class schema for the fluid Domain. For simplicity, the prefix CIM\_, or SDC\_ has been removed from the names of the classes.

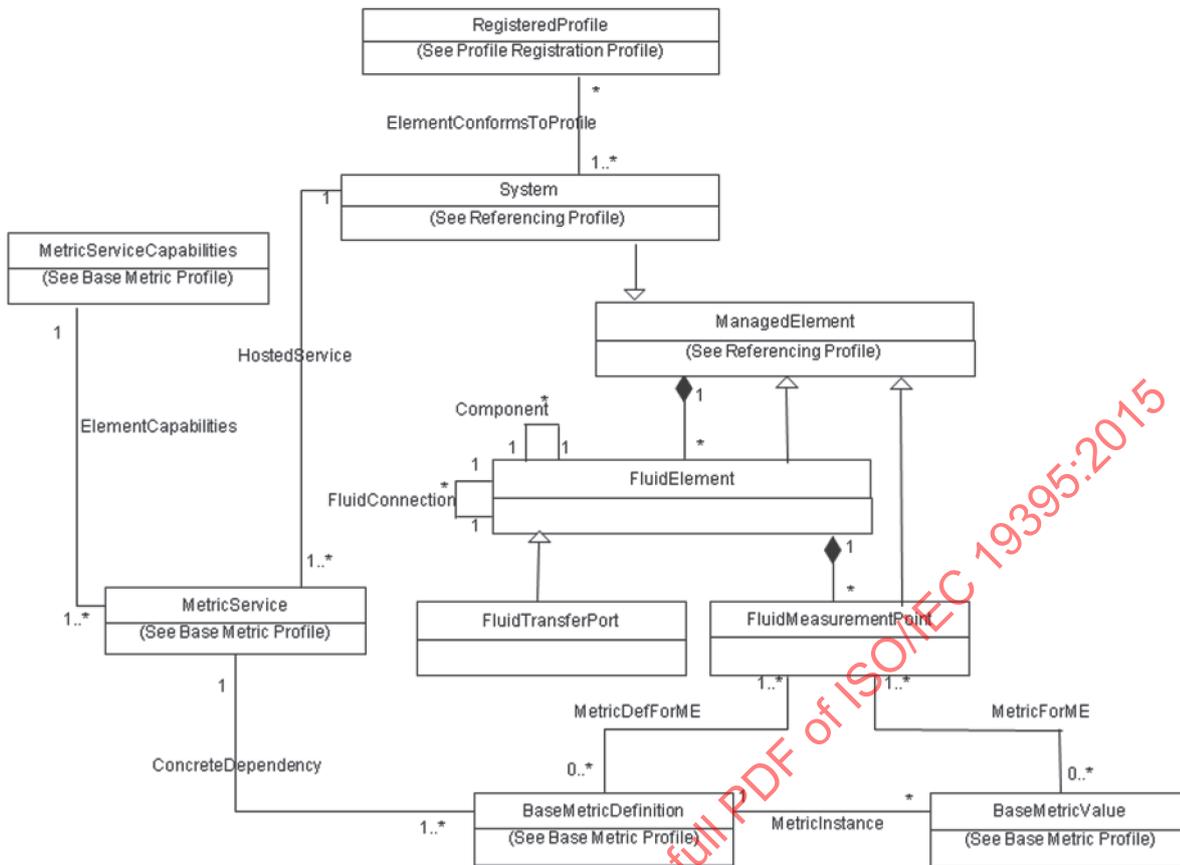


Figure 10 — Fluid Domain class schema

SDC\_FluidMeasurementPoint represents a point to measure fluid flowing through the SDC\_FluidElement.

CIM\_RegisteredProfile represents the advertisement of the implementation of this schema.

Instances of CIM\_BaseMetricDefinition are associated to instances of SDC\_FluidMeasurementPoint through the CIM\_MetricDefForME association. The metric definition instances contain semantic information data and meta information on metrics. Instances of this class are defined later in this schema. The individual metric values are contained in CIM\_BaseMetricValue instances.

Figure 11 represents CIM schema of cooling system. In Figure 11, SDC\_CoolingSettingData represents generic setting parameter for a cooling system.

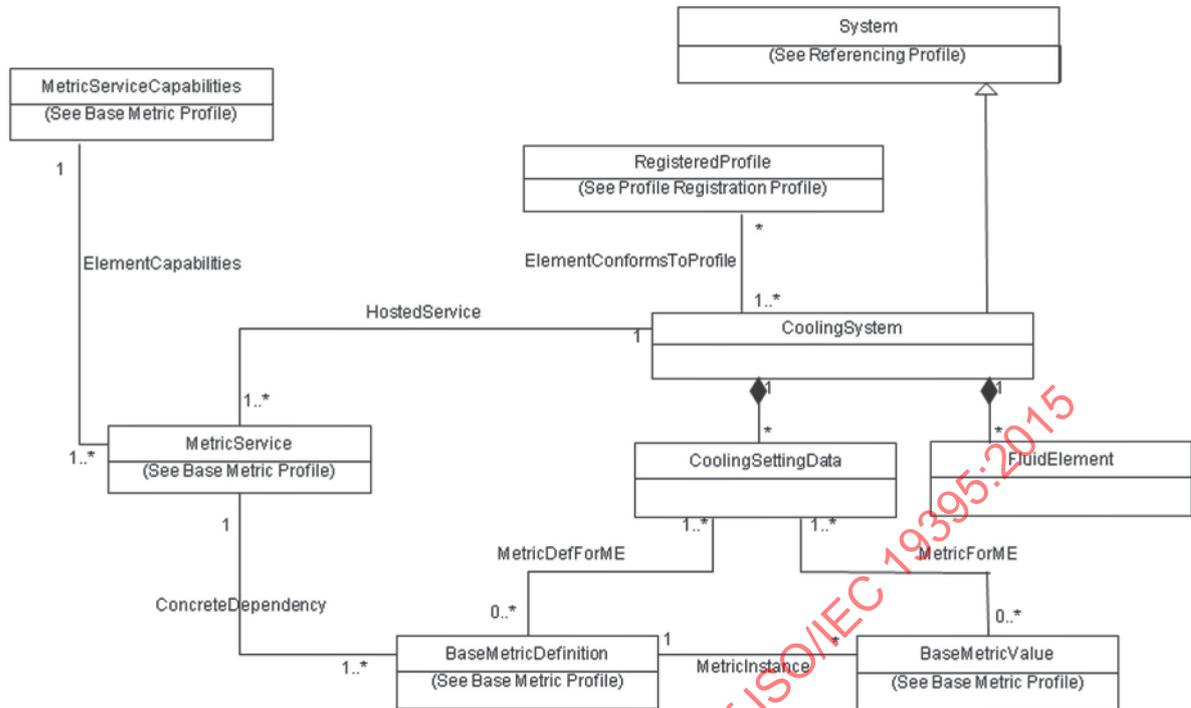


Figure 11 — Cooling system class schema

### 5.5.1 SDC\_FluidConnection

SDC\_FluidConnection shall be used to associate SDC\_FluidElement to another SDC\_FluidElement. The source of fluid flow shall be the Antecedent reference. The destination of fluid flow shall be the Dependent reference. Table 13 details the requirements for instances of SDC\_FluidConnection.

Table 13 — Class: SDC\_FluidConnection

Properties	M/O	Requirements on value
Antecedent	Mandatory	<b>Key:</b> Shall be a reference to SDC_FluidElement instance depending upon the direction of fluid flow with Cardinality 1 indicating one reference
Dependent	Mandatory	<b>Key:</b> Shall be a reference to SDC_FluidElement instance depending upon the direction of fluid flow with Cardinality 1..* indicating one or more references

### 5.5.2 SDC\_FluidElement

SDC\_FluidElement shall be used to represent logical Properties of a fluid element. A fluid element serves as a source, sink, or conveyor of a fluid. The element may or may not do work on the fluid or extract energy from the fluid. The element may or may not conserve mass flow -- i.e. it may include fluid storage. A fluid element may include other fluid elements internally as components.

SDC\_FluidElement is a subclass of CIM\_LogicalDevice. One or more SDC\_FluidElement instances shall be associated with one instance of CIM\_ComputerSystem through an instance of the CIM\_SystemDevice association.

SDC\_FluidElement may have SDC\_FluidMeasurementPoint.

Additionally an instance of SDC\_FluidElement may be associated to other instances of SDC\_FluidElement through an instance of the SDC\_FluidConnection association to represent the fluid flow internal to the SDC\_FluidElement.

**5.5.3 SDC\_FluidMeasurementPoint**

SDC\_FluidMeasurementPoint shall be used to represent logical Properties of a generic measurement point in the cooling facility where fluid metrics can be measured.

**5.5.4 SDC\_FluidTransferPort**

SDC\_FluidTransferPort is a subclass of SDC\_FluidElement. SDC\_FluidTransferPort shall be used to represent a specific port on the periphery of a SDC\_FluidElement where a fluid enters or leaves the SDC\_FluidElement. A connection may be made to the external side of a SDC\_FluidTransferPort.

**5.5.5 SDC\_CoolingSystem**

SDC\_CoolingSystem shall be used to represent logical Properties of a cooling system. SDC\_CoolingSystem may have SDC\_CoolingSettingData.

**5.5.6 SDC\_CoolingSettingData**

SDC\_CoolingSettingData shall be used to represent a generic cooling setting. SDC\_CoolingSettingData may include temperature set point and humidity set point.

**6 Properties**

Management Functions use Messages (Clause 7) to monitor and control Properties specified herein of a Resource. Available Properties are listed in Table 14, Table 15, Table 16 and Table 17. In the tables, “G/S”, “G”, “S” indicate a Property that may be used in a GET and SET, GET, SET command respectively.

**Table 14 — Base Domain Properties**

Property Name	Description	G/S
	CIM Class/Association/Property/Method	
Resource ID	Uniquely identifies a Resource  ElementName For example, a rack, a server, a VM and an air conditioner are identified by CIM_Rack.ElementName, CIM_ComputerSystem.ElementName, CIM_VirtualComputerSystem.ElementName and SDC_FluidElement.ElementName, respectively.  The CIM_EnabledLogicalElementCapabilities instance that is associated with the CIM_ComputerSystem, CIM_VirtualComputerSystem, etc. instance shall have property and value below. CIM_EnabledLogicalElementCapabilities.ElementNameEditSupported = “TRUE”	G/S
Sensor value	Values that this sensor senses  CIM_NumericSensor.CurrentReading  The instance shall have properties below. CIM_NumericSensor.SensorType CIM_NumericSensor.BaseUnits	G

Table 15 — IT Domain Properties

Property Name	Description	G/S
VM Allocation	CIM Class/Association/Property/Method	G/S
	CIM_HostedDependency	
Average load percentage	Average load percentage of this core over the last minute	G
	CIM_ProcessorCore.LoadPercentage [PUnit1: percent]	
Current clock speed	Current clock speed of this core	G
	CIM_Processor.CurrentClockSpeed [PUnit1: hertz * 10 <sup>6</sup> ]	
Free physical memory	Size of physical memory currently unused and available	G
	CIM_OperatingSystem.FreePhysicalMemory [PUnit1: byte * 2 <sup>10</sup> ]	
Free virtual memory	Size of virtual memory currently unused and available. For example, this may be calculated by adding the amount of free RAM to the amount of free paging space	G
	CIM_OperatingSystem.FreeVirtualMemory [PUnit1: byte * 2 <sup>10</sup> ]	
Kbytes read	Cumulative count of data read	G
	KbytesRead In the case that this Resource is a Disk and vDisk, the following properties shall be used, respectively. CIM_BlockStorageStatisticalData.KbytesRead [PUnit1: byte * 10 <sup>3</sup> ] CIM_BlockStorageStatisticalData.KbytesRead [Units: KiloBytes]	
Kbytes written	Cumulative count of data written	G
	KbytesWritten In the case that this Resource is a Disk and vDisk, the following properties shall be used, respectively. CIM_BlockStorageStatisticalData.KbytesWritten [PUnit1: byte * 10 <sup>3</sup> ] CIM_BlockStorageStatisticalData.KbytesWritten [Units: KiloBytes]	
Read hit IOs	Cumulative count of all read cache hits	G
	CIM_BlockStorageStatisticalData.ReadHitIOs	
Read IOs	Cumulative count of all reads	G
	CIM_BlockStorageStatisticalData.ReadIOs	
Duration	Time over which the other values are accumulated	G/S
	SampleInterval [Data Type: datetime] For storage systems and network systems, CIM_BlockStorageStatisticalData.SampleInterval and CIM_NetworkPortStatistics.SampleInterval shall be used, respectively. If the statistics are not sampled at consistent time intervals, SampleInterval shall be set to a zero time interval. Duration shall be expressed as follows. delta CIM_BlockStorageStatisticalData.StatisticTime [DataType: datetime]	
Write hit IOs	Cumulative count of write cache hits	G
	CIM_BlockStorageStatisticalData.WriteHitIOs	

Table 15 (continued)

Write IOs	Cumulative count of all writes	G
	CIM_BlockStorageStatisticalData.WritelOs	
Bytes received	Total number of bytes that are received.	G
	<p>BytesReceived</p> <p>In the case that this Resource is a Network and vNetwork, the following properties shall be used, respectively.</p> <p>CIM_NetworkPortStatistics.BytesReceived [PUnit1: byte]</p> <p>CIM_NetworkPortStatistics.BytesReceived [Units: Bytes]</p>	
Bytes transmitted	Total number of bytes that are transmitted	G
	<p>BytesTransmitted</p> <p>In the case that this Resource is a Network and vNetwork, the following properties shall be used, respectively.</p> <p>CIM_NetworkPortStatistics.BytesTransmitted [PUnit1: byte]</p> <p>CIM_NetworkPortStatistics.BytesTransmitted [Units: Bytes]</p>	
Packets received	Total number of packets that are received	G
	CIM_NetworkPortStatistics.PacketesReceived	
Packets transmitted	Total number of packets that are transmitted	G
	CIM_NetworkPortStatistics.PacketsTransmitted	
Reservation	Specifies the amount of the resource guaranteed to be available for the VM	G/S
	<p>CIM_ResourceAllocationSettingData.Reservation</p> <p>The instance shall have properties and values below.</p> <p>CIM_ResourceAllocationSettingData.ResourceType = 3 (Processor)</p> <p>CIM_ResourceAllocationSettingData.AllocationUnits = "hertz", "percent" or "count" or a multiple of the units expressed through a regular expression.</p>	
Limit	Specifies the upper bound of the resource that will be granted for the VM	G/S
	<p>CIM_ResourceAllocationSettingData.Limit</p> <p>The instance shall have properties and values below.</p> <p>CIM_ResourceAllocationSettingData.ResourceType = 3 (Processor)</p> <p>CIM_ResourceAllocationSettingData.AllocationUnits = "hertz", "percent" or "count" or a multiple of the units expressed through a regular expression</p>	
Load percentage	Load percentage of this vCPU, averaged over the last minute, in Percent of maximum capability.	G
	CIM_Processor.LoadPercentage [PUnit1: percent]	
Current clock speed	Current clock speed of this vCPU	G
	<p>CIM_ResourcePool.CurrentlyConsumedResource</p> <p>The instance shall have properties and values below.</p> <p>CIM_ResourcePool.ResourceType = 3 (Processor)</p> <p>CIM_ResourcePool.AllocationUnits = "hertz", "percent" or "count" or a multiple of the units expressed through a regular expression</p>	

Table 15 (continued)

Weight	Relative priority for this allocation in relation to other allocations	G/S
	<p>CIM_ResourceAllocationSettingData.Weight</p> <p>In the case that this Resource is a vCPU, vMemory and vNetwork, the instance shall have properties and values below, respectively.</p> <p>CIM_ResourceAllocationSettingData.ResourceType = 3 (Processor)</p> <p>CIM_ResourceAllocationSettingData.ResourceType = 4 (Memory)</p> <p>CIM_EthernetPortAllocationSettingData.ResourceType = 10 (Ethernet Adapter), 30 (Ethernet Switch Port) or 33 (Ethernet Connection)</p>	
Free physical memory	Size of physical memory currently unused and available	G
	<p>CIM_ResourcePool.Capacity – CIM_ResourcePool.Reserved</p> <p>The instance shall have properties and values below.</p> <p>CIM_ResourcePool.ResourceType = 4 (Memory)</p> <p>CIM_ResourcePool.AllocationUnits = "byte * 2<sup>10</sup>"</p>	
Maximum resource	Upper bound, or maximum amount of resource that will be granted for this allocation	G/S
	<p>CIM_ResourceAllocationSettingData.Limit</p> <p>In the case that this Resource is a vMemory, the instance shall have properties and values below.</p> <p>CIM_ResourceAllocationSettingData.ResourceType = 4 (Memory)</p> <p>CIM_ResourceAllocationSettingData.AllocationUnits = "byte * 2<sup>10</sup>"</p> <p>In the case that this Resource is a vNetwork, the instance shall have properties and values below.</p> <p>CIM_EthernetPortAllocationSettingData.ResourceType = 10 (Ethernet Adapter), 30 (Ethernet Switch Port) or 33 (Ethernet Connection)</p> <p>CIM_EthernetPortAllocationSettingData.AllocationUnits = "bits per second" or "count" or a multiple of the units expressed through a regular expression</p>	
Minimum resource	Amount of resource guaranteed to be available for this allocation	G/S
	<p>CIM_ResourceAllocationSettingData.Reservation</p> <p>In the case that this Resource is a vMemory, the instance shall have properties and values below.</p> <p>CIM_ResourceAllocationSettingData.ResourceType = 4 (Memory)</p> <p>CIM_ResourceAllocationSettingData.AllocationUnits = "byte * 2<sup>10</sup>"</p> <p>In the case that this Resource is a vNetwork, the instance shall have properties and values below.</p> <p>CIM_EthernetPortAllocationSettingData.ResourceType = 10 (Ethernet Adapter), 30 (Ethernet Switch Port) or 33 (Ethernet Connection)</p> <p>CIM_EthernetPortAllocationSettingData.AllocationUnits = "bits per second" or "count" or a multiple of the units expressed through a regular expression</p>	
Physical memory size	The total amount of physical memory	G/S
	<p>CIM_ResourceAllocationSettingData.VirtualQuantity</p> <p>The instance shall have properties and values below.</p> <p>CIM_ResourceAllocationSettingData.ResourceType = 4 (Memory)</p> <p>CIM_ResourceAllocationSettingData.AllocationUnits = "byte * 2<sup>10</sup>"</p>	

Table 15 (continued)

Time counter	Cumulative time	G/S
	<p>SampleInterval [Data Type: datetime]</p> <p>In the case that this Resource is a vDisk and a vNetwork, the following properties shall be used, respectively.</p> <p>CIM_BlockStorageStatisticalData.SampleInterval [Data Type: datetime]</p> <p>CIM_NetworkPortStatistics.SampleInterval [DataType: datetime]</p> <p>If the statistics are not sampled at consistent time intervals, SampleInterval shall be set to a zero time interval. Duration shall be expressed as follows.</p> <p>delta CIM_BlockStorageStatisticalData.StatisticTime</p>	
Total disk size	The total amount of vDisk	G/S
	<p>CIM_StorageAllocationSettingData.VirtualQuantity</p> <p>The instance shall have properties and values below.</p> <p>CIM_StorageAllocationSettingData.ResourceType = 31 (Logical Disk)</p> <p>CIM_StorageAllocationSettingData.VirtualQuantityUnits [count (fixed size block)]</p>	
Network bandwidth	Maximum speed of vNetwork	G/S
	<p>CIM_EthernetPortAllocationSettingData.Limit</p> <p>The instance shall have properties and values below.</p> <p>CIM_EthernetPortAllocationSettingData.ResourceType = 10 (Ethernet Adapter), 30 (Ethernet Switch Port) or 33 (Ethernet Connection)</p> <p>CIM_EthernetPortAllocationSettingData.AllocationUnits = "bits per second" or "count" or a multiple of the units expressed through a regular expression</p> <p>or</p> <p>CIM_ResourcePool.Capacity</p> <p>The instance shall have properties and values below.</p> <p>CIM_ResourcePool.ResourceType = 10 (Ethernet Adapter), 30 (Ethernet Switch Port) or 33 (Ethernet Connection)</p> <p>CIM_ResourcePool.AllocationUnits = "bits per second" or "count" or a multiple of the units expressed through a regular expression</p>	

1 PUnit stands for a Programmatic Unit, which is an expression of a unit of measure for programmatic access.

Table 16 — Power Domain Properties

Property Name	Description	G/S
	CIM Class/Association/Property/Method	
Input power	Input power of this Resource	G
	<p>CIM_NumericSensor.CurrentReading</p> <p>In the case that this Resource is a server, a chassis, or a rack, the instance shall have properties and values below.</p> <p>CIM_NumericSensor.SensorType = 13 (Power Consumption).</p> <p>CIM_NumericSensor.BaseUnits = 7 (Watts)</p>	
Power status	Power status of this Resource, e.g., Active or Off. In case that this Resource is a server or a VM, the status shall be those specified in ENERGY STAR (R) Program Requirements for Computers version 5.0, e.g., Active, Idle, Sleep or Off.	G/S
	<p>CIM_AssociatedPowerManagementService.PowerState</p> <p>The property value can be modified with extrinsic methods, such as CIM_PowerManagementService.RequestPowerStateChange().</p>	

**Table 17 — Fluid Domain Properties**

Property Name	Description	G/S
	CIM Class/Association/Property/Method	
Inlet air temperature	Temperature of the air suctioned into this Resource CIM_NumericSensor.CurrentReading In the case that this Resource is a server, a chassis, or a rack, the instance shall have properties and values below. CIM_NumericSensor.SensorType = 2 (Temperature). CIM_NumericSensor.BaseUnits = 2 (Degrees C), 3 (Degrees F) or 4 (Degrees K)	G
Supply air temperature	Temperature of the air supplied to the room/floor chamber from this A/C CIM_BaseMetricValue.MetricValue The instance shall have properties and values below. CIM_BaseMetricDefinition.ProgrammaticUnits = degree Celsius, degree Fahrenheit or Kelvin CIM_BaseMetricDefinition.Description = "Supply air temperature"	G
Return air temperature	Temperature of the air suctioned from the room into the return grill on this A/C CIM_BaseMetricValue.MetricValue The instance shall have properties and values below. CIM_BaseMetricDefinition.ProgrammaticUnits = degree Celsius, degree Fahrenheit or Kelvin CIM_BaseMetricDefinition.Description = "Return air temperature"	G
Set temperature	Value set to this A/C as supply air temperature, return air temperature or room temperature CIM_BaseMetricValue.MetricValue The instance shall have properties and values below. CIM_BaseMetricDefinition.ProgrammaticUnits = degree Celsius, degree Fahrenheit or Kelvin CIM_BaseMetricDefinition.Description = "Set temperature"	G/S
Outdoor air temperature	Temperature of the environment around the outdoor unit of this A/C CIM_BaseMetricValue.MetricValue The instance shall have properties and values below. CIM_BaseMetricDefinition.ProgrammaticUnits = degree Celsius, degree Fahrenheit or Kelvin CIM_BaseMetricDefinition.Description = "Outdoor air temperature"	G
Supply air humidity	Humidity of the air supplied to the room/floor chamber from this A/C CIM_BaseMetricValue.MetricValue The instance shall have properties and values below. CIM_BaseMetricDefinition.ProgrammaticUnits = percent CIM_BaseMetricDefinition.Description = "Supply air humidity"	G
Return air humidity	Humidity of the air suctioned from the room into the return grill on this A/C CIM_BaseMetricValue.MetricValue The instance shall have properties and values below. CIM_BaseMetricDefinition.ProgrammaticUnits = percent CIM_BaseMetricDefinition.Description = "Return air humidity"	G

Table 17 (continued)

Set humidity	Value set to this A/C as supply air humidity, return air humidity or room humidity	G/S
	<p>CIM_BaseMetricValue.MetricValue</p> <p>The instance shall have properties and values below.                      CIM_BaseMetricDefinition.ProgrammaticUnits = percent                      CIM_BaseMetricDefinition.Description = "Set humidity"</p>	
Supply air flow rate	Flow rate of the air supplied to the room/floor chamber from this A/C	G
	<p>CIM_BaseMetricValue.MetricValue</p> <p>The instance shall have properties and values below.                      CIM_BaseMetricDefinition.ProgrammaticUnits = cubic meters per hour                      CIM_BaseMetricDefinition.Description = "Supply air flow rate"</p>	
Return air flow rate	Flow rate of the air suctioned from the room into the return grill on this A/C	G
	<p>CIM_BaseMetricValue.MetricValue</p> <p>The instance shall have properties and values below.                      CIM_BaseMetricDefinition.ProgrammaticUnits = cubic meters per hour                      CIM_BaseMetricDefinition.Description = "Return air flow rate"</p>	
Set flow rate	Value set to this A/C as supply air flow rate	G/S
	<p>CIM_BaseMetricValue.MetricValue</p> <p>The instance shall have properties and values below.                      CIM_BaseMetricDefinition.ProgrammaticUnits = cubic meters per hour                      CIM_BaseMetricDefinition.Description = "Set flow rate"</p>	

7 Messages

Messages represent commands, responses or events. Management Functions use Messages to monitor and control Resources. Messages are CIM message requests and responses as specified in *CIM Operations over HTTP* (DSP0200). This Clause specifies requests and responses in pairs; each received request requires a response as specified in DSP0200. A Management Function uses a CIM Listener and a CIM Client to send and receive Messages. Resources use a CIM Server, which implements the HTTP server, to send and receive Messages.

Properties of a Resource are represented as Properties of an instance of a CIM class. Management Function shall have information of the instance name and the CIM Server that represents a Resource to query the properties of the Resource.

To query Properties of a Resource, Management Functions shall include the corresponding instance name and the CIM Server that represents the Resource in CIM messages. The CIM Server shall respond a CIM message request as a proxy for the Resource. Unimplemented Properties or Event Conditions shall be signalled in responses that carry "CIM\_ERR\_NO\_SUCH\_PROPERTY" or "CIM\_ERR\_NOT\_FOUND" error codes respectively.

## 7.1 Commands and responses

### 7.1.1 GET

#### 7.1.1.1 GET command

GET command specified in the table below shall be used to request Resource Properties or Event Descriptions. GET command shall be issued by Management Function and be received by Resource.

Item		Corresponding CIM-XML header
Message type		<IMETHODCALL NAME="GetProperty">
Request ID		<MESSAGE ID="Request ID">
Object data	Target	<IPARAMVALUE NAME = "InstanceName"> <IPARAMVALUE NAME = "PropertyName">

#### 7.1.1.2 GET response

GET response specified in the table below is the response to the GET command. GET response is issued by Resource and is received and processed by Management Function.

Item		Corresponding CIM-XML header
Message type		<IMETHODRESPONSE NAME="GetProperty">
Request ID		<MESSAGE ID="Request ID">
Result code		<IRETURNVALUE> (indicating success) or <ERROR Code="error code"> (indicating error)
Object data	Target	Not specified in GET response (Target of the received GET command)
	Value	<IRETURNVALUE> <VALUE>"Value"</VALUE> </IRETURNVALUE>

### 7.1.2 SET

#### 7.1.2.1 SET command

SET command shall include the following items to set Properties of Resources or to set Event Conditions. SET command is issued by Management Function and is received and processed by Resource.

Item		Corresponding CIM-XML header
Message type		<IMETHODCALL NAME="SetProperty">
Request ID		<MESSAGE ID="Request ID">
Object Data	Target	<IPARAMVALUE NAME="InstanceName"> <IPARAMVALUE NAME="PropertyName">
	Value	<IPARAMVALUE NAME="PropertyValue"> <Value>"New Value"</Value> </IPARAMVALUE>

7.1.2.2 SET response

SET response shall include the following items. SET response is issued by Resource and is received and processed by Management Function.

Item	Corresponding CIM-XML header
Message type	<IMETHODCALL NAME=" SetProperty">
Request ID	<MESSAGE ID=" Request ID">
Result Code	<IRETURNVALUE> (indicating success) or <ERROR Code="error code"> (indicating error)

7.2 Event subscription and notification

7.2.1 Event subscription

To specify the conditions under which Management Functions need to be notified, they shall create an instance of CIM\_IndicationFilter as described in *CIM Event Model White Paper* (DSP0107). Management Function issues Event subscription request to Resources that register the Event subscriptions that may result in event notifications. In the table, "M" and "O" indicate a field is mandatory or optional respectively.

Field name	Corresponding property of CIM_Indication-Filter		G/S	M/O
Event subscription ID	Name	-	G/S	M
Host	SystemCreationClassName, SystemName, CreationClassName	-	G/S	M
Interval	RepeatNotificationPolicy,	s	G/S	O
Beginning	OtherRepeatNotificationPolicy,	-	G/S	O
End	RepeatNotificationInterval, RepeatNotificationGap, RepeatNotification-Count	-	G/S	O
Conditions	Query, QueryLanguage	-	G/S	M