ecma INTERNATIONAL

Standard ECMA-400

1st Edition / December 2011

Smart Data Centre Resource Monitoring and Control

Standard

Rue du Rhône 114 CH-1204 Geneva T: +41 22 849 6000 F: +41 22 849 6001

is the registered trademark of Ecma International

COPYRIGHT PROTECTED DOCUMENT

Contents

Page

Introduction

In recent years, energy consumption in data centres has increased drastically. The analysis on the breakdown of the energy consumption in data centres has shown that about half of energy consumption comes from IT equipment such as servers and storage systems and the other half comes from facilities such as power supplies and air-conditioners, which enable operation of IT equipment. Therefore, to achieve substantial energy efficiency benefits, a holistic approach is required.

To realize energy reduction, integrated management of IT and facility equipment is necessary. It is difficult, however, to use information from IT and facility equipment islands because there are big differences in the types and formats of information. In addition IT and facility equipment use different protocols, IT equipment frequently uses SNMP whereas facilities use e.g. BACnet and LONWORKS. UPS and PLC (sensors) use serial and analogue interfaces.

This standard specifies unified semantics for monitoring and control messages to be exchanged over the interfaces and protocols mentioned above. Languages binding the semantics are compatible and translatable to each other even if they adopt a syntax specific to those protocols. Using the unified semantics, systems can easily be managed for energy reduction in data centres.

This Ecma Standard has been adopted by the General Assembly of December 2011.

Smart Data Centre Resource Monitoring and Control

1 Scope

This Ecma Standard models IT & facility equipment, systems and components in Smart Data Centre as Resources, organises the Resources in a graph, and specifies the semantics – but not the syntax - of Messages for commands, responses and events.

This first edition covers consolidating compute and cooling resources to minimise power.

Smart Clients use the Resource graph to address individual - or a group of - Resources. Smart Clients use the Messages to monitor and control the Properties of Resources.

The communication protocol bindings (e.g., HTTP, FTP, SNMP, BACnet) that transport Messages between Resources and Management Function(s) are out of the scope as illustrated in Figures 1 and 2, in addition, session management and security aspects such as authentication, authorization are out of the scope. Static information such as location, CPU models are out of scope.

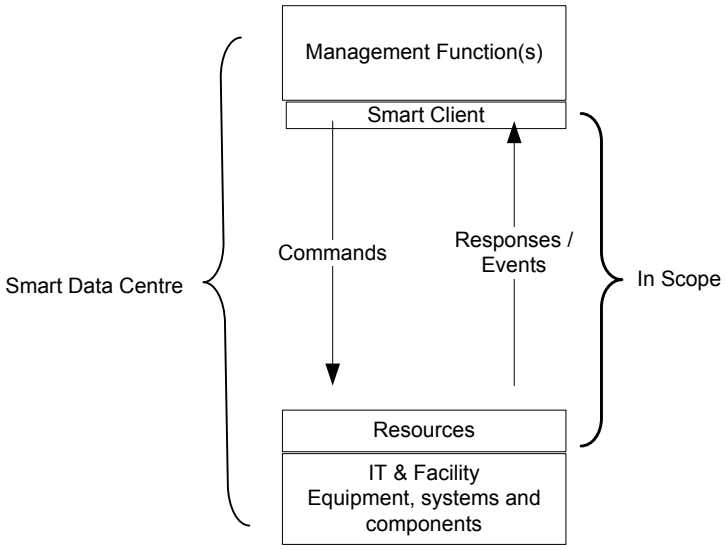

Figure 1 — Scope

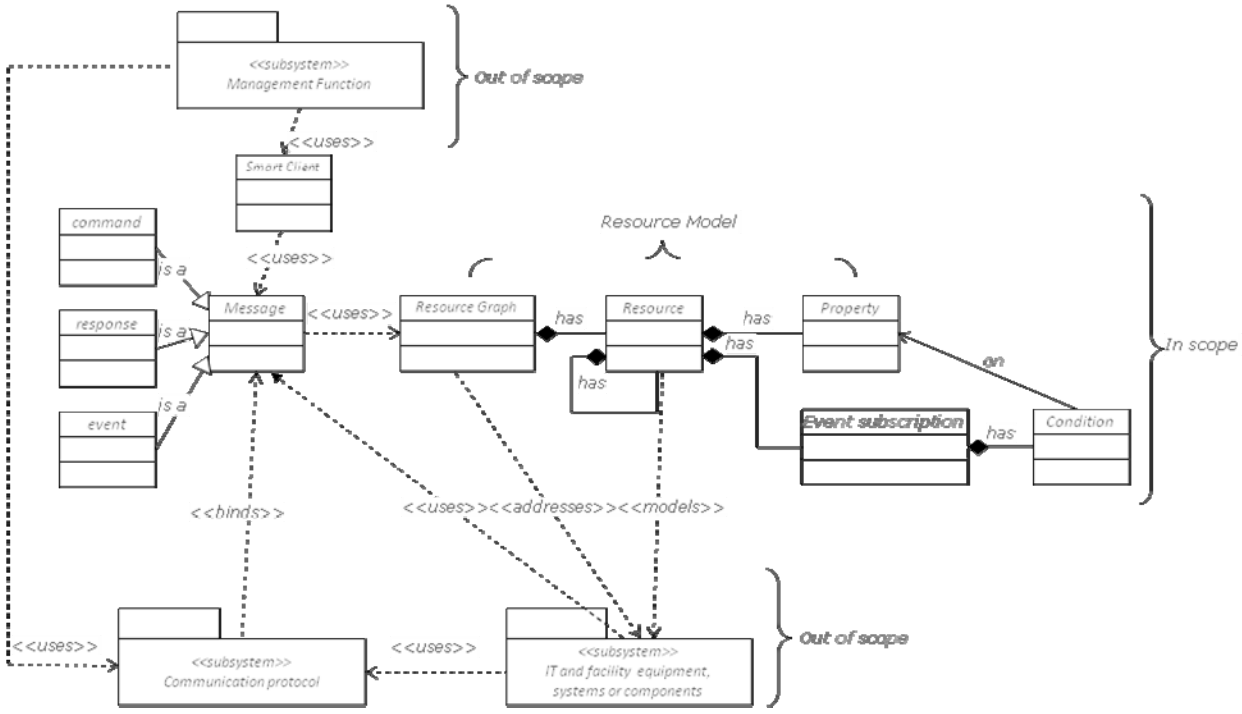

Figure 2 — detailed scope (UML Notation)

2 Conformance

Conformant command messages from Smart Clients to monitor and control Properties use the Resource, and their Properties. Smart Clients query their root Resource for the Resources that the root represents and their inter-relationships, if any.

In response to the commands, conformant responses and events from Resources use the Messages specified herein, where “unsupportedProperty” or “unsupportedEventCondition” codes as specified in 5.2.1 signal unimplemented optional Properties or Event Conditions respectively.

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.

None.

4 Terms and definitions

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

4.1
condition
expression on Property value

4.2
event description
set of Conditions and associated parameters

4.3
IT
Information Technology

4.4
message
command, response or event

4.5
Management Function
MF
user of a Smart Client

4.6
Smart Client
SC
emitter of commands and consumer of responses and events

4.7
property
resource attribute

4.8
resource
representation of IT and facility equipment, systems or components as a consumer of commands and emitter of responses and events

Examples: IT equipment includes server, network and storage equipment. Facility equipment includes air conditioners (A/C) and power units.

4.9
Smart Data Centre
SDC
arrangement of all the Resources and Management Function(s)

5 Resources

Smart Clients use Messages (see 6) to monitor and control Properties (see 5.2) of a Resource.

5.1 Addressing Resources

Resources are modelled and may be organised in a hierarchical tree to express that Resources may contain other Resources. The figure below illustrates this “has” relationship between Resources using a black diamond (♦). The Root is the common ancestor for all the other Resources. The address of a Resource may be the concatenation of the Resource instance IDs from the Root to the Resource to be addressed. Instance IDs may be the Resource names concatenated with the instance number. To address the instances of a Resource as a group, their Resource name may be used without instance number.

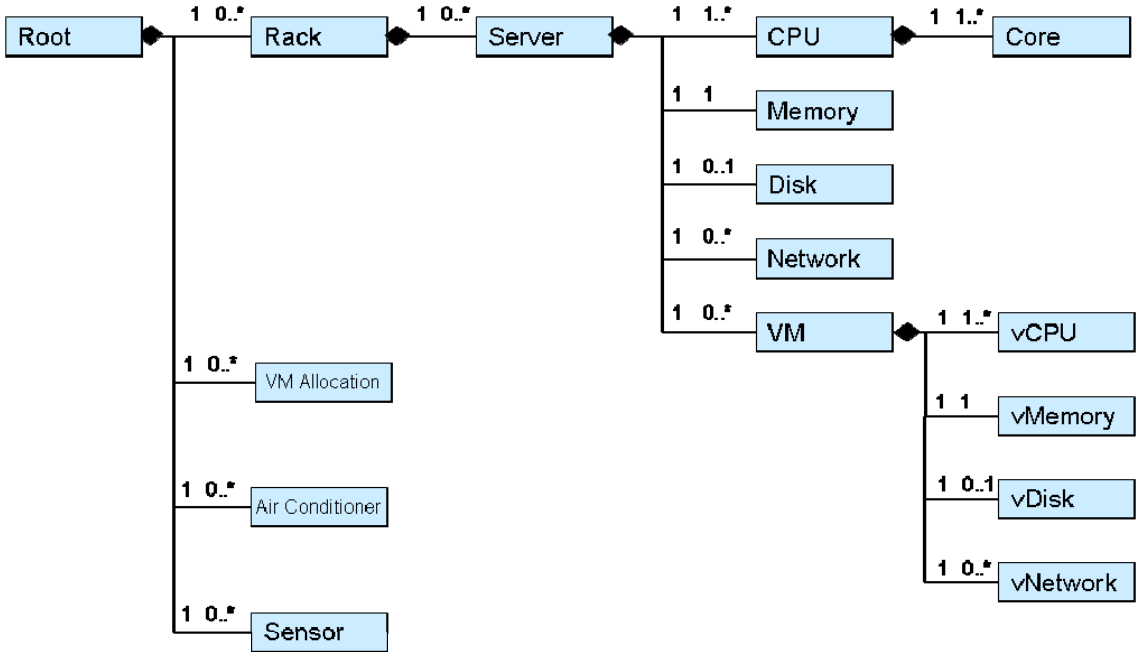

Figure 3 — Example Resource tree (UML class notation)

5.2 Resource Property model

5.2.1 Notation

Messages exchanged between Resources and SCs carry Property names (and values, if any) using the templates of following Resources. In the template specifications “G/S”, “G”, “S” indicate a Property that may be used in a GET and SET, GET, SET command respectively.

In the column “M/O”, “M” and “O” indicate that supporting the Property value is “mandatory” and “optional”, respectively. “C” with a number indicates that supporting the Property value is conditional to occasion. If a GET command carries a name of a mandatory Property, the response to the command shall carry the value of the mandatory Property. If a SET command carries a name and a value of a mandatory Property or Event Condition, the Property value specified in the SET command shall be set to the relevant Resource as indicated in the SET command.

5.2.2 VM Allocation

Name of Property	Description	Dimension	G/S	M/O
VM Allocation	Tuples of server and VM. VMs shall be (re)allocated to the server indicated in the SET command. SET command has 2 parameters of server and VM. If the first parameter is empty, the VM in the second parameter shall be deleted. If the both parameters are not empty, the VM in the second parameter shall be migrated according to the first parameter.	-	G/S	M

5.2.3 Rack

Name of Property	Description	Dimension	G/S	M/O
Rack ID	Uniquely identifies a rack	-	G/S	M
Rack input power	Input power of this rack	W	G	C1
Rack inlet air temperature	Temperature of the air suctioned into this rack	K	G	C2
Rack power status	Power status of this rack, e.g., Active or Off	-	G/S	O

C1: This Property shall be supported if one or more of its servers do not report server input power.

C2: This Property shall be supported if one or more of its servers do not report server inlet air temperature.

5.2.4 Server

Name of Property	Description	Dimension	G/S	M/O
Server ID	Uniquely identifies a server in SDC	-	G/S	M
Input power	Input power of this server	W	G	C3
Server inlet air temperature	Temperature of the air suctioned into this server	K	G	C4
Server power status	Power status of this server, e.g., Active, Idle, Sleep or Off as specified in ENERGY STAR (R) Program Requirements for Computers version 5.0.	-	G/S	M

C3: This Property shall be supported if the rack on which this server is located does not report the rack input power.

C4: This Property shall be supported if the rack on which this server is located does not report rack the inlet air temperature.

5.2.4.1 CPU

Name of Property	Description	Dimension	G/S	M/O

5.2.4.1.1 Core

Name of Property	Description	Dimension	G/S	M/O
Average load percentage	Average load percentage of this core over the last minute	%	G	M
Current clock speed	Current clock speed of this core	Hz	G	M

5.2.4.2 Memory

Name of Property	Description	Dimension	G/S	M/O
Free physical memory	Size of physical memory currently unused and available	Byte	G	M
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	Byte	G	M

5.2.4.3 Disk

Name of Property	Description	Dimension	G/S	M/O
Kbytes read	Cumulative count of data read	Byte	G	O
Kbytes written	Cumulative count of data written	Byte	G	O
Read hit IOs	Cumulative count of all read cache hits	-	G	O
Read IOs	Cumulative count of all reads	-	G	O
Duration	Time over which the other values are accumulated	s	G/S	O
Write hit IOs	Cumulative count of write cache hits	-	G	O
Write IOs	Cumulative count of all writes	-	G	O

5.2.4.4 Network

Name of Property	Description	Dimension	G/S	M/O
Bytes received	Total number of bytes that are received.	Byte	G	O
Bytes transmitted	Total number of bytes that are transmitted	Byte	G	O
Packets received	Total number of packets that are received	-	G	O
Packets transmitted	Total number of packets that are transmitted	-	G	O
Duration	Time over which the other values are accumulated	s	G/S	O

5.2.5 VM

Name of Property	Description	Dimension	G/S	M/O
VM ID	Uniquely identifies a VM in SDC	-	G/S	M
Power status	Power status of this VM, e.g., Active, Idle, Sleep or Off as specified in ENERGY STAR (R) Program Requirements for Computers version 5.0.	-	G/S	M

5.2.5.1 vCPU

This class shall be implemented when VM class is implemented.

Name of Property	Description	Dimension	G/S	M/O
Reservation	Specifies the amount of the resource guaranteed to be available for the VM	Hz, %	G/S	O
Limit	Specifies the upper bound of the resource that will be granted for the VM	Hz, %	G/S	O
Load percentage	Load percentage of this vCPU, averaged over the last minute, in Percent of maximum capability.	%	G	M
Current clock speed	Current clock speed of this vCPU	Hz	G	M
Weight	Relative priority for this allocation in relation to other allocations	-	G/S	O

5.2.5.2 vMemory

This class shall be implemented when VM class is implemented.

Name of Property	Description	Dimension	G/S	M/O
Free physical memory	Size of physical memory currently unused and available	Byte	G	M
Maximum resource	Upper bound, or maximum amount of resource that will be granted for this allocation	Byte, % or -	G/S	O
Minimum resource	Amount of resource guaranteed to be available for this allocation	Byte, % or -	G/S	O
Physical memory size	The total amount of physical memory	Byte	G/S	M
Weight	Relative priority for this allocation in relation to other allocations	-	G/S	O

5.2.5.3 vDisk

Name of Property	Description	Dimension	G/S	M/O
Kbytes read	Cumulative count of data read	Byte	G	O
Kbytes written	Cumulative count of data written	Byte	G	O
Read hit IOs	Cumulative count of all read cache hits	-	G	O
Read IOs	Cumulative count of all read	-	G	O
Time counter	Cumulative time	s	G/S	O
Total disk size	The total amount of vdisk	Byte	G/S	M
Write hit IOs	Cumulative count of write cache hits	-	G	O
Write IO	Cumulative count of all writes	-	G	O

5.2.5.4 vNetwork

Name of Property	Description	Dimension	G/S	M/O
Bytes received	Total number of bytes that are received.	Byte	G	O
Bytes transmitted	Total number of bytes that are transmitted	Byte	G	O
Maximum resource	Upper bound, or maximum amount of resource that will be granted for this allocation	Byte/s, % or -	G/S	O
Minimum resource	Amount of resource guaranteed to be available for this allocation	Byte/s, % or -	G/S	O
Network bandwidth	Maximum speed of vNetwork	Byte/s	G/S	M
Packets received	Total number of packets that are received	-	G	O
Packets transmitted	Total number of packets that are transmitted	-	G	O
Time counter	Cumulative time	S	G/S	O
Weight	Relative priority for this allocation in relation to other allocations	-	G/S	O

5.2.6 Air conditioner

Name of Property	Description	Dimension	G/S	M/O
Air Conditioner ID	Uniquely identifies an air conditioner (A/C) in SDC	-	G/S	M
Operation status	Operation status of this A/C, e.g., ON/OFF	-	G/S	M
Supply air temperature	Temperature of the air supplied to the room/floor chamber from this A/C	K	G	M
Return air temperature	Temperature of the air suctioned from the room into the return grill on this A/C	K	G	M
Set temperature	Value set to this A/C as supply air temperature, return air temperature or room temperature	K	G/S	M
Outdoor air temperature	Temperature of the environment around the outdoor unit of this A/C	K	G	M
Supply air humidity	Humidity of the air supplied to the room/floor chamber from this A/C	%	G	O
Return air humidity	Humidity of the air suctioned from the room into the return grill on this A/C	%	G	O
Set humidity	Value set to this A/C as supply air humidity, return air humidity or room humidity	%	G/S	O
Input power	Moving average of input power of this A/C	W	G	M

5.2.7 Sensor

Sensors may be used to measure various values including input power of servers and rack inlet air temperature.

Name of Property	Description	Dimension	G/S	M/O
Sensor ID	Uniquely identifies a sensor in SDC	-	G/S	M
Sensor value	Values that this sensor senses	*1	G	M

*1: Depends on the sensor type

6 Messages

Messages are commands, responses and events used for monitoring and control of Resources. This clause specifies commands and responses in pairs; each received command requires a response.

6.1 Commands and responses

6.1.1 GET

6.1.1.1 GET command

The GET command specified in the table below shall be used to request Resource Properties or Event Descriptions.

Item		Description
Message type		GET command
Request ID		Identifier of this GET command
Object data	Target	List of identifier of (a) Property(ies) and/or identifier of (a) Event Property(ies). Property may be identified with identifier of parent Resource and wild cards.

6.1.1.2 GET response

The GET response specified in the table below is the response to the GET command.

Item		Description
Message type		GET response
Request ID		Request ID of the received GET command
Result code		Code meaning: “normally processed”, “unsupported property”, “unsupported Event Condition” or “Resource error”.
Object data	Target	Target of the received GET command.
	Value	List of value(s) of (a) Property(ies) and/or (a) Event Property(ies) specified in the received GET command If the result code is not a code meaning “normally processed”, this item shall be empty.

6.1.2 SET

6.1.2.1 SET command

The SC shall include the following items in a SET command to set Properties of Resources or to set Event Conditions.

Item		Description
Message type		SET command
Request ID		Identifier of this SET command
Object Data	Target	The identifier of the Resource whose Property value is set or whose Event Description is created/modified, where the identifier is unique (at least) in a SDC.
	Value	List of tuples including Property name and value (or difference from the current Property value) or list of Event Descriptions to be created/modified. If the Target corresponds to a non-leaf node, this tuple shall also include Resource identifiers.

6.1.2.2 SET response

SET response shall include the following items.

Item	Description
Message type	SET response
Request ID	Identifier of the received SET command
Result Code	Code meaning: “normally processed”, “unsupported Property”, “unsupported Event Condition” or “Resource error”

6.2 Event subscription and notification

6.2.1 Event subscription

To specify the conditions under which SCs need to be notified, they shall include the Event subscription below in a Set command.

Field name	Description	Dimension	G/S	M/O
Event subscription ID	Uniquely identifies Event subscription	-	G/S	M
Host	The Resource that has the Properties to which the Conditions refer.	-	G/S	M
Interval	Minimal duration between successive event reports (specifies the maximum Event frequency)	s	G/S	O
Beginning	Specifies when to start sending Events (e.g. “immediately”, “2010-04-01 12:00:00”)	-	G/S	O
End	Specifies when to stop sending Events (e.g. “100 times”, “2010-04-01 18:00:00”)	-	G/S	O
Conditions	Condition(s) for raising Events, where the statement of this condition follows an expression rule, e.g., CQL expression rules. The Resources given as parameters in these conditions shall belong to the sub-tree of the Target.	-	G/S	M

NOTE CQL is standardized in “DSP0202, CIM Query Language Specification, DMTF”.

6.2.2 Event notification

When the Conditions in the Event subscriptions have been met, owners shall be notified using this Event Message:

Item		Description
Message type		NOTIFY event
Source		The identifier of a Resource who sent this event, where the identifier is unique (at least) in SDC
Event subscription ID		Identifies the Event subscription ID of this event
Object Data	Value	List of tuples of Resource identifier, Property name and value of Properties appeared in the Condition in Event subscription of this event. The Resource identifier in the tuple is optional if the Source is a leaf node.
Event Time		The time when this event occurred

Annex A
(informative)

VM load consolidation and air conditioner control (Use Case)

(The VM load is consolidated on one server and the rest of the servers that become vacant are turned off. Over-cooling is reduced to save energy. The Air conditioner operation is controlled according to the projected VM load after consolidation.)

Figure A.1 illustrates the steps in this Annex that assumes the resource tree in Figure 3, and the following is the configuration:

(1) Server configuration
  (i) List of Servers
  (ii) Resource (IDs, CPU clock speed, memory size, HDD size, network bandwidth)

(2) VM
  (i) Number of VMs
  (ii) Resource (IDs, CPU clock speed, memory size, HDD size, network bandwidth)

1. Retrieving operation information of servers and VMs

   Step 1: Retrieving load percentage, memory usage and network traffic of each of the servers
   - GET “Server1.CPU1.Core1” “Load Percentage”

   Step 2: Identifying VMs that are loaded on the servers
   - GET “VM Allocation” “ VM Allocation”

   Step 3: Retrieving load percentage, memory usage and network traffic of each VM
   - GET “Server1.VM1.vCPU1” “Load Percentage”

   Step 4: Retrieving the air temperature of the air conditioner
   - GET “Air Conditioner 1” “Return Air Temperature”

2. Planning and verifying feasibility of VM reallocation based on the retrieved information in steps 1 to 4 and the configuration

3. Planning air conditioner operation

4. Step 5: Setting supply air temperature of the air conditioner

   - SET “Air Conditioner 1” “Supply Air Temperature = [295K]”

5. Step 6: Reallocating VMs

   - SET “VM Allocation” “VM Allocation = [Server1,VM1; Server1,VM2; Server1,VM3]”

6. Step 7: Turning off the vacant server

   - SET “Server2” “Server Power Status=[OFF]”

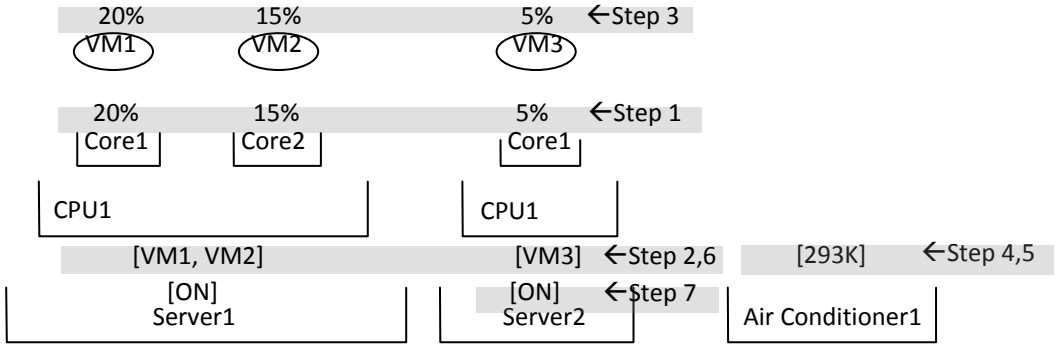

Figure A.1 — VM consolidation and air conditioner control steps