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Cloud Infrastructure Management Interface (CIMI) Model and RESTful HTTP-based Protocol — An Interface for Managing Cloud Infrastructure

Model d'interface de management de l'infrastructure du nuage informatique (CIMI) et protocole RESTful basé HTTP — Une interface pour le management de l'infrastructure du nuage informatique

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

The *Cloud Infrastructure Management Interface (CIMI) Model and RESTful HTTP-based Protocol* specification (DSP0263) was prepared by the DMTF Cloud Management Working Group. It defines a logical model for the management of resources within the Infrastructure as a Service domain.

DMTF is a not-for-profit association of industry members dedicated to promoting enterprise and systems management and interoperability.

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The DMTF acknowledges the following individuals for their contributions to this document:

Editors (past and present):

- Marios Andreou – Red Hat
- Doug Davis – IBM
- Jacques Durand – Fujitsu
- Gilbert Pilz – Oracle

Contributors:

- Ghazanfar Ali – ZTE Corporation
- Marios Andreou – Red Hat
- Keith Bankston – Microsoft Corporation
- Winston Bumpus – VMware Inc.
- Nathan Burkhart – Microsoft Corporation
- Mark Carlson – Oracle
- Steve Carter – Novell
- Junsheng Chu – ZTE Corporation
- Josh Cohen – Microsoft Corporation
- Derek Coleman – Hewlett-Packard Company
- John Crandall – Brocade Communications Systems
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- Fernando de la Iglesia – Telefónica
- Hiroshi Dempo – NEC Corporation
- Jacques Durand – Fujitsu
- Yigal Edery – Microsoft Corporation
- George Ericson – EMC
- Colleen Evans – Microsoft Corporation
- Norbert Floeren – Ericsson AB
- Robert Freund – Hitachi, Ltd.
- Fermín Galán – Telefónica
- Krishnan Gopalan – Microsoft Corporation
- Kazunori Iwasa – Fujitsu
- Mark Johnson – IBM
- Bhumip Khasnabish – ZTE Corporation
- Dies Köper – Fujitsu
- Vincent Kowalski – BMC Software
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- Lawrence Lamers – VMware Inc.
- Paul Lipton – CA Technologies
- James Livingston – NEC Corporation
- Vince Lubsey – Virtustream Inc.

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- Jeff Mischkinsky – Oracle
- Jesus Molina – Fujitsu
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- Alvaro Polo – Telefónica
- Enrico Ronco – Telecom Italia
- Federico Rossini – Telecom Italia
- Matthew Rutkowski – IBM
- Tom Rutt – Fujitsu
- Hemal Shah – Broadcom
- Nihar Shah – Microsoft Corporation
- Alan Sill – Texas Tech University
- Zhexuan Song – Huawei
- Marvin Waschke – CA Technologies
- Eric Wells – Hitachi, Ltd.
- Jeff Wheeler – Huawei
- Maarten Wiggers – Fujitsu
- Daniel Wilson – Ericsson AB
- Steve Winkler – SAP AG
- Jack Yu – Oracle
- Aaron Zhang – Huawei
- HengLiang Zhang – Huawei

Cloud Infrastructure Management Interface (CIMI) Model and RESTful HTTP-based Protocol

1 Scope

This specification describes the model and protocol for management interactions between a cloud Infrastructure as a Service (IaaS) Provider and the Consumers of an IaaS service. The basic resources of IaaS (machines, storage, and networks) are modeled with the goal of providing Consumer management access to an implementation of IaaS and facilitating portability between cloud implementations that support the specification. This document specifies a Representational State Transfer (REST)-style protocol using HTTP. However, the underlying model is not specific to HTTP, and it is possible to map it to other protocols as well.

CIMI addresses the management of the lifecycle of infrastructure provided by a Provider. CIMI does not extend beyond infrastructure management to the control of the applications and services that the Consumer chooses to run on the infrastructure provided as a service by the Provider. Although CIMI may be to some extent applicable to other cloud service models, such as Platform as a Service ("PaaS") or Storage as a Service ("SaaS"), these uses are outside the design goals of CIMI.

1.1 Document structure

This document defines a model and a RESTful HTTP-based protocol.

The core REST patterns are defined first and, after each resource is defined, any HTTP-specific information for that resource is specified.

1.2 Document versioning scheme

This document adheres to the versioning scheme defined in clause 6.3 of DSP4004.

As the specification changes over time certain features might be deprecated. These are identified in the specification and should not be supported. Each of these deprecated features is clearly denoted in the clause in which they were previously defined.

1.3 Typographical conventions

This specification uses the following conventions:

In the narrative text of the specification:

- The regular or narrative font is Arial.
- Proper CIMI nouns such as Resource names, attribute names, operation names, reserved variable names are in `Courier` font. (e.g. `Machine`, `volumes`, `$expand`). The plural form applies to such names to indicate several instances of such Resources (e.g. `Machines`, `Systems`).
- Examples text are in small `Courier` font and over a darker background.
- Quotes are used for any text that needs be distinguished as name or value of a particular concept (e.g. the "value constraints" attribute, the “Resource Name” column, a “false” value). In such cases, the string in quotes is always qualified by the concept it is an instance of.
- Names for CIMI concepts that may be common English words but have a very specific meaning in CIMI, are in narrative font but capitalized, e.g. Provider, Consumer, Resource, Collection.

When used in their common English sense they remain lower-case. However, CIMI modeling concepts that are used in a commonly understood manner remain in lower-case, such as: attribute, operation.

Inside tables describing the Resource data model:

- The narrative font is used for all terms, as the table structure qualifies them sufficiently.
- Where textual descriptions are introduced, the rules for narrative text apply.
- If a name is used as types (i.e., names of embedded structures as well as atomic types such as "integer", "string"), are in *italic*.
- Names that are just placeholders for actual names that may vary with each model instance, are between < > (e.g., <componentTemplate>).

Where the serialization of Resources is described, a pseudo-schema notation is used with the following conventions:

- Values in *italics* indicate data types instead of literal values.
- Characters are appended to items to indicate cardinality:
  - "?" (0 or 1)
  - "*" (0 or more)
  - "+" (1 or more)
- Vertical bars, "|", denote choice. For example, "a|b" means a choice between "a" and "b".
- Parentheses, "(" and ")", are used to indicate the scope of the operators "?", "*", "+" and "|".
- Ellipses (i.e., "...") indicate points of extensibility. Note that the lack of an ellipses does not mean no extensibility point exists, rather it is just not explicitly called out - usually for the sake of brevity.

Operation names Create, Update, Delete, Read are abstract operations that convey the semantics of concrete corresponding operations, such as HTTP methods or CIMI operation URIs.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated or versioned references, only the edition cited (including any corrigenda or DMTF update versions) applies. For references without a date or version, the latest published edition of the referenced document (including any corrigenda or DMTF update versions) applies.

DMTF DSP0223, *Generic Operations 1.0*,
http://www.dmtf.org/standards/published_documents/DSP0223_1.0.pdf

DMTF DSP0243, *Open Virtualization Format Specification 1.1*,
http://www.dmtf.org/sites/default/files/standards/documents/DSP0243_1.1.pdf

DMTF DSP1001, *Management Profile Specification Usage Guide 1.1,*
http://www.dmtf.org/standards/published_documents/DSP1001_1.1.pdf

DMTF DSP4004, *DMTF Release Process 2.4*,
http://www.dmtf.org/sites/default/files/standards/documents/DSP4004_2.4.pdf

IANA HTTP Header Registry, http://www.iana.org/assignments/message-headers/perm-headers.html

IEC 80000-13:2008, International Organization for Standardization, Geneva, Switzerland, *Quantities and units – Part 13: Information science and technology*, April 2008, http://www.iso.org/iso/catalogue_detail?csnumber=31898

IETF RFC2616, R. Fielding et al, *Hypertext Transfer Protocol -- HTTP/1.1*, http://www.ietf.org/rfc/rfc2616.txt

IETF RFC3986, T.Berners-Lee et al, *Uniform Resource Identifiers (URI): Generic Syntax*, August 1998, http://www.ietf.org/rfc/rfc3986.txt

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IETF RFC5246, T. Dierks and E. Rescorla, *The Transport Layer Security (TLS) Protocol Version 1.2*, http://www.ietf.org/rfc/rfc5246.txt

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ISO/IEC Directives, Part 2, *Rules for the structure and drafting of International Standards*, http://isotc.iso.org/livelink/livelink.exe?func=ll&objId=4230456&objAction=browse&sort=subtype

NIST Special Publication 800-145, Peter Mell and Timothy Grance, *The NIST Definition of Cloud Computing*, Sept. 2011, http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

NIST Special Publication 500-292, Fang Liu, Jin Tong, Jian Mao, Robert Bohn, John Messina, Lee Badger and Dawn Leaf, *NIST Cloud Computing Reference Architecture*, Sept. 2011, http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/ReferenceArchitectureTaxonomy/NIST_SP_500-292_-_090611.pdf

Representational State Transfer, Roy Fielding, Doctoral dissertation, University of California, *Architectural Styles and the Design of Network-based Software Architectures (Chapter 5)*, 2000, http://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm

XMLSchema - Part 1, World Wide Web Consortium (W3C) Recommendation, H. Thompson, et al., Editors, *XML Schema Part 1: Structures Second Edition*, 28 October 2004, http://www.w3.org/TR/xmlschema-1/

XMLSchema - Part 2, World Wide Web Consortium (W3C) Recommendation, P. Biron, A. Malhotra, Editors, *XML Schema Part 2: Datatypes (Second Edition)*, 28 October 2004, http://www.w3.org/TR/xmlschema-2/

3 Terms and definitions

In this document, some terms have a specific meaning beyond the normal English meaning. Those terms are defined in this clause.

The terms "shall" ("required"), "shall not," "should" ("recommended"), "should not" ("not recommended"), "may," "need not" ("not required"), "can" and "cannot" in this document are to be interpreted as described in ISO/IEC Directives, Part 2, Annex H. The terms in parenthesis are alternatives for the preceding term, for use in exceptional cases when the preceding term cannot be used for linguistic reasons. Note that ISO/IEC Directives, Part 2, Annex H specifies additional alternatives. Occurrences of such additional alternatives shall be interpreted in their normal English meaning.

The terms "clause," "subclause," "paragraph," and "annex" in this document are to be interpreted as described in ISO/IEC Directives, Part 2, Clause 5.

The terms "normative" and "informative" in this document are to be interpreted as described in ISO/IEC Directives, Part 2, Clause 3. In this document, clauses, subclauses, or annexes labeled "(informative)" do not contain normative content. Notes and examples are always informative elements.

The terms defined in DSP4004, DSP0223, and DSP1001 apply to this document. The following additional terms are used in this document.

3.1
authentication

The process of verifying a claim, made by a subject, that it should be allowed to act on behalf of a given principal (person, service, etc.). Typical authentication mechanisms involve the use of username/password combination or public/private key pairs.

3.2
authorization

The process of verifying that an authenticated principal (person, service, etc.) has permission to perform certain operations (e.g., read, update) on specific Resources. (Also known as Access Control.)

3.3
cloud

Synonymous with “cloud computing” as defined in section 2 of the NIST Definition of Cloud Computing [SP800-145].

3.4
Cloud Service Consumer

A category of actors that includes the Consumer Business Manager (who approves business and financial expenditures for consumed services; accounts for used service instances; establishes business relationships; sets up accounts, budget, and terms; etc.); the Consumer Service Administrator (who requests service instances and changes to service instances; purchases services within the business relationship; creates Service Users (including policies); allocates resources, such as computer and storage; generates reports, such as usage; etc.); and Service Users (who use service instances provided by a Cloud Service Provider). The term "Consumer" is used if the indicated action or activity could involve one or more of the above actors. In cases where the distinction between the actors in this category is relevant, the more detailed term is used.

For purposes of comparison and alignment, it should be noted that a Cloud Service Consumer is equivalent to the “Cloud Consumer” actor defined in the NIST Reference Architecture [SP500-292].

3.5
Cloud Service Provider

A category of actors that includes the Service Operations Manager (who manages the technical infrastructure required for providing cloud services; monitors and measures performance and utilization against SLAs; provides reports from monitoring and measurement; etc.); Service Business Manager (who offers all types of services developed by cloud service developers; accounts for services potentially offered by service Providers themselves and services offered on behalf of cloud service developers; establishes a portfolio of business relationships; and sets up accounts and terms for Consumers, etc.); and Service Transition Manager (who enables a customer to use the cloud service, including "onboarding", integration, and process adoption; defines and creates service offerings based on Templates and Configurations that can be used by Consumers and are populated into the catalog; etc.). The term "Provider" is used if the indicated action or activity could involve one or more of the above actors. In cases where the distinction between the actors in the category is relevant, the more detailed term is used.

For purposes of comparison and alignment, it should be noted that a Cloud Service Provider is equivalent to the “Cloud Provider” actor defined in the NIST Reference Architecture [SP500-292].

3.6
Collection

A particular kind of Resource that contains a collection of other Resources and has a representation and serialization defined in this specification. Synonym for “CIMI collection”.

3.7
Configuration

A set of metadata, the values of which serve as the parameters of a discrete conformation of a specific type of virtual resource.

3.8
Infrastructure as a Service (IaaS)

A cloud computing service model defined in section 2 of the NIST Definition of Cloud Computing [SP800-145].

3.9
message confidentiality

A quality of a message that prevents anyone but the intended receiver(s) from viewing its contents.

3.10
message integrity

A quality of a message that allows a receiver of that message to determine whether the contents of the message have been altered since its creation.

3.11
Resource

A representation of an entity managed by the [Cloud Service] Provider that is generally available to the [Cloud Service] Consumer to access or operate on by the way of the interface described in this specification. Synonym for “CIMI resource”.

3.12
Template

Synonym for “CIMI template”. A Resource that represents the set of metadata and instructions used to instantiate some other Resource (e.g., a `MachineTemplate` is used to create `Machines`). Templates may aggregate other metadata Resources such as other Templates, Configurations, and Images. For example, a `MachineTemplate` refers to a `MachineConfiguration` and a `MachineImage`.

How a specific protocol mapping, or implementation, chooses to supply Templates as inputs to the instantiation process may vary. However, some common patterns should be considered:

1. By reference - allow Consumers to reference a Template (that exists as a Resource in the Provider) as part of the instantiation operation.
2. By value - allow Consumers to dynamically provide the Template information as part of the instantiation operation.
3. Reference with overrides - allow Consumers to reference a Template (that exists as a Resource in the Provider) and provide additional values that override the attributes of that Template as part of the instantiation operation.

4 HTTP-based protocol

4.1 Introduction

All operations are based on the *HyperText Transfer Protocol (HTTP)*, version 1.1 [RFC2616]. Each request is sent by using an HTTP verb such as PUT, GET, DELETE, HEAD, or POST and includes a message body in either JSON or XML format. Each response uses a standard HTTP status code, whose semantics are interpreted in the context of the particular request that was made. Each Resource in the model has a MIME type that further contextualizes the payload of requests and responses.

Resources in the model are identified by URIs, and each Resource's representation shall contain an "ID" attribute, of type URI, that acts as a "self pointer." This URI shall be unique within the context of the Provider's implementation. Dereferencing (through an HTTP GET) the URI of a Resource yields a representation of the Resource containing attributes and links to associated Resources. To begin operations, a client shall know the URI to the main entry point of a Provider - also known as the "Cloud Entry Point" Resource. All other Resources within the environment shall then be discoverable by the way of the iterative following of links to associated Resources within each Resource retrieved.

4.1.1 Protocol evolution and client expectations

Future versions of this specification structure changes in such a way that clients that conform to an earlier version of this specification continue to work, and are not be adversely affected by the evolution of the protocol. Clients are expected to follow a few simple rules to ensure this compatibility:

1. Clients shall not assume that the serializations shown for responses in this specification are complete. In particular, clients shall accept responses that contain data mixed in with the serializations shown here, and shall ignore such data. However, per clause 4.2.1.3, clients shall include unknown data in PUT requests to update Resources.

2. Clients shall not assume anything about the operations supported by a server. They are expected to discover operations that are supported (and permissible) by navigating to Resources from the cloud entry point. The serializations of Resources encountered indicate which operations are supported by the server.

4.1.2 XML namespaces

Table 1 lists the XML namespaces that are used in this specification. The choice of any namespace prefix is arbitrary and not semantically significant.

Table 1 – XML namespaces

Prefix	XML Namespaces	Specification
cimi	http://schemas.dmtf.org/cimi/1	This specification
xs	http://www.w3.org/2001/XMLSchema	XML Schema Part2

4.1.3 URI space

While URIs returned by Providers are to be treated as opaque by Consumers, and Consumers shall not make assumptions about the layout of the URIs or the structures of the URIs for the Resources, a Consumer may augment URIs with any well-defined query parameters that are supported by the Provider as defined in clause 4.1.6.

The sample URIs used in this specification are not normative and the patterns used shall not be interpreted as guidance for implementations. For example, any of the following URIs might be used by Providers to reference a particular `Machine` Resource:


```
http://example.com/machines/12345
http://example.com/machines?id=12345
http://example.com/12345
http://example.com/Cloud/resource?id=12345
```

4.1.4 Media types

In this specification, Resource and response representations are encoded either in JSON, as specified in RFC4627 or in XML. If serialized in JSON, the media-type for CIMI resources shall be "application/json". If serialized in XML, the media-type shall be "application/xml".

In the JSON serialization of CIMI representations sent by Providers, there shall be an additional attribute on the root object called "`resourceURI`" that contains the unique URI that is associated with the type of CIMI resource being serialized.

Note that this requirement applies even if the `$select` attribute is used to subset the Resource being acted upon.

In the XML serialization of Collection representations sent by Providers there shall be a `resourceURI` attribute, as shown in the example XML serialization of Collections in clause 5.5.12.

This attribute is optional for Consumers to include. If included, this attribute's value shall match the "`typeURI`" attribute of the corresponding `ResourceMetadata` Resource (see clause 5.11), if `ResourceMetadata` is supported. This value shall also be equivalent to the wrapping element of the XML serialization; in other words, the namespace of the wrapper element concatenated a "/" and then its localName.

Any CIMI resource implemented by a Provider shall have representations in JSON and XML. The client implementation may thus use either JSON or XML in requests with any server implementation, and may request a specific serialization using server-driven content negotiation (using the Accept request header).

4.1.5 Request headers

This specification uses general-header, request-header, and entity-header headers as defined in RFC2616 in request messages to provide metadata about the message. Applications using messages defined in this specification shall use headers consistent with the requirements of RFC2616.

4.1.6 Request query parameters

Providers may choose to include query parameters as part of the URIs returned to Consumers. Consumers shall include those query parameters when sending messages to those URIs. If Providers choose to define query parameters care should be taken to avoid conflicts with CIMI defined query parameters.

To modify the behavior of the Provider when processing request messages, Consumers may augment request URIs as described in the following clauses. As stated in clause 4.1.3, URIs returned from Providers are to be treated as opaque by Consumers; however, it is the responsibility of the Consumer to understand the use of the query parameters defined in the following clauses and ensure correctness when making a request.

Unsupported, or unknown, query parameters shall be silently ignored by Providers. Consumers may examine the CloudEntryPoint's capabilities to determine whether support of these query parameters is enabled.