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OCCI-WG

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Open Cloud Computing Interface - Core

Status of this Document

This document provides information to the community regarding the specification of the Open Cloud Computing Interface. Distribution is unlimited.

Obsoletes

This document obsoletes all previous versions of this document.

Trademarks

OCCI is a trademark of the Open Grid Forum.

Abstract

This document, part of a document series, produced by the OCCI working group within the Open Grid Forum (OGF), provides a high-level definition of a Protocol and API. The document is based upon previously gathered requirements and focuses on the scope of important capabilities required to support modern service offerings.

Contents

1 Introduction

The Open Cloud Computing Interface (OCCI) is a RESTful Protocol and API for all kinds of Management tasks. OCCI was originally initiated to create a remote management API for IaaS[1] model based Services, allowing for the development of interoperable tools for common tasks including deployment, autonomic scaling and monitoring. It has since evolved into an flexible API with a strong focus on interoperability while still offering a high degree of extensibility. The current release of the Open Cloud Computing Interface is suitable to serve many other models in addition to IaaS, including e.g. PaaS and SaaS.

In order to be modular and extensible the current OCCI specification is released as a suite of complimentary documents which together form the complete specification. The documents are divided into three categories consisting of the OCCI Core, the OCCI Renderings and the OCCI Extensions.

- The OCCI Core specification consist of a single document defining the OCCI Core Model. The OCCI Core Model can be interacted with *renderings* (including associated behaviours) and expanded through *extensions*.
- The OCCI Rendering specifications consist of multiple documents each describing a particular rendering of the OCCI Core Model. Multiple renderings can interact with the same instance of the OCCI Core Model and will automatically support any additions to the model which follow the extension rules defined in OCCI Core.
- The OCCI Extension specifications consist of multiple documents each describing a particular extension of the OCCI Core Model. The extension documents describe additions to the OCCI Core Model defined within the OCCI specification suite.

The current specification consist of three documents. Future releases of OCCI may include additional rendering and extension specifications. The documents of the current OCCI specification suite are:

OCCI Core describes the formal definition of the the OCCI Core Model [1].

OCCI HTTP Rendering defines how to interact with the OCCI Core Model using the RESTful OCCI API [2]. The document defines how the OCCI Core Model can be communicated and thus serialised using the HTTP protocol.

OCCI Infrastructure contains the definition of the OCCI Infrastructure extension for the IaaS domain [3]. The document defines additional resource types, their attributes and the actions that can be taken on each resource type.

2 Notational Conventions

All these parts and the information within are mandatory for implementors (unless otherwise specified). 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 [4].

3 OCCI Core

The Open Cloud Computing Interface is a boundary protocol and API that acts as a service front-end to a provider's internal management framework. Figure 1 shows OCCI's place in a provider's architecture.

Service consumers can be both end-users and other system instances. OCCI is suitable for both cases. The key feature is that OCCI can be used as a management API for all kinds of resources while at the same time maintaining a high level of interoperability.

[1] Infrastructure as a Service

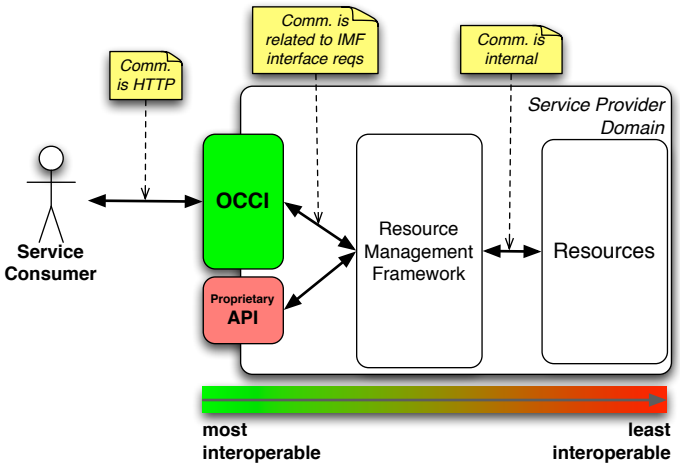

Figure 1. OCCI's place in a provider's architecture

This document, the OCCI Core specification, defines the OCCI Core Model. This model is the core of the specification suite and it can be interacted with by renderings (including associated behaviours) and expanded through extensions. In itself, the core model is only useful for a very limited set of use cases. However, it provides the basis for renderings and extensions to build upon.

4 OCCI Core Model

The OCCI Core Model defines a representation of instance types which can be manipulated through an OCCI Rendering implementation. It is an abstraction of real-world resources, including the means to identify, classify, associate and extend those resources.

A fundamental feature of the OCCI Core Model is that it can be extended in such a way that any extension will be discoverable and visible to an OCCI client at run-time. An OCCI client can connect to an OCCI implementation using an extended OCCI Core Model, without knowing anything in advance, and still be able to discover and understand, at run-time, the various Resource and Link sub-types supported by that implementation. What Mixins are supported is also discoverable in the same fashion. For example, a web-based OCCI client could easily be reused as the management tool for a wide variety of services.

The OCCI Core Model can be extended through inheritance but also using a "mix-in" like concept.

> Mixins first appeared in the Symbolics' object-oriented Flavors [5] system (developed by Howard Cannon), which was an approach to object-orientation used in Lisp Machine Lisp. [2]

The mix-in model only applies at the instance level, i.e. the "object level", and thereby differs from the more common uses of the mix-in concept. A mix-in in OCCI can never be applied to a type, only to an instance.

4.1 Overview

The UML class diagram shown in figure 2 gives an overview of the OCCI Core Model. It must be noted that the UML diagram in itself is not a complete definition of the model. The diagram is merely provided as an overview to help understanding the model.

The heart of the OCCI Core Model is the Resource type. Any resource exposed through OCCI is a Resource or a sub-type thereof. A resource can be e.g. a virtual machine, a job in a job submission system, a user, etc.

The Resource type contains a number of common attributes that Resource sub-types inherit. The Resource type is complemented by the Link type which associates one Resource instance with another.

[2] http://en.wikipedia.org/wiki/Mixin.

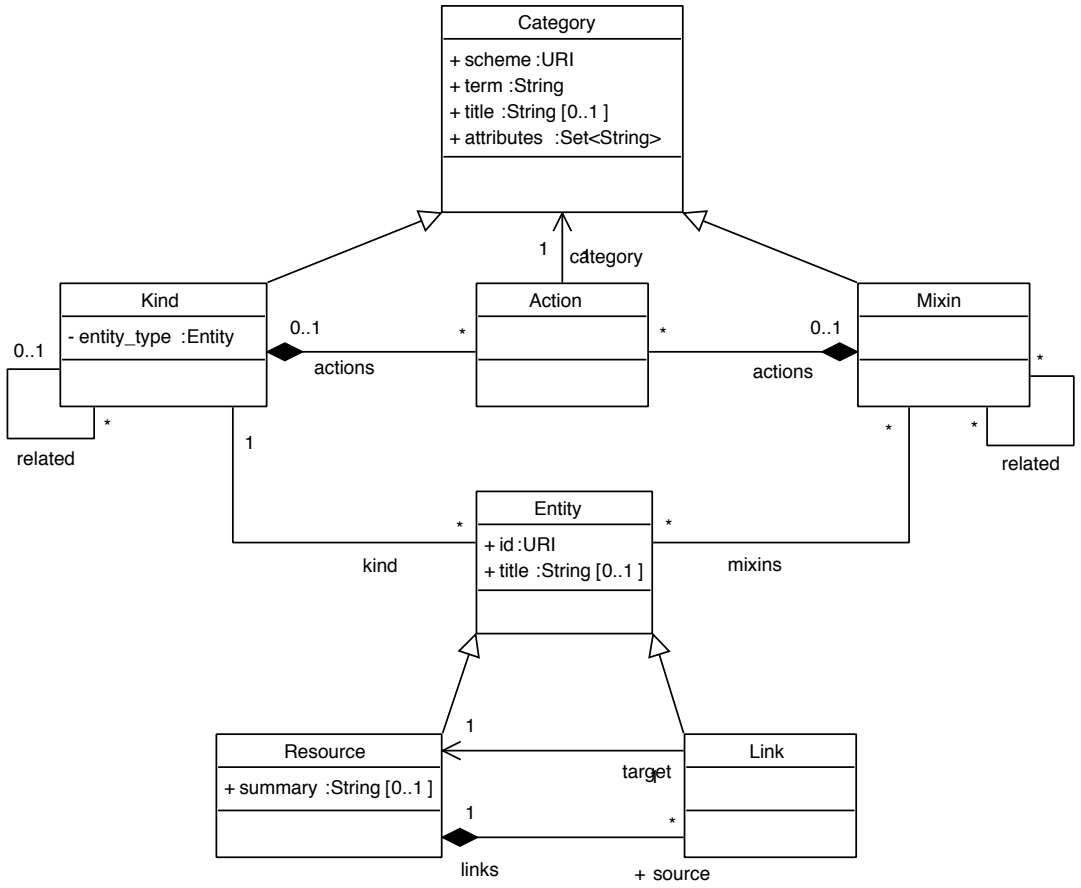

Figure 2. UML class diagram of the OCCI Core Model. The diagram provides an overview of the OCCI Core Model but is not a standalone definition thereof

The Link type contains a number of common attributes that Link sub-types inherit.

Entity is an abstract type which both Resource and Link inherit. Each sub-type of Entity is identified by a unique Kind instance.

The Kind type is the core of the type classification system built into the OCCI Core Model. Kind is a specialisation of Category and introduces additional resource capabilities in terms of Actions. An Action represent an invocable operation applicable to a resource instance.

The last type defined by the OCCI Core Model is the Mixin type. An instance of Mixin can be associated with a resource instance, i.e. a sub-type of Entity, to "mix-in" additional resource capabilities at run-time.

For compliance with OCCI Core, all of the types defined in the OCCI Core Model MUST be implemented. The following sections of the specification contain the formal definition of the OCCI Core Model.

4.2 Terms and definitions

Section 6 provides a glossary of all terms and definitions with a specific meaning to the OCCI specification suite. However, for reader convenience, a sub-set of the glossary is provided here as well. The following terminology have specific meaning in the OCCI context:

concrete type/sub-type A concrete sub-type is a type that can be instantiated.

mix-in An instance of the Mixin type associated with a **resource instance**. The "mix-in" concept as used by OCCI *only* applies to instances, never to Entity types.

OCCI base type(s) The OCCI base types are Entity, Resource, Link and Action.

resource capabilities Resource capabilities refer to attributes and Actions exposed by a resource instance.

resource instance An instance of a sub-type of Entity. The OCCI model defines two sub-types of Entity, the Resource type and the Link type. However, the term **resource instance** is defined to include any instance of a *sub-type* of Resource or Link as well.

type A **type** refer to one of those defined by the OCCI Core Model. The OCCI Core Model types are Category, Kind, Mixin, Action, Entity, Resource and Link.

4.3 Mutability

Attributes of an OCCI Core Model type instance are either client mutable or client immutable. If an attribute is noted to be mutable this MUST be interpreted that a client can create an instance that is parametrised by the attribute. Likewise, if an attribute is mutable, a client can update that instance's mutable attribute value and the server side MUST support this. If an attribute is marked as immutable, it indicates that the server side implementation MUST manage these exclusively. Immutable attributes MUST NOT be modifiable by clients under any circumstance.

4.4 Classification and Identification

The OCCI Core Model provides a built-in type classification system allowing for safe extension towards domain-specific usage (e.g. infrastructure). This system is the OCCI type system and offers the means to be easily and transparently (i.e. no format translation required) exposed over either a text or binary based protocol.

The classification system can be summarised with the following key features:

- Each OCCI base type and extension thereof is assigned a unique type identifier (a Kind instance), which allow for dynamic discovery of available types. All Entity sub-types, including core model extensions, are assigned a unique Kind instance.
- The inheritance structure of Entity, Resource and Link is client discoverable. This also applies to any sub-type of Resource and Link and therefore an OCCI client can discover the type inheritance structure used by a particular OCCI implementation. The discovery of the inheritance structure is made possible through the relationship of Kind instances.
- The classification system allows Mixin instances to be associated to resource instances in order to assign additional resource capabilities in terms of attributes and Actions at run-time.
- Tagging of resource instances is supported through the association of Mixin instances. A tag is simply a Mixin instance which define no additional resource capabilities.
- A collection of associated resource instances is implicitly defined for each Kind and Mixin instance. I.e. all resource instances associated with a particular Kind or Mixin instance form a collection.

4.4.1 Category

The Category type is the basis of the type identification mechanism used by the OCCI classification system. It MUST be implemented. Instances of the Category type itself are only used to identify Action types. All other uses of Category properties are managed through its sub-types Kind and Mixin.

Table 1 defines the attributes the Category type MUST implement to be compliant.

A Category instance is uniquely identified by concatenating the categorisation scheme with the category term, e.g. *http://example.com/category/scheme#term*. This is done to enable discovery of Category definitions in text based renderings such as HTTP. All renderings MUST make use of and understand concatenated unique type identifiers of Category instances.

Sub-types of Category such as Kind and Mixin inherit this property.

Table 1. Attributes defined for the Category type

Attribute	Type	Multiplicity	Client Mutability	Description
term	String	1	Immutable	Unique identifier of the Category instance within the categorisation scheme.
scheme	URI	1	Immutable	The categorisation scheme.
title	String	0..1	Immutable	The display name of an instance.
attributes	String	0..*	Immutable	The set of resource attribute names defined by the Category instance.

The categorisation schemes defined in the OCCI specification all use the *http://schemas.ogf.org/occi/* base URL. This base URL is reserved for OCCI an MUST NOT be used by service provider extensions.

A Category instance [3] define the *names* of the attributes exposed by any instance associated with the Category. For example a "resize" Action having a `size` attribute would have an identifying Category with Category.`attributes = [ size ]`.

4.4.2 Kind

The Kind type, together with the Mixin type, defines the classification system of the OCCI Core Model. It MUST be implemented. The Kind type represents the type identification mechanism for all Entity types present in the model.

A unique Kind *instance* MUST be assigned to each and every Entity sub-type defined in an OCCI implementation.

Every instance of Kind represents a unique type identifier for a particular sub-type of Entity. Consequently, when an Entity sub-type is instantiated the resource instance MUST be associated with its type identifier, i.e. the Kind instance. A resource instance MUST remain associated with its Kind instance throughout its lifetime.

For example an instance of Resource MUST always be associated with the Kind instance which identifies the Resource *type*.

In the initial instantiation of the OCCI Core Model, with no core model extensions, three instances of Kind will be present: one for Entity, another for Resource and the last one for Link.

Table 2. Attributes defined for the Kind type

Attribute	Type	Multiplicity	Client Mutability	Description
actions	Action	0..*	Immutable	Set of Actions defined by the Kind instance.
related	Kind	0..*	Immutable	Set of related Kind instances.
entity_type	Entity	1	Immutable	Entity type uniquely identified by the Kind instance.
entities	Entity	0..*	Immutable	Set of resource instances, i.e. Entity sub-type instances. Resources instantiated from the Entity sub-type which is uniquely identified by this Kind instance.

The Kind type inherits the Category type. To be compliant the Kind type MUST implement the attributes defined in table 2 and the inherited attributes defined in table 1. The following rules apply to all instances of the Kind type:

- A unique Kind instance MUST be assigned to each and every sub-type of Entity, including Entity itself.
- A Kind instance MUST expose the attribute names of the Entity sub-type it identifies. The attribute names are exposed through the "`attributes`" attribute inherited from Category. E.g. the Kind instance identifying the Link type has Kind.`attributes = [ source, target ]`.

[3] Also applies to Kind and Mixin instances.

- A Kind instance MUST expose the Actions defined for its Entity sub-type. Actions are exposed through the Kind.`actions` attribute which represent the association between a Kind instance and the Actions it defines.
- A Kind instance MUST be related, either directly or indirectly, to the Kind instance of Entity, i.e. *http://schemas.ogf.org/occi/core#entity*. The Kind.`related` attribute represent the relationship to another Kind instance.
- If type **B** inherits type **A**, where **A** is a sub-type of Entity, the Kind instance of **B** MUST be directly related to the Kind instance of **A**. See Kind Relationships below.

Kind Relationships Kind relationships are defined through the `related` attribute present in every Kind instance. The `related` attribute define which other Kind instances a particular Kind is related to.

A Kind instance identify a unique type, either the Entity type itself or a sub-type thereof. Each Kind instance MUST be related to the Kind of the parent type.

The OCCI base types Resource and Link both extend Entity and therefore their identifying Kind instances MUST be related to Kind assigned to the Entity type.

These rules imply a hierarchy of related Kind instances. The Kind relationships thus mirror the type inheritance structure of the OCCI Core Model and any extension thereof.

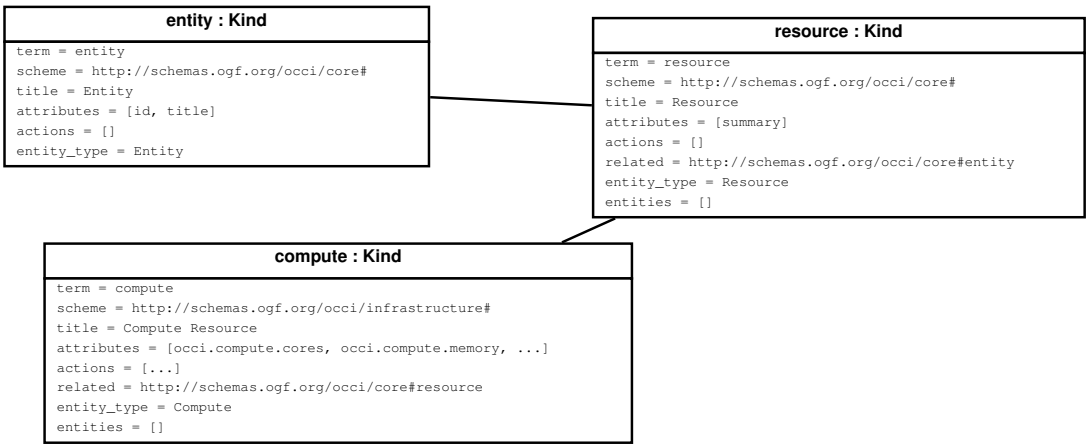

Figure 3. Object diagram illustrating the Kind instances involved for the Entity, Resource and Compute types. The Compute type is an extension to the OCCI Core Model defined in the OCCI Infrastructure document [3].

Figure 3 illustrates the relationship of the Kind instances assigned to the Entity, Resource and Compute [4] types.

Compute inherits Resource and therefore the Kind instance assigned to Compute is related to the Kind instance of Resource. The same applies to the Resource type which inherit Entity.

As can be seen in figure 3 the Kind instance relationships mirror the inheritance structure of the types.

4.4.3 Mixin

The Mixin type complements the Kind type in defining the OCCI Core Model type classification system. It MUST be implemented. The Mixin type represent an extension mechanism, which allow new resource capabilities to be added to resource instances both at creation-time and/or run-time.

A Mixin *instance* can be associated with any existing resource instance and thereby add new resource capabilities, i.e. attributes and Actions, to the resource instance. However, a Mixin can never be applied to a type. In the initial instantiation of the OCCI Core Model, with no extensions, no Mixin instances are present.

[4] The Compute type is defined in the OCCI Infrastructure document [3].

A Mixin instance MAY be associated with any resource instance, either at instance creation-time or at run-time. Although the OCCI Core Model has no such restrictions, an OCCI implementation MAY impose restrictions on which resource instances can be associated with a particular Mixin instance.

When a client attempts to associate a Mixin instance to a resource at a stage not supported by a particular provider's OCCI implementation, the provider MUST notify the client it has issued a bad request.

For example a "geographical location" Mixin might by applicable to all resource instances while a "bandwidth" Mixin may only applicable to resources instantiated from the Network [5] type. Such restrictions, if not otherwise stated, are up to the provider to implement.

Table 3. Attributes defined for the Mixin type

Attribute	Type	Multiplicity	Client Mutability	Description
actions	Action	0..*	Immutable	Set of Actions defined by the Mixin instance.
related	Mixin	0..*	Immutable	Set of related Mixin instances.
entities	Entity	0..*	Mutable	Set of resource instances, i.e. Entity sub-type instances, associated with the Mixin instance.

The Mixin type inherits the Category type. To be compliant the Mixin type MUST implement the attributes defined in table 3 and the inherited attributes defined in table 1. The following rules apply to all instances of the Mixin type:

- A Mixin instance MUST only be associated with resource *instances*, not types, either at creation-time or run-time.
- A Mixin instance MAY introduce additional resource attributes when applied to a resource instance. The names of those attributes MUST be exposed through the Mixin.`attributes` attribute inherited from Category. E.g. a Location Mixin defining the "com.example.location" attribute MUST have Location.`attributes = [ com.example.location ]`.
- A Mixin instance MAY define Actions which will be made applicable to any resource instance associated with the Mixin. Actions defined by a Mixin are exposed through the Mixin.`actions` attribute which represent the association between a Mixin instance and the Actions it defines.
- A Mixin instance MAY be related to another Mixin instance. If Mixin **B** is related to Mixin **A**, any resource instance associated with Mixin **B** will receive the resource capabilities defined by both Mixin **B** and Mixin **A**. See Mixin Relationships below.
- A Mixin instance defining no additional resource capabilities is considered to be a tag.
- A Mixin instance applied a resource instantiation time MAY cause additional provider-defined side-effects to occur, side-effects not visible through the OCCI discovery mechanism. Templates that pre-populate certain attributes of a resource instance SHOULD be implemented using such Mixin instances.

Mixin Relationships A Mixin instance MAY be related to another Mixin instance for type classification purposes. For example a set of operating system templates, implemented as Mixin instances, could be related to an "OS-template" Mixin in order to help identification.

Attributes and Actions defined by different Mixin instances are combined when Mixin relationships are present. Therefore a resource instance associated with a particular Mixin will receive the additional capabilities defined by any related Mixin instances as well as those defined by the Mixin associated.

[5] The Network type is defined in OCCI Infrastructure [3].

4.4.4 Resource Instantiation

To create a resource instance a client MUST supply the concrete Entity sub-type by a submitting a reference to the type-identifying Kind. The reference MUST consist of the term and categorisation scheme which uniquely identify the Kind instance, see section 4.4.1. All OCCI implementations MUST understand these requests.

A client MAY also submit any number of references to Mixin instances to be associated with the resource to be created. A Mixin reference submitted by a client MUST consist of the term and categorisation scheme which identify the Mixin instance, see section 4.4.1.

Associating a Mixin at resource instantiation time MAY have additional provider defined side-effects, side-effects not visible through the OCCI discovery mechanism. Templates that pre-populate certain attributes of a resource instance SHOULD be implemented using such Mixin instances.

4.4.5 Collections

One or more resource instances associated with the same Kind or Mixin instance, automatically form a collection. Each Kind and Mixin instance in the system identifies a collection consisting of all different resource instances associated with the Kind or Mixin.

A resource instance is always a member of the collection indicated by the Entity sub-type's unique Kind instance. A Kind instance maintains the collection of all resource instances (of the type identified by the Kind).

Since a Mixin instance can be associated to any resource instance, a collection can contain resource instances of different Entity sub-types.

For example, an instance of the Resource type will always be associated to the Kind instance *http://scheme.ogf.org/occi/core#resource* and thus part of the collection implied by that Kind instance.

Adding a resource instance to a collection is accomplished by associating the resource instance to the corresponding Mixin instance.

Removing a resource instance from a collection is accomplished by disassociating the resource instance from the corresponding Mixin instance.

An OCCI implementation MUST allow a client to navigate collections. The following basic navigation operations MUST be supported:

- Retrieve the whole collection.
- Retrieve a specific item in a collection.
- Retrieve a subset of a collection.

The details of collection navigation is rendering specific.

4.4.6 Discovery

An OCCI client MUST be able to discover all instances of Kind, Mixin and Category a particular service provider's OCCI implementation has defined. By examining these instances a client MUST be able to, at a minimum, deduce the following information:

- The Entity sub-types available from the service provider, including core model extensions. This information is provided through the Kind instances of the OCCI implementation.
- The attributes defined for each Entity sub-type. The identifying Kind instance provide this information.

- The invocable operations, i.e. Actions, defined for each Entity sub-type. The identifying Kind instance provide this information.
- Any Mixin instances that can be associated to resource instances.
- Additional capabilities defined by a particular Mixin instance, i.e. attributes and Actions.

The above requirements comprise the OCCI discovery mechanism. It MUST be implemented.

The details of exactly how the Category, Kind and Mixin instances are exposed to an OCCI client is specific to the particular rendering used.

The relevant details can be found in the OCCI Rendering documents.

4.5 The OCCI Core Base Types

The following sections describe the OCCI base types defined by the OCCI Core Model. The base types are Entity, Resource, Link and Action. All base types MUST be implemented.

4.5.1 Entity

The Entity type is an abstract type of the Resource type and the Link type. It MUST be implemented.

Table 4 defines the attributes the Entity type MUST implement to be compliant.

Table 4. Attributes defined for the Entity type.

Attribute	Type	Multiplicity	Client Mutability	Discover-able	Description
id	URI	1	Immutable	Yes	A unique identifier (within the service provider's name-space) of the Entity sub-type instance.
title	String	0..1	Mutable	Yes	The display name of the instance.
kind	Kind	1	Immutable	No	The Kind instance uniquely identifying the Entity sub-type of the resource instance.
mixins	Kind	0..*	Mutable	No	The Mixin instances associated to this resource instance. Consumers can expect the attributes and Actions of the associated Mixins to be exposed by the instance.

Entity enforces for all sub-types a required `id` attribute and an optional `title` attribute.

Every sub-type of Entity MUST be assigned a Kind instance, see section 4.4.2.

Table 5. The Kind instance assigned to the Entity type.

Attribute	Value
term	entity
scheme	`http://schemas.ogf.org/occi/core#`
title	Entity type
attributes	id, title
actions	–

Entity itself is assigned the Kind instance *http://schemas.ogf.org/occi/core#entity* for type identification, see table 5.

Being an abstract type Entity itself can never be instantiated.

An Entity sub-type instance, a resource instance, MAY be associated with one or more Mixin instances.

An Entity sub-type instance MUST expose its identifying Kind instance and any associated Mixin instances together with the attributes and Actions defined by them.

4.5.2 Resource

The Resource type inherits Entity and describes a concrete resource that can be inspected and manipulated. It represents a general object in the OCCI model and MUST be implemented. A Resource is suitable to represent real world resources, e.g. virtual machines, networks, services, etc. through specialisation.

The Resource type MUST implement all attributes inherited from Entity as well as the attributes defined in table 6 in order to be compliant.

Table 6. Attributes defined for the Resource type.

Attribute	Type	Multiplicity	Client Mutability	Description
summary	String	0..1	Mutable	A summarising description of the Resource instance.
links	Link	0..*	Mutable	A set of Link compositions. Being a composite relation the removal of a Link from the set MUST also remove the Link instance.

The Resource type is assigned the Kind instance *http://schemas.ogf.org/occi/core#resource*, see table 7.

Table 7. The Kind instance assigned to the Resource type.

Attribute	Value
term	resource
scheme	`http://schemas.ogf.org/occi/core#`
title	Resource
attributes	summary
actions	–

Resource enforces the inheritance of a set of common attributes into sub-types. Moreover, it introduces relationships to other Resource instances through instances of the Link type.

The Resource type is the first of three entry points to extend the OCCI Core Model, see section 4.6.

4.5.3 Link

An instance of the Link type defines a base association between two Resource instances. It MUST be implemented. A Link instance indicates that one Resource instance is connected to another.

The Link type MUST implement all attributes inherited from the Entity type together with the attributes defined in table 8 in order to be compliant.

Table 8. Attributes defined for the Link type.

Attribute	Type	Multiplicity	Client Mutability	Description
source	Resource	1	Mutable	The Resource instances the Link instance originates from.
target	Resource	1	Mutable	The Resource instances the Link instance points to.

The Link type is assigned the Kind instance *http://schemas.ogf.org/occi/core#link*.

Table 9. The Kind instance assigned to the Link type.

Attribute	Value
term	link
scheme	`http://schemas.ogf.org/occi/core#`
title	Link
attributes	source, target
actions	–

The `source` and `target` attribute of a Link instance MUST refer to resource *instances* within the service provider's namespace. A Link MAY refer to an external resource, i.e. a resource of which the service provider has no direct control, if and only if that external resource is mapped into a Entity sub-type instance.

A provider MAY however introduce a sub-type of Link with different semantics, e.g. having a target attribute containing an URI and thus the ability of linking with external resources.

The Link type is the second of three entry points to extend the OCCI Core Model, see section 4.6.

4.5.4 Action

The Action type is an abstract type. Each sub-type of Action defines an invocable operation applicable to an Entity sub-type instance or a collection thereof. It MUST be implemented. In general, Actions modify state by, for example, performing a complex operation such as rebooting a virtual machine.

Table 10 defines the attributes the Action type MUST implement to be compliant.

Table 10. Attributes defined for the Action type.

Attribute	Type	Multiplicity	Client Mutability	Description
category	Category	1	Immutable	The identifying Category of the Action.

An Action MUST always bound to either a Kind or a Mixin instance through a composite association. An Action is considered to be a capability of the Kind or Mixin instance it is associated with. An Action MAY be invoked on any resource instance associated with the Kind or Mixin instance defining the Action. An OCCI implementation MAY however refuse an Action from being invoked if currently not applicable.

An Action MAY be invoked on a collection of Entity sub-type instances. The Action is only considered valid if all resource instances of the collection are associated with the Kind or Mixin defining the Action.

Table 11. The Category instance assigned to the Action type.

Attribute	Value
term	action
scheme	`http://schemas.ogf.org/occi/core#`
title	Action
attributes	–

The Action type is assigned the Category type identifier *http://schemas.ogf.org/occi/core#action*, see table 11.

An Action can expose attributes which correspond to arguments of the invocable operation. A sub-type of Action define the attributes available for the invocable operation represented. The names of any such attributes MUST be exposed through Category.`attributes` of the Action sub-type's identifying Category instance.

For example, a "resize" Action sub-type defined for a storage resource could have a "size" attribute which represent the size argument of the resize operation. In that example the identifying Category instance would have Category.`attributes = [ size ]`.

The Action type is the third and last of the entry points to extend the OCCI Core Model, see section 4.6. Since Action is an abstract type a sub-type is always necessary to define a specific Action.

4.6 Extensibility

The OCCI Core Model has a flexible yet fairly simple extension mechanism based on the type classification system described in section 4.4.

The OCCI Core Model can be extended using two different methods, sub-typing and mix-in. Custom sub-typing require provider-specific Kind instances and custom mix-ins require provider-specific Mixin instances.

Both methods MAY involve the use of provider-specific Category instance since those are REQUIRED for provider-specific Action sub-types. The following sections define the rules for extending the OCCI Core Model.

The rules defined in section 4.4 and 4.5 are REQUIRED for all extensions of the OCCI Core Model.

4.6.1 Category instances

Provider-specific instances of Category, Kind and Mixin MAY be introduced by an OCCI implementation. Since Kind and Mixin both inherit Category the extension rules for Category, defined below, applies to them as well.

A Category instance defined outside of the OCCI specification MUST use a Category scheme unique to the provider, e.g. *http://example.com/occi#*. The `term` of a provider-specific Category instance can be any string corresponding to a "token" as defined in RFC2616 [6].

An attribute introduced by a provider-specific Category MUST use an attribute name prefix. This prefix MUST NOT be the "`occi.`" prefix which is reserved for the OCCI specification. Domain-specific attribute names SHOULD use a prefix consisting of the provider's reverse domain name, e.g. "`com.example.`".

4.6.2 Sub-typing

The OCCI Core Model MAY be extended through sub-typing. Three OCCI Core Model types MAY be sub-typed, those are Resource, Link and Action.

In order to define a sub-type of Resource or Link a provider-specific Kind instance MUST be defined and assigned to the sub-type. This Kind instance MUST be directly related to the Kind instance of the type extended.

In order to define a sub-type of Action a provider-specific Category instance MUST be assigned to the Action sub-type as its unique type identifier. Furthermore the Action sub-type MUST be associated as a capability of a provider-specific Kind or Mixin instance.

4.6.3 Mix-ins

The OCCI Core Model MAY be extended using a "mix-in" like concept by defining provider-specific Mixin instances. A Mixin instance can be associated with any resource instance although a provider MAY apply restrictions.

In order to support user-defined tags [6] an OCCI implementation must allow custom Mixin instances to be created and destroyed by request of a client. There is no limitation in the OCCI Core Model from doing so but it is RECOMMENDED to assign a separate Category scheme for each user's Mixin instances (e.g. per-user schemes).

5 Security Considerations

In the scope of this OCCI specification document the security features are implemented in the Protocol and Renderings. Therefore please see the *RESTful HTTP Rendering* Document [2].

[6] A tag is a Mixin instance, which does not introduce additional resource capabilities.

6 Glossary

Term	Description
Action	An OCCI base type. Represent an invocable operation on a Entity sub-type instance or collection thereof.
Category	A type in the OCCI model. The parent type of Kind.
Client	An OCCI client.
Collection	A set of Entity sub-type instances all associated to a particular Kind or Mixin instance.
Entity	An OCCI base type. The parent type of Resource and Link.
Kind	A type in the OCCI model. A core component of the OCCI classification system.
Link	An OCCI base type. A Link instance associate one Resource instance with another.
mixin	An instance of the Mixin type associated with a **resource instance**. The "mixin" concept as used by OCCI *only* applies to instances, never to Entity types.
Mixin	A type in the OCCI model. A core component of the OCCI classification system.
OCCI	Open Cloud Computing Interface
OCCI base type	One of Entity, Resource, Link or Action.
OGF	Open Grid Forum
Resource	An OCCI base type. The parent type for all domain-specific resource types.
resource instance	An instance of a sub-type of Entity. The OCCI model defines two sub-types of Entity, the Resource type and the Link type. However, the term *resource instance* is defined to include any instance of a *sub-type* of Resource or Link as well.
Tag	A Mixin instance with no attributes or actions defined.
Template	A Mixin instance which if associated at resource instantiation time pre-populate certain attributes.
type	One of the types defined by the OCCI model. The OCCI model types are Category, Kind, Mixin, Action, Entity, Resource and Link.
concrete type/sub-type	A concrete type/sub-type is a type that can be instantiated.
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
URN	Uniform Resource Name

7 Contributors

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