GWD-C-I
OCCI-WG
augusto@di.unipi.it

Augusto Ciuffoletti, Dept. Of Computer Science - Univ. of Pisa
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Describing a monitoring infrastructure with an OCCI-compliant schema

Status of This Document

Group Working Draft (GWD)

Document Change History

Febraury 1st, 2013: First revision (Augusto Ciuffoletti)

June 12, 2013: Second revision (Augusto Ciuffoletti):

- Set document label to indicate Informational
- Mixins may be associated to all Entity subtypes (not only Sensors or Collectors) for very simple layouts.
- For the same reason measurements may be included in REST resource representation.
- Example without HTTP rendering.
- Publishing moved from Collector to Sensor.
- Changed names of *mixins* (ToolSet to Metric, the others removing "Set")

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Abstract

This document *provides information* to the Grid community about resource monitoring. It *describes* an OCCI Extension that allows to inspect the operation of functional resources; the provision of this API is considered as optional for the provider.

This document *presents* two further *Kinds*: the *Sensor Resource*, that processes metrics, and the *Collector Link*, that extracts and transports metrics. They are defined as OCCI types whose instances need to be specialized using OCCI *mixin*s. Using this API, the user is provided with a monitoring infrastructure *on demand*.

This document does not define any standards or technical recommendations.

One relevant target of this document is to provide a building block for the design of an API for Service Level Agreement (SLA): under this light, the API for the Resource Monitoring Infrastructure offers the tools to verify and implement the Service Level Objectives (SLO).

Contents

1 Introduction

This document describes an interface useful to define a monitoring infrastructure. It is based on the concepts introduced by the OCCI Working Group of the OGF, and it is intended to be a first step towards the definition of a protocol to measure service quality: its appicability extends to fault detection, billing, and the implemetation of a server level agreement (SLA).

The purpose of this specification is that of giving the user the possibility to arrange a monitoring infrastructure in the way that best suits user's needs: notably, the existence of a standard specification enables the user to manage distinct cloud providers, possibly at the same time, using the same interface.

The importance of a configurable monitoring infrastructure emerges in many scenarios, starting from the simple case of the user that wants to monitor the activity of a web service, to complex use cases where the user is in fact an intermediate service provider, that provides services to third party users: in that case, the intermediate provider may decide to offer quality of service options that differ from that of the low level provider, thus needing to perform specific measurements on the infrastructure leased by the low level provider(s).

The management of the monitoring capabilities should also extend to the adaptive, and dynamic configuration of the components that contribute to the monitoring activity: the specification schema must give the user the possibility to explore the available functionalities in order to adaptively arrange a monitoring infrastructure, and to modify them according with changing needs.

One relevant fact about monitoring infrastructures is that it is extremely difficult to give a *detailed* framework for them that extends its validity to any reasonable use case or provider. The reason is that each of them exhibits local variants that do not fit a rigid approach. Also, the metrics that are used to evaluate the performance of the system are many, and subject to continuous changes due to the introduction of new technologies. Thus we have made an effort to introduce a generic schema that can be adapted to effectively describe the relevant aspects of a monitoring infrastructure, but that does not interfere with details that depend on the specific environment.

The OCCI Core Model [OGF(2011a)] is well suited for the task, since it embeds the tools needed to extend a framework with provider specific details: this enables the specification of the abstract model, leaving to the user the task of making explicit the details, targeting a specific provider or technology. Furthermore, we claim that the specifications given in this document can find an application in environments other than computing infrastructures, since we abstract from the details that characterize cloud infrastructure resources.

The approach followed in this document is similar to that found in the infrastructure document (GFD-P-R.184 [OGF(2011b)]): the monitoring capability is associated with a new *Kind* instance, the *Collector*, that is related with the OCCI Core Model *Link* type. The source of the *Collector Link* is the monitored resource that originates measurements that are delivered to the *target* resource. The role of a *Collector Link* instance is to indicate a specific monitoring technique applied on the *source*. The processing of the measurements and their delivery are described by the *Sensor kind*, that is related with the OCCI Core Model *Resource* type. A *Sensor Resource* instance collects metrics across a *Collector Link* and publishes aggregated metrics with a defined modality: for instance a *Sensor Resource* might produce the average load of an array of servers and publish it on a web page.

The three aspects of monitoring that we have thus outlined – namely production, processing, and publishing – are specified through the association of specific *mixin*s, primarily with a *Sensor Resource* or *Collector Link*. For the sake of simplicity, we introduce the possibility to associate such mixins to ordinary resources: this option is regarded as a tradeoff between simplicity and adherence to the REST approach.

The incapsulation of technology dependent functions into *mixin* leaves the specific provider free to introduce specific supporting technologies, or to simplify the configuration with the provision of templates. To enable the discovery of such *mixin*s, they are related with a *depends* relationship with well-known *mixin*s.

Although the interface based on *Sensor Resource*s and *Collector Link*s may describe very simple use cases with minimal effort, the designer is able to assemble complex, multilayer monitoring infrastructures using the same basic building blocks: for instance, a *Sensor Resource* can be used to aggregate a storage throughput using the input from three *Collector Link*s, one for the average response time, one for the mean time between failures, and another for network delay, and provide the results to an upstream *Sensor Resource* that aggregates the same results from other *Sensor Resource*s.

We point out that the interface is transparent to the existence of a standard for metric identifiers: if one exists, the interoperability of distinct monitoring infrastructures is certainly improved. We consider that the user that interacts with the monitoring infrastructures either knows about the identifiers used by the provider, or uses an interface (e.g., a SLA negotiation service) that translates provider specific identifiers into interoperable ones. This document highlights other similar standardization issues.

Summarizing, the specifications introduced in this document require that the conformant provider implements two *Kind*s: the Collector Link and the Sensor Resource. Three generic *mixin*s are also defined to enable the classification of *mixin*s that are specific for the provider: namely *Metric* to specify the production of measurement, *Aggregator* for their processing, and *Publisher* for their publication. The generic *mixin*s are used to identify and apply restrictions to provider-specific *mixin*s.

1.1 Terminology shortcuts

To distinguish an *Entity* instance from the related *Kind*, we will use the indeterminative article for the instance (e.g., "a *Resource*"), and the determinative article for the *Kind* (e.g., "the *Resource*"). The plural is reserved to instances (e.g., "the *Resources*"). In case of ambiguity we will use "*Entity* instance related with" or "*Kind*".

Similarly, we will use the term *a <mixin id>* mixin to indicate a *mixin* that *depends* on the *<mixin id> mixin*. The provider ensures that *mixins* inherit defined semantics from the *mixin* they depend on, as explained in the rest of this paper.

To disambiguate the usage of the term "resource" we will use the term "REST resource" when appropriate, and simply *Resource* when referring to the concept defined in the OCCI Core model.

2 Specification of the compliant server

The compliant server MUST define the following *Kinds*:

Collector Link that describes the extraction of measurements (see table 1);

Sensor Resource that describes how measurements are aggregated and used (see table 2);

In addition, the compliant server MUST define the following *Mixin* tags (see table **??**):

Metric that is used as a tag for *mixins* that describe a measurement activity;

Aggregator that is used as a tag for *mixins* that describe a measurement aggregation function;

Publisher that is used as a tag for *mixins* that describe measurement utilization;

These tags are used to define features that are common to the *mixins* that share the same tag. In principle, a *mixin* may be related with more than one of those tags.

2.1 The *Collector Link*

The *Collector Link* (see table 1) models the activity that extracts measurements from a source *resource* and the transfer of such measurements to another *resource*.

The OCCI attributes of the *Collector Link* define the timing of the monitoring activity. The execution rate is defined using three attributes: the rate itself, and an optional definition of the quality of the timing. This latter attribute contains a triple of numbers encoded as a string, that define the granularity with which the rate is measured, and the accuracy of rate

Model attribute	value
scheme	http://schemas.ogf.org/occi/monitoring#
term	collector
title	*Collector Link*
attributes	see below

name	type	mutable	required	Description
occi.collector.period	number	true	true	The time between two following measurements
occi.collector.periodspec	string	true	false	granularity, accuracy, exponent of period measument

Table 1: Definition of the *Collector Link* Kind

measurement, and the floating point exponent. By default `periodspec="NaN, NaN, 0"`. All time values are represented as numbers.

A *Collector Link* can be related ONLY with *metric mixins*.

2.2 The *Sensor Resource*

The *Sensor Resource* (see table 2) models the processing of the measurements, like their aggregation in composite metrics, as well as their effects outside the monitoring infrastructure, like their delivery to a billing office.

A *Sensor Resource* is characterized by OCCI attributes that define the rate with which new observations are produced, and by the scheduling times of its operation.

The execution rate is defined using two attributes: the rate itself, and an optional definition of the quality of the timing. This latter attribute contains a triple of numbers encoded as a string, that define the granularity with which the rate is measured, the accuracy of rate measurement, and the floating point exponent. By default `periodspec="NaN, NaN, 0"`.

The activation of a *Sensor Resource* is controlled by two attributes that describe the scheduling of sensor activity: to schedule the execution of a sensor the user modifies the `starttime` with a value indicating how far in the future the instance is going to start its activity. A value of zero corresponds to the immediate start. The server sets the `timebase` attribute corresponding to the reference time of the start time.

All time values are represented as numbers. The `timebase` corresponds to Unix seconds, all timing values use a floating point notation. Also for time values there is a `timespec` attribute analogous to `periodspec`.

A *Sensor Resource* can related ONLY with *Aggregator* and *Publisher mixins*.

<table>
<tr><th>Model attribute</th><th>value</th></tr>
<tr><td>scheme</td><td>http://schemas.ogf.org/occi/monitoring#</td></tr>
<tr><td>term</td><td>sensor</td></tr>
<tr><td>title</td><td>Sensor Resource</td></tr>
<tr><td>attributes</td><td>
<table>
<tr><th>name</th><th>type</th><th>mutable</th><th>required</th><th>Description</th></tr>
<tr><td>occi.sensor.period</td><td>number</td><td>true</td><td>true</td><td>The time between two following measurements</td></tr>
<tr><td>occi.sensor.periodspec</td><td>string</td><td>true</td><td>false</td><td>granularity, accuracy, exponent of period measument</td></tr>
<tr><td>occi.sensor.timebase</td><td>number</td><td>false</td><td>true</td><td>The server time when the timestart and timestop are modified</td></tr>
<tr><td>occi.sensor.timestart</td><td>number</td><td>true</td><td>true</td><td>The delay after which the session is planned to start</td></tr>
<tr><td>occi.sensor.timestop</td><td>number</td><td>true</td><td>true</td><td>The delay after which the session is planned to stop</td></tr>
<tr><td>occi.sensor.timespec</td><td>string</td><td>true</td><td>false</td><td>granularity, accuracy, exponent of time measurement</td></tr>
</table>
</td></tr>
</table>

Table 2: Definition of the *Sensor Resource* Kind

Term	Scheme	Title
metric	http://schemas.ogf.org/occi/monitoring/collector#	A measurement tool
aggregator	http://schemas.ogf.org/occi/monitoring/sensor#	An aggregation algorithm
publisher	http://schemas.ogf.org/occi/monitoring/sensor#	A sensor Resource

Table 3: The *Mixin* tags defined for the monitoring API

<table>
<tr><th>Model attribute</th><th>value</th></tr>
<tr><td>scheme</td><td>http://acme.com/monitoring#</td></tr>
<tr><td>term</td><td>iostat</td></tr>
<tr><td>related</td><td>http://schemas.ogf.org/occi/monitoring#metric</td></tr>
<tr><td>attributes</td><td>
<table>
<tr><th>name</th><th>type</th><th>Description</th></tr>
<tr><td>com.acme.monitoring.cpuutilization</td><td>number</td><td>metric</td></tr>
<tr><td>com.acme.monitoring.what</td><td>enum(user,system)</td><td>control</td></tr>
</table>
</td></tr>
</table>

Table 4: Example – Definition of the `iostat` metric *mixin*

2.3 Features of the *mixin*s that have the *metric* tag

A *mixin* with a *metric* tag represents the availability of measurements from the associated *Entity*. We envision two distinct cases, the latter justified to allow extremely simple configurations (see an example in the Appendix):

- if the related *Entity* is a *Collector Link*, the measurement activity is integrated in the source *Resource* of the *Collector Link*;
- otherwise the measurement activity is integrated in the related *Entity* sub-type instance itself;

In principle, each provider may associate a different semantic to a given *mixin*, so here there is ground for further standardization. If the provider does not adhere to a defined standard, it MUST give an exhaustive documentation of the monitoring tool associated with a *mixin*.

The OCCI attributes of a *mixin* related with the *metric* tag are divided into two groups:

- Metric attributes: they correspond to the metrics delivered to the target *Sensor Resource*, and MAY hold a reasonably updated value for the metric. For instance, a metric providing the CPU utilization of a *Compute Resource* may have an attribute named `cpuutilization`.
- Control attributes: they control the operation of the measurement activity. For instance the `iostat` *mixin* implementing a cpu utilization tool may have a control attribute defined as (see figure 4)

  ```
  name=com.acme.monitoring.what,
  type=enum{"user","system"}
  ```

  The role of the attributes is part of the specification of the specific *mixin*[1]

[1] In the definition of OCCI attributes we have sometimes omitted the model attributes **mutable**, **required** and **default** for typographical reasons.

To enable interoperabilty, the provider SHOULD follow a defined standard for the naming of metric and control attributes, but its specification falls outside the scope of this document. Such naming MAY help the discovery of *mixin* that are appropriate for a given task.

The metric attributes of the *metric mixin* associated with a *Collector Link* instance contribute to the scope of the target *Sensor Resource* referenced in sect. 2.4.

2.4 Features of the *mixin*s that have the *aggregator* tag

A *mixin* with the *aggregator* tag is meant to implement the computation of an aggregated metric starting from raw metrics.

In principle, each provider may associate a different semantic to a given *mixin*, so here there is ground for further standardization. If the provider does not adhere to a defined standard, it MUST give an exhaustive documentation of the aggregation algorithm associated with a *mixin*.

The attributes of a *mixin* with the *Aggregator* tag are divided into three groups:

- Input attributes: they bind a metric attribute in the scope of the *Entity* to which it is applied with an input of the aggregating algorithm. The scope of an *Entity* consists of the `name`s of all the metric attributes of the incoming *Collector Link*s and of the *metric mixins* associated with the same *Entity*. A metric indicated as the value of an input attribute MUST be in the scope of the *Sensor Resource*. For instance, a *Sensor Resource* that computes the maximum CPU utilization for three *Compute Resources* may have a `input` attributes urn:acme:user529/collector1#occi.collector.cpuutilization, urn:acme:user529/collector2#occi.collector.cpuutilization, urn:acme:user529/collector3#occi.collector.cpuutilization where `cpuutilization` is a metric attribute of the incoming *Collector Link*s `collector1`, `collector2`, and `collector3`.
- Control attributes: they control the operation of the aggregating function (for instance, the gain of an EWMA);
- Metric attributes: they correspond to the metrics delivered. Their value MAY correspond to the last computed value. They also contribute to the scope of the *Sensor Resource* they are associated with.

To enable interoperabilty, the provider SHOULD follow a defined standard for the naming of input, control and result attributes, but its specification falls outside the scope of this document. Such naming MAY help the discovery of *mixin* that are appropriate for a given task.

Model attribute	value		
scheme	http://acme.com/monitoring#		
term	max		
related	http://schemas.ogf.org/occi/monitoring#aggregator		
attributes	**name**	**type**	Description
	com.acme.monitoring.max	number	metric
	com.acme.monitoring.data	String	input

Table 5: Example – Definition of the `max` aggregation *mixin*

Model attribute	value		
scheme	http://acme.com/monitoring#		
term	max		
related	http://schemas.ogf.org/occi/monitoring#publisher		
attributes	**name**	**type**	Description
	com.acme.monitoring.in	URI	input
	com.acme.monitoring.source	URI	control
	com.acme.monitoring.port	number	control

Table 6: Example – Definition of the `tcp` publishing *mixin*

2.5 Features of the *mixin*s with the *Publisher* tag

How data are delivered is defined by a *Publisher mixin*.

In principle, each provider may associate a different semantic to a given *mixin*, so here there is ground for further standardization. If the provider does not adhere to a defined standard, it MUST give an exhaustive documentation of publishing mode associated with a *mixin*.

Examples of measurement delivery modes are through a Unix pipe, on demand through a TCP connection, pushed through HTTP or UDP, persistently recorded in a database. However a *Publisher* can be associated also to an activity outside the monitoring infrastructure, like triggering recovery strategies in case of failure.

The attributes of a *Publisher mixin* are divided into two groups:

- Input attributes: their value MUST correspond to URIs of one of the metrics in the scope of the *Sensor Resource*;
- Control attributes: they determine the process used to publish input attributes.

To enable interoperabilty, the provider SHOULD follow a defined standard for the naming of input and control attributes, but its specification falls outside the scope of this document. Such naming MAY help the discovery of *mixin* that are appropriate for a given task.

2.6 Constraints on the associations between instances and *mixin*s

The constraints on the association of *Sensor Resource* and *Collector Link* instances with the defined *mixin*s are the following:

- a *Sensor Resource* MUST be the *target* of at least one *Collector Link*;
- a *Collector Link* can be associated ONLY with *metric mixin*s;
- a *Sensor Resource* can be associated ONLY with *publisher* and *aggregator mixin*s;

3 Conformance profiles

The definition of conformance profiles is appropriate because the provision of an interface for the management of a monitoring infrastructure is optional.

Profile 0 The *Collector Link* and *Sensor Resource Kind* s MUST NOT be implemented: attempt of instantiating such *Kinds* fails. In an HTTP rendering a POST and GET over the corresponding URI returns `404 Notfound`. The *Aggregator*, *Metric*, and *Publisher mixin*s MUST NOT be implemented: discovery fails. In an HTTP rendering a GET over the *mixin* returns `404 Notfound`;

Profile 1 The *Collector Link* and *Sensor Resource Kind* s MUST be implemented, and the user MUST be allowed to create new instances of such *Kinds*. In an HTTP rendering a POST or a GET over the corresponding URI return respectively `201` and `200`. In case of error, the server MUST NOT return `404 Notfound`. The *Aggregator*, *Metric*, and *Publisher mixin* MUST be implemented, and discovery is successful. The server MUST NOT allow to introduce *depends* relationships with the *Aggregator*, *Metric*, and *Publisher mixin*s. In an HTTP rendering, a POST over their URIs returns `405 Method Not allowed`;

Profile 2 The *Collector Link* and *Sensor Resource Kind* s MUST be implemented, and the user MUST be allowed to create new instances of such *Kinds*. In an HTTP rendering a POST and GET over the corresponding URI returns respectively `201` and `200`. In case of error, the server MUST NOT return `404 Notfound`. The *aggregator*, *metric*, and *publisher mixin*s MUST be implemented, and discovery is successful. The user MUST be allowed to introduce *depends* relationships with the *aggregator*, *metric*, and *publisher mixin*s. In an HTTP rendering, a POST over their URIs returns `200`.

4 Related works

The model is reminiscent of a monitoring infrastructure that I designed and implemented in the CoreGRID EU-project [Ciuffoletti et al.(2008)Ciuffoletti, Marchetti, Papadogiannakis, and Polychrona that in its turn is inspired by various other works (see the bibliography in the paper). The reading of the CompatibleOne prototype [Marshall and Laisné(2012)] has been enlightening concerning (among the rest) the need and possibility of modularizing the monitoring part. The 2012 revision of the OCCI core model [OGF(2011a)] has been used as a reference.

5 Security Considerations

The API described in this document relies on the same mechanism as the basic OCCI API, of which it is an extension. In its turn, the OCCI API is designed according with a RESTFul model, a style of exposing a web service to the users.

The way this API is exposed inherits the security aspects of the RESTFul model, that can be summarized as follows:

- the web site MUST be protected to allow access only to authorized users, and to protect the content of the communication;
- the content uploaded on the web site by the user (using POST) MUST be protected;
- the content cached on third party sites not directly accessible by the user and by the provider (proxies etc.) MUST be protected.

We stress that these security warnings are shared with any ReStFul API.

The provider must ensure that a user defined *mixin* does not compromise the security of other services. The provider may attain this by restricting the functionalities associated to a *mixin* (the limit case is the provision of templates) or run the functionalities associated to a *mixin* in a protected environment (e.g., as a Unix user in a chroot jail). This issue is shared with the OCCI model.

Concerning the kind of monitoring infrastructure deployed using the *Sensor Resource* and the *Collector Link*, security aspects are managed using appropriate *mixin*s. For instance the *Collector Link* might be associated with a *mixin* describing a secure transport protocol, while the sensor might be configured to be accessible only from authenticated users (?). The provider SHOULD offer the user a set of predefined *mixin*s that introduce the appropriate level of security. User defined *mixin*s SHOULD be avoided for this kind of options.

6 Glossary

metric a metric is a mathematical representation of a well defined aspect of a physical entity

measurement a measurement is the process of extracting a metric from a physical entity, and by extension also the result of such process. The measurement seldom corresponds exactly to the value of the metric.

SLA *"An agreement defines a dynamically-established and dynamically managed relationship between parties. The object of this relationship is the delivery of a service by one of the parties within the context of the agreement."* from *SLA@SOI Glossary*

Restful model *"REST is a coordinated set of architectural constraints that attempts to minimize latency and network communication, while at the same time maximizing the independence and scalability of component implementations."* [Fielding and Taylor(2002)]

OCCI "*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 model-based services, allowing for the development of interoperable tools for common tasks including deployment, autonomic scaling and monitoring"* [OGF(2011a)]

OCCI *Kind* *"The Kind type represents the type identification mechanism for all Entity types present in the model"* [OGF(2011a)]

OCCI Link *"An instance of the Link type defines a base association between two Resource instances."* [OGF(2011a)]

OCCI *mixin* *"The Mixin type represent an extension mechanism, which allows new resource capabilities to be added to resource instances both at creation-time and/or run-time."* [OGF(2011a)]

OCCI *Resource* *"A Resource is suitable to represent real world resources, e.g. virtual machines, networks, services, etc. through specialisation."* [OGF(2011a)]

Sensor Resource The *Sensor Resource* is a *Resource* that collects metrics from its input side, and delivers aggregated metrics from its output

Collector Link The *Collector Link* is a link that conveys metrics: it defines both the transport protocol and the conveyed metrics.

7 Contributors

Augusto Ciuffoletti (corresponding author)
Dept. of Computer Science
L.go B. Pontecorvo - Pisa
Italy
Email: augusto.ciuffoletti@gmail.com

Andrew Edmonds
Institute of Information Technology
Zürich University of Applied Sciences
Zürich
Switzerland
Email: andrew.edmonds@zhaw.ch

Metsch, Thijs
Intel Ireland Limited
Collinstown Industrial Park
Leixlip, County Kildare, Ireland Email: thijsx.metsch@intel.com

Ralf Nyren
Email: ralf@nyren.net

Appendix - Examples: from simple to complex

The OCCI Monitoring API is able to meet the demands of a wide range of users. It is understood that a user that has a limited interest in monitoring (for instance to trigger human intervention to cope with a fault) wants an interface able to configure in a straightforward way a simple strategy. In contrast, the user that is faced with a complex infrastructure and tight quality requirements needs an expressive interface. On the provider side as well there is interest for the possibility of restricting the monitoring tools available to certain users to a restricted set, with limited capabilities. The challenge for the overall scheme is to cover the whole range, from simple to complex.

In this appendix we explore use cases starting from a very simple one, approached in a simplistic way. The involved *Entities* are described by listing their attributes; both model attributes, in bold, and OCCI attributes. We recall that model attributes are not discoverable by the client, while OCCI attributes are.

Case 1: too simple

We start from an extremely simple case, that the user wants to implement trading off efficiency for simplicity. We focus on the `iostat` *mixin* used above, that a user wants to use to be warned about the overload of a server `vm1`.

The simplistic, yet suboptimal, solution is to associate the server with the monitoring tool. At a certain point in time, when the cpuutilization is 78%, the state of a certain server might be the following:

Attribute	value
id	urn:acme:user529/vm1
kind	compute
mixin	iostat
occi.compute.architecture	x86
occi.compute.cores	4
occi.compute.hostname	vm1
occi.compute.speed	3
occi.compute.memory	250
com.acme.collector.cpuutilization	78
com.acme.collector.what	user

The provider declares to update the *metric* attribute `cpuutilization` every 10 minutes, and the user is happy with that latency. From time to time the user will download the REST resource associated with the *Compute Resource* and parse out the value of the attribute, that will be processed in user's premises.

Let's consider a possible implementation on provider's side. Whenever the user associates the `iostat` mixin to the *Compute Resource*, the Cloud Management Infrastructure will install and launch a script that performs the call to the `iostat` command, and then sends the data to the Cloud Management Interface. In its turn, the Cloud Management server will update the record describing the Compute Resource. At this time any cached content of the same record should become invalid.

It is a quite complex operation that hardly fits in a REST environment.

This solution, which is admissible for our API, is extremely simple for the user, but extremely inefficient and complex for the provider. Let us explore an slightly more complex alternative that exhibits a reasonable footprint.

Case 2: simple but effective

The user, in addition to the *metric mixin*, associates to `vm1` also a *publisher mixin*: for instance a `tcp` mixin. Its semantic is that the data is returned after a `connect` to a given TCP address, that we assume to be located on the same virtual machine.

Attribute	value
id	urn:acme:user529/vm1
kind	compute
mixin	iostat, tcp
occi.compute.architecture	x86
occi.compute.cores	4
occi.compute.hostname	vm1
occi.compute.speed	3
occi.compute.memory	250
com.acme.collector.cpuutilization	N/A
com.acme.collector.what	user
com.acme.sensor.in	urn:acme:user529-vm1#com.acme.collector.cpuutilization
com.acme.sensor.source	urn:acme:user529-vm1
com.acme.sensor.port	4321

The provider declares that the latency of the data is less than 10 minutes. The user will poll the socket from time to time, and obtain the CPU utilization.

Let's consider a possible implementation on the provider's side. Upon association of the two *mixin*, the Cloud Management server will trigger the `iostat` script, and implement a pipe to trasfer the results to a TCP server listening on the indicated port. The data needed to configure the pipe are taken from the correspondence between the *metric attribute* of the `iostat` *mixin*, and the *input attribute* of the `tcp` *mixin*.

In a similar way, not shown in this example, the user may associate also an *aggregator mixin* to `vm1` to process the raw measurements and obtain a filtered metric.

Note that the activity of the Cloud Management server is limited to the configuration of the two *mixins*. After that, the record of `vm1` will be updated with the presence of the two *mixin*s. There is no further activity on the side of the provider, and the caches will remain consistent after that operation.

Widening the horizon

Consider that the user has allocated a pool of servers `vm1...vmn` and that she needs only the maximum CPU utilization in the pool. Instead of downloading all measurements and find the maximum in her premises, she prefers to delegate the task to the Cloud Management.

Our solution is to create one *Collector Link* instance in egress from each server, and to associate a `iostat` *mixin* to each of them, thus adding the possibility to control the timing of the measurements. There will be one addressable REST resource for each of them.

All the *Collector Link* instances will share the same destination, that might be one of the servers. There an *aggregator mixin* aggregates the data by computing the maximum each time a new value is received, and delivering the data to the TCP server described in the previous example. The following is the state of one of the collectors:

Attribute	value
id	urn:acme:user529/c1
kind	collector
mixin	iostat
occi.core.source	urn:acme:user529/vm1
occi.core.target	urn:acme:user529/master
occi.collector.period	600
com.acme.collector.cpuutilization	N/A
com.acme.collector.what	user

and this is the state of the master server that receives all measurements, computes the output value and delivers the result throufh a TCP socket:

Attribute	value
id	urn:acme:user529/master
kind	compute
mixin	max, tcp
links	urn:acme:user529/c1, urn:acme:user529/c2, urn:acme:user529/c3
occi.compute.architecture	x86
occi.compute.cores	4
occi.compute.hostname	master
occi.compute.speed	3
occi.compute.memory	250
com.acme.sensor.in	urn:acme:user529/c1#occi.sensor.max
com.acme.sensor.source	urn:acme:user529/master
com.acme.sensor.port	4321
com.acme.sensor.data	urn:acme:user529/c1#occi.collector.cpuutilization, urn:acme:user529/c2#occi.collector.cpuutilization, urn:acme:user529/c3#occi.collector.cpuutilization
com.acme.sensor.max	N/A

The use of *Collector Link* has a number of advantages, that are all related with the fact that the activities associated with the *mixin* obtain a distinguished address in the system, and thus are REST resources on their own. For instance, multiple instances of the same monitoring tool may run on the same *Resource*, and the existence of *mixin*s sharing the same identifer for attributes is tolerated.

Separation of concern

In the above example the measurements are processed on a generic computing resource: however, there are cases when monitoring data deserve a specific treatment, that can be hardly implemented inside a generic virtual machine. For instance when it has an heavy footprint, or it requires accurate timing, or it has effects that cannot be triggered by a generic virtual machine, or it is considered as confidential. If this is the case, then it is time to create an instance of a *Sensor Resource*.

For our example, we consider a user that wants to put in place a mechanism that instantiates a new server as soon as the maximum `cpuutilization` on one of the servers reaches a given threshold. For reasons related with system integrity, the provider does not allow to associate this activity to a generic *Resource*, but it implements this privileged operation in a *publisher mixin* that can be associated only with a *Sensor Resource*. The *mixin* that manages the generation of the new request is called *elasticpool*: for simplicity, we assume that it exposes a single attribute, the threshold, in the interval [0..1], but we may imagine that a realistic *mixin* may indicate a template for the new resource, a *Collection* where to include the resource, and a deallocation rule.

The layout of the system is now made of a number of *Collector Link*, one for each server in the pool, and one sensor that aggregates all results and allocates new *Compute* when needed.

Each of the collectors will be defined as follows:

Attribute	value
id	urn:acme:user529/c1
kind	collector
mixin	iostat
source	urn:acme:user529/vm1
target	urn:acme:user529/s1
occi.collector.period	600
com.acme.collector.cpuutilization	N/A
com.acme.collector.what	user

The *Sensor Resource* state is the following :

Attribute	value
id	urn:acme:user529/s1
kind	sensor
mixin	max, tcp
links	urn:acme:user529/c1, urn:acme:user529/c2, urn:acme:user529/c3
occi.sensor.period	600
occi.sensor.timebase	1371025907
occi.sensor.timestart	10
occi.sensor.timestop	3610
com.acme.sensor.in	urn:acme:user529/c1#occi.sensor.max
com.acme.sensor.source	urn:acme:user529/master
com.acme.sensor.port	4321
com.acme.sensor.data	urn:acme:user529/c1#occi.collector.cpuutilization, urn:acme:user529/c2#occi.collector.cpuutilization, urn:acme:user529/c3#occi.collector.cpuutilization
com.acme.sensor.max	N/A

A A use case: OCCI Monitoring and SLA

We want to immerge the Cloud Monitoring API schema explained in this document into a Service Level Agreement (SLA) scenario, so let's try to define a SLA in terms of OCCI concepts.

An OCCI-SLA is a contract between a user and a provider: the terms of the contract are in a form that may be provider-independent, and they are published as an OCCI-Resource in a specific namespace "occi/#sla" possibly refined with mixins. There are two basic flavors for a SLA contract:

- The provider offers a SLA: the providers offers the user the ability to monitor the conformance to SLA contract
- The user offers a SLA: the provider offers the User the tools to implement resource monitoring to meet internal SLA requirements.

Both of them are compatible with the monitoring infrastructure management schema illustrated in this paper, but are otherwise quite different.

The Service Level Agreement is an aggregate of many *Resource* that describe financial, administrative, security aspects and much more. Among such *Resource* there are the Service Objectives (SLO). Their function is to specify the meaning of "quality of service" for the specific infrastructure. This concept is translated in a function of system parameters of operation, or metrics. The SLA resource contains the instructions to associate an action to a given SLO pattern.

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