

Portability and Interoperability in Clouds: contributions from the mOSAIC Project

Project mOSAIC: Open-Source API and Platform for Multiple Clouds
<http://www.mosaic-cloud.eu>



Beniamino Di Martino
Project Coordinator - Second University of Naples
beniamino.dimartino@unina.it



Univerza v Ljubljani



mOSAIC european FP7 project: main facts

- **Project acronym:** mOSAIC
- **Project full title:** Open-Source API and Platform for Multiple Clouds
- **Grant agreement no:** 256910
- **Funding Scheme:** STREP
- **Call:** FP7-ICT-2009-5 **Obj:** ICT-2009.1.2
- **Cost:** 3,705 Meur (EC financing: 2,85 M)
- **Duration:** 32 months
- **Start:** Sept 1st 2010. **End:** April 28th 2013
- **Web site:** <http://www.mosaic-cloud.eu>



mOSAIC Partners

Second University of Naples – It (Prj Coordinator)



IeAT – Ro (Sci Coordinator)



European Space Agency - Fr



AITIA - Hu



Tecnalía - Sp



Terradue - It



XLAB - Slo

Univerza v Ljubljani



University of Ljubljana - Slo



Brno University of Technology - Ck



Portability and Interoperability issues

The process of developing, deploying, executing cloud applications is strongly influenced by the specifics of the cloud providers.

Application Programming Interfaces

- ✓ Syntactical differences
- ✓ Differences in programming models
 - ❖ Object oriented
 - ❖ REST based
 - ❖ Event driven
- ✓ Differences in API semantics
 - ❖ Different functional abstractions (expecially at PaaS level)
 - ❖ Linked to application domains (expecially at SaaS level e.g. enterprise patterns)



Portability and interoperability issues (cont.)

Resources and services

- ✓ Different resource semantics (expecially at PaaS: e.g. stores)
- ✓ Different resources' configurations and templates
- ✓ Different linkages of resources and configurations to provided services
- ✓ In order to interoperate, resources and services need to be retrieved and accessed; a Resource/Service Catalogue is needed, where the resources and services are (semantically) described, together with their groundings



Portability and interoperability issues (cont.)

Non-functional requirements and service levels

- ✓ Differences in semantics of Service level offerings and their level
- ✓ Mismatch between nonfunctional requests and offers
- ✓ no linkage of provided services and resources with service levels (expecially at PaaS and SaaS)
- ✓ No standard or common KPIs and mechanisms to measure them



Portability and Interoperability: main contributions from the mOSAIC project

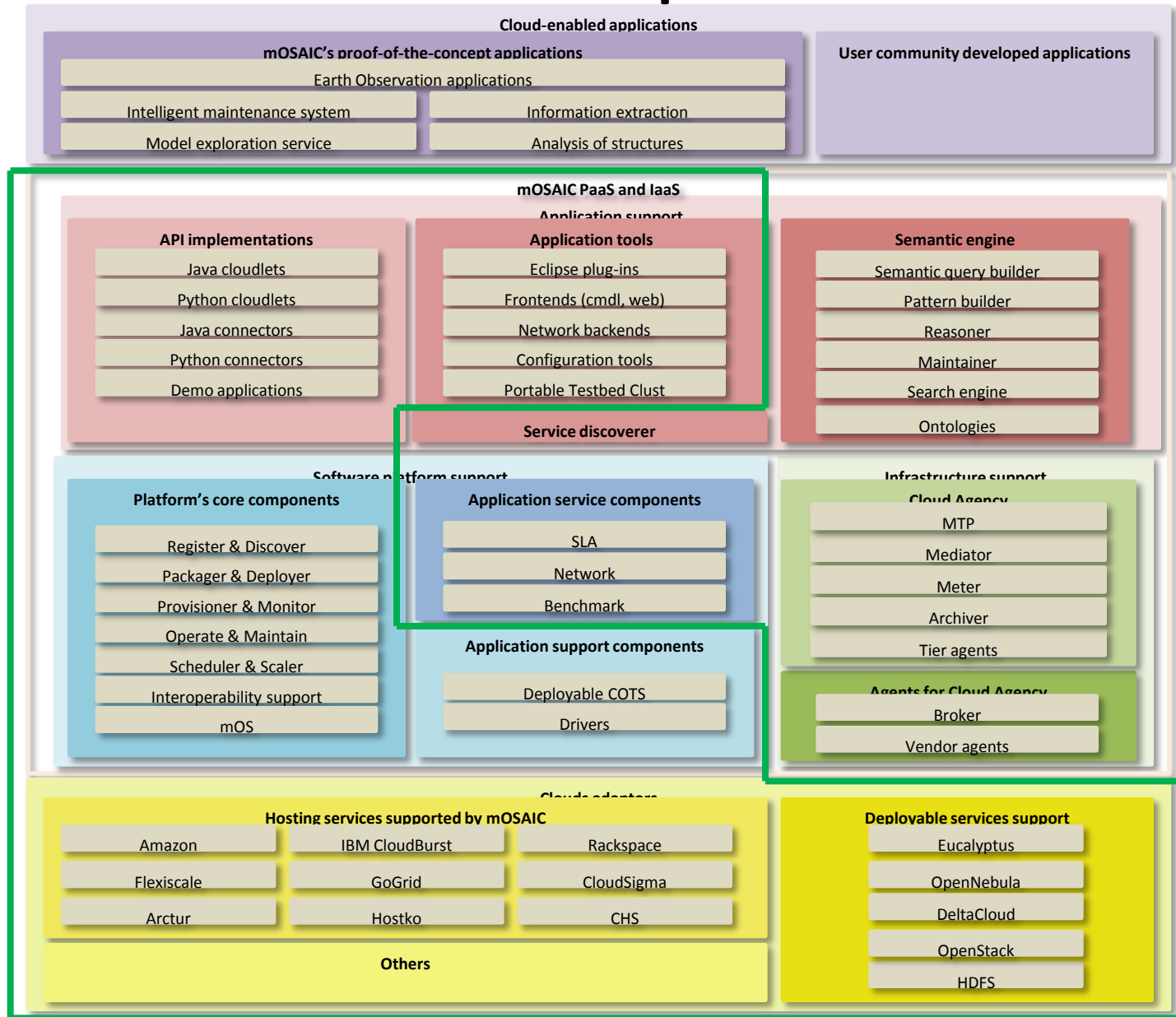
- ✓ An Agnostic, vendor neutral, API at PaaS level and an Open Source Platform, with adapters to most notable Cloud Providers' APIs
- ✓ A Cloud Agency for multiCloud Services brokering, SLA monitoring and dynamic reconfiguration
- ✓ A machine-readable Cloud Ontology
- ✓ A Semantic Engine, for discovering Cloud API components, resources and Services, driven by functional and Application domain concepts, Cloud Patterns and inference rules
- ✓ A Dynamic Semantic Discovery Service, for discovering Cloud providers' resources and services, mapping, aligning and composing them



mOSAIC Components

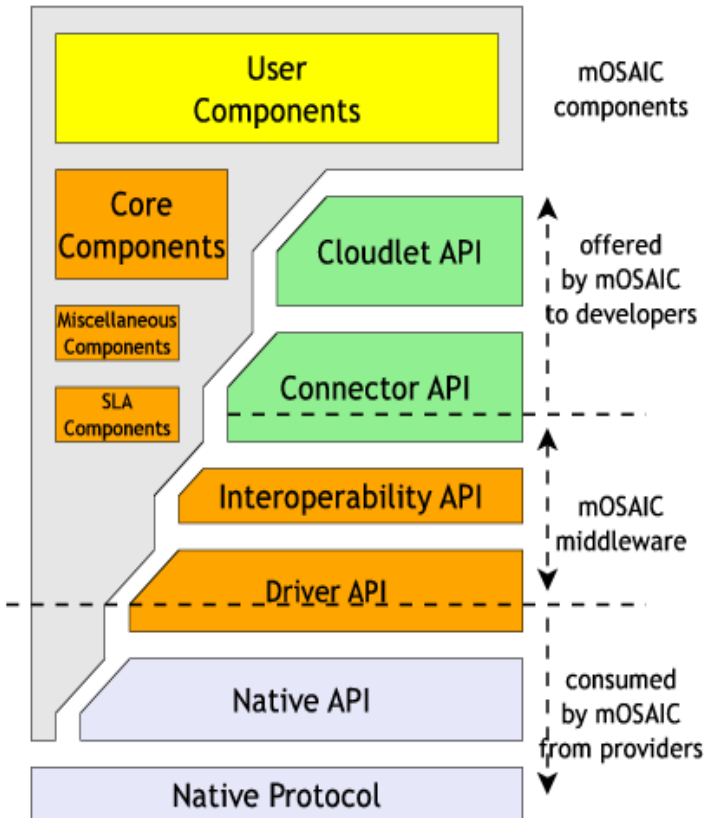
O
p
e
n

S
o
u
r
c
e



mOSAIC API Architecture

mOSAIC API Layers



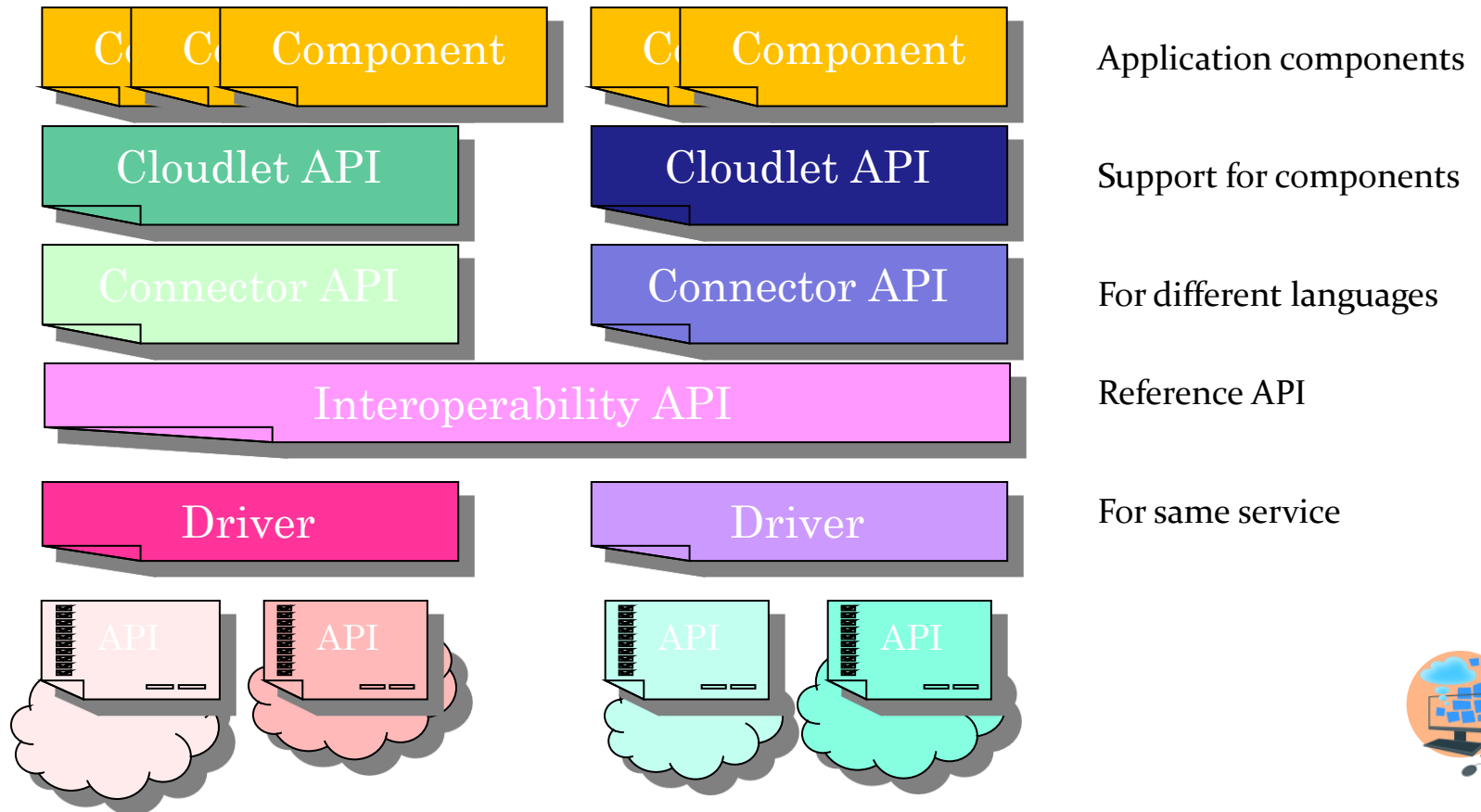
Lowest Layer: Native resource protocol (Web service, RPC, etc.), or a native resource API provided as a library by the vendor for a certain programming language. No uniformity.

Driver API: Wraps the native API, providing the first level of uniformity: all resources of the same type are exported with the same interface. Thus exchanging, for example, an Amazon S3 with a Riak key-value store is just a matter of configuration.

Connector API: depending on the programming language, provides abstractions for the cloud resources, suitable for the programming paradigm. This is where we provide the second kind of uniformity for the programming paradigms, as all the implementations of the connector API in object oriented programming languages will have similar class hierarchies, method signatures, or patterns.

Cloudlet API: Even though the developer already can access cloud resources, he or she must restrict himself or herself to a cloud compliant programming methodology, which we provide (integrated with all the layers already mentioned) that we call Cloudlet, as similar with the existing Java Servlet technology that provides standard programming components in J2EE environments.

mOSAIC API's Layers



Semantic technology for portability - interoperability

To define a common, machine readable, dictionary, able to express resources, services, APIs and related parameters, SL requirements and offers, and related KPIs

To support code portability, by allineating and reconciliating different APIs and resources

To bridge the gap between the domain related functionalities and cloud resources and services

To support interoperability, by matchmaking Service interfaces

To support (semantic based) Cloud vendors' resource and services discovery, and integration within an agnostic API



Semantic technology for portability - interoperability

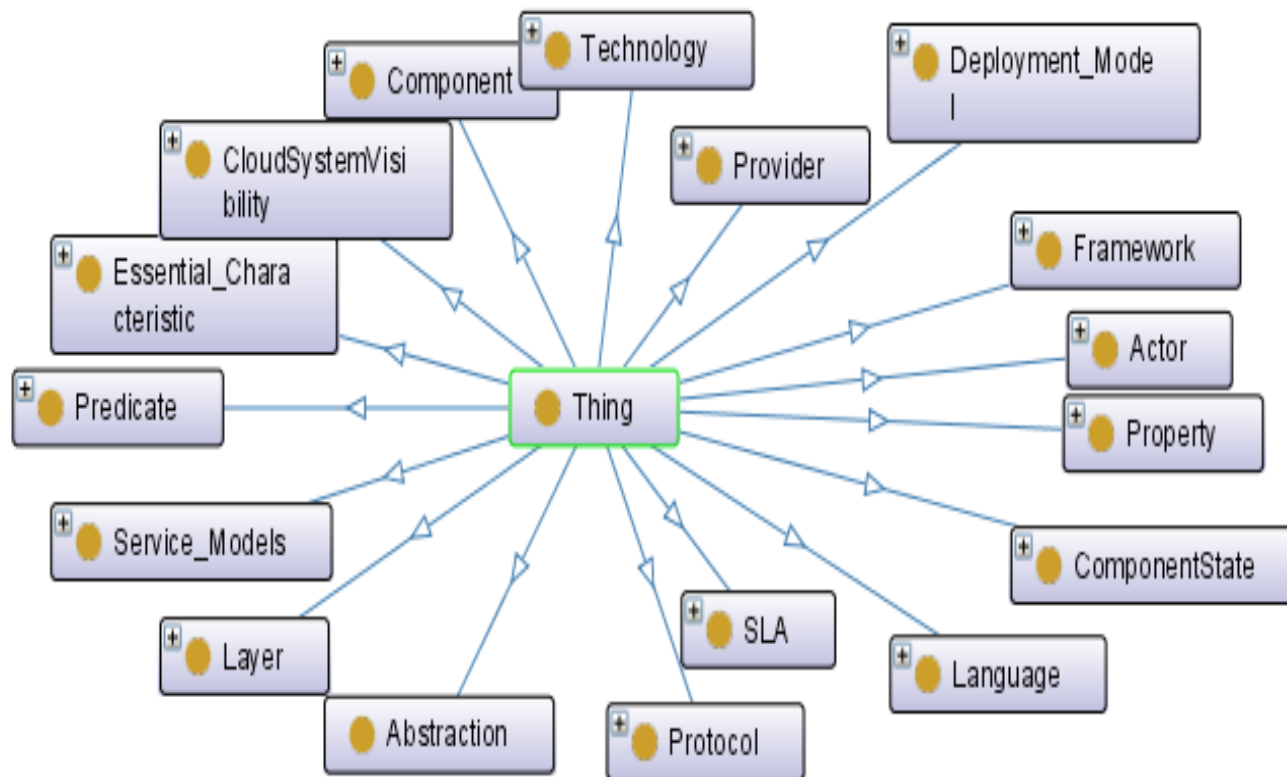
To support Brokering, Negotiation and Service level Agreement, by matchmaking nonfunctional user requirements and provider offers

To support dynamic resources reconfiguration, by monitoring SL parameters and reacting with applying heuristic rules

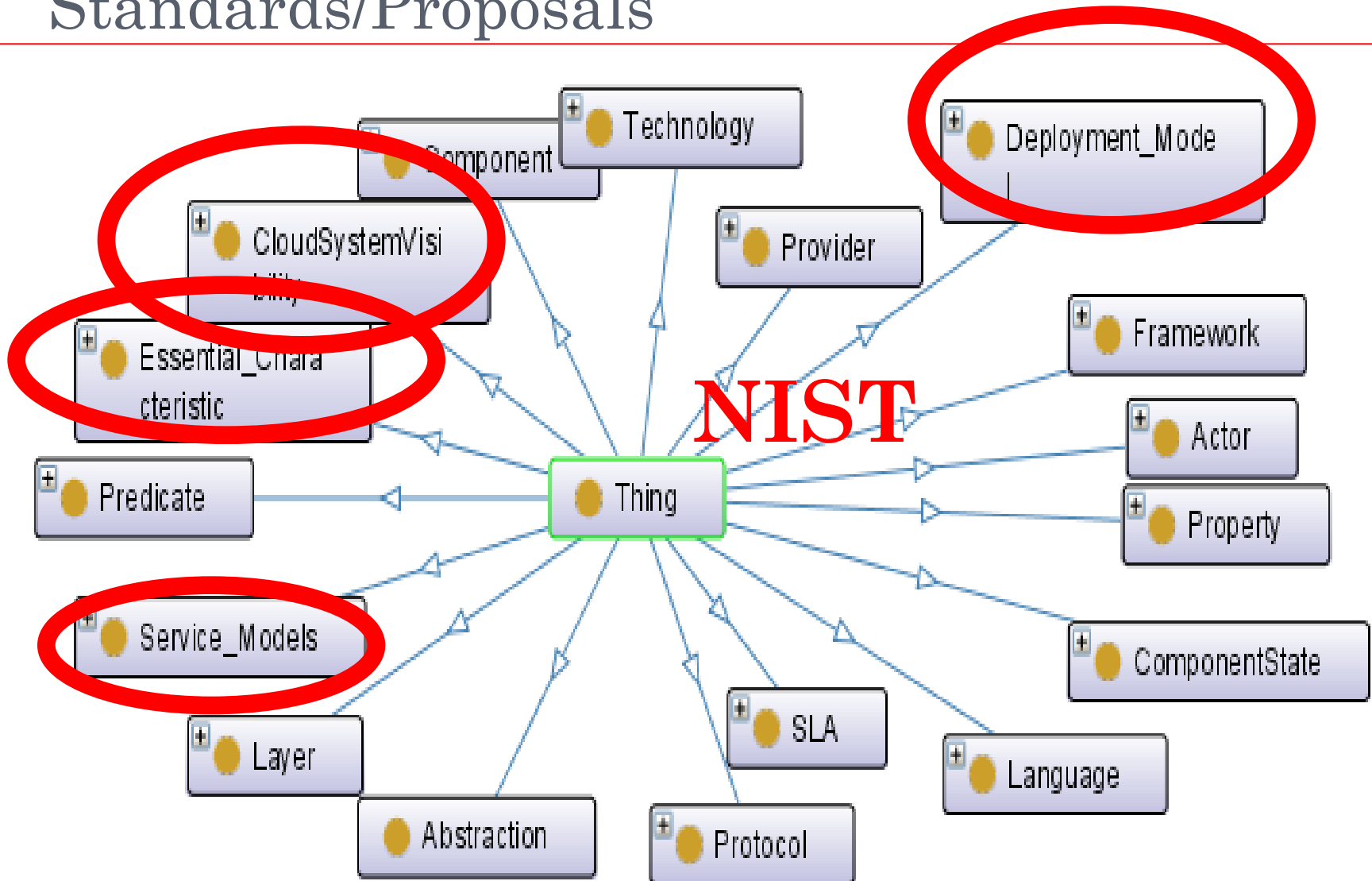


Semantic technologies in the mOSAIC project

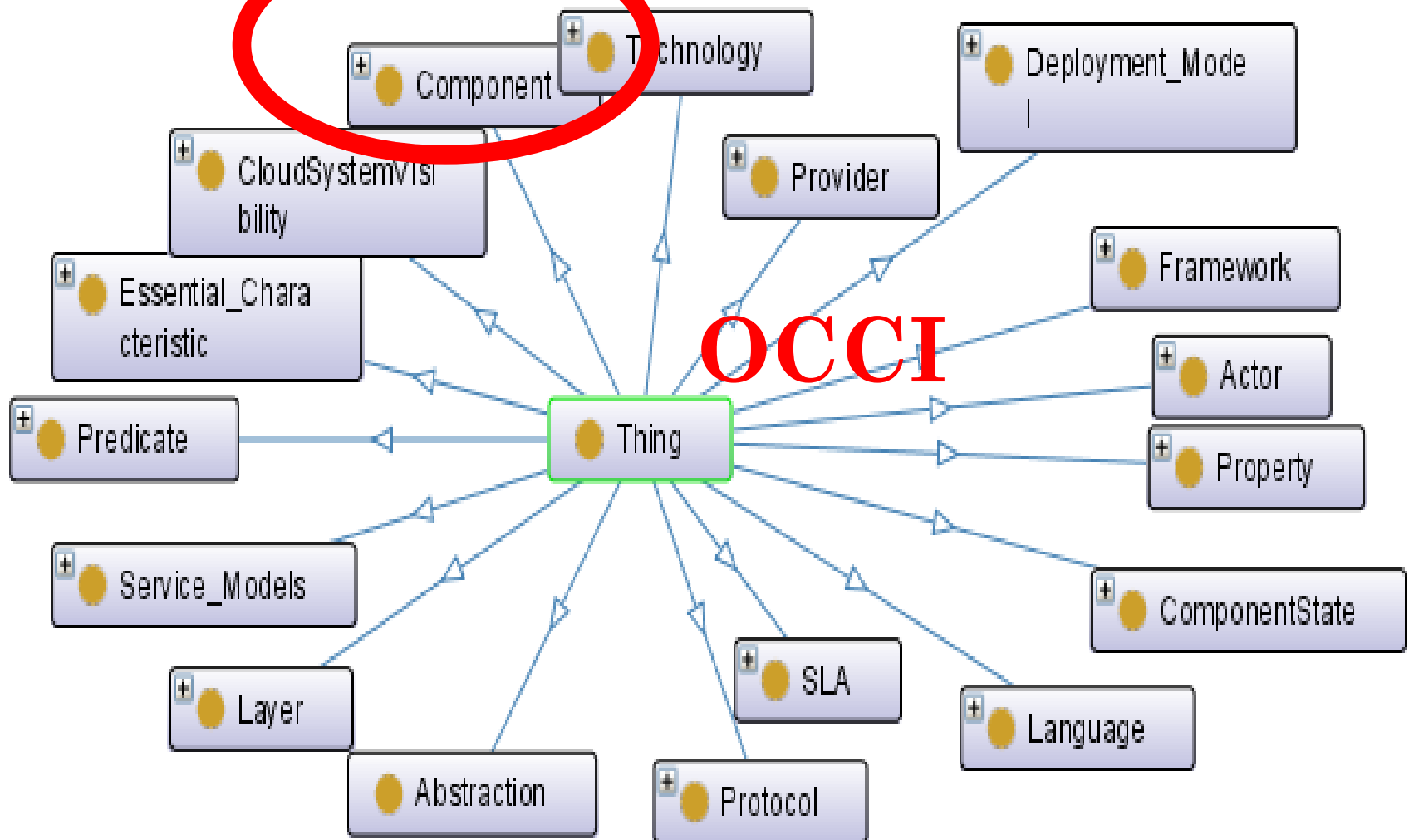
A Cloud Ontology able to provide a common definition of concepts related to Cloud domains and to describe Cloud components like infrastructures, platforms and services.



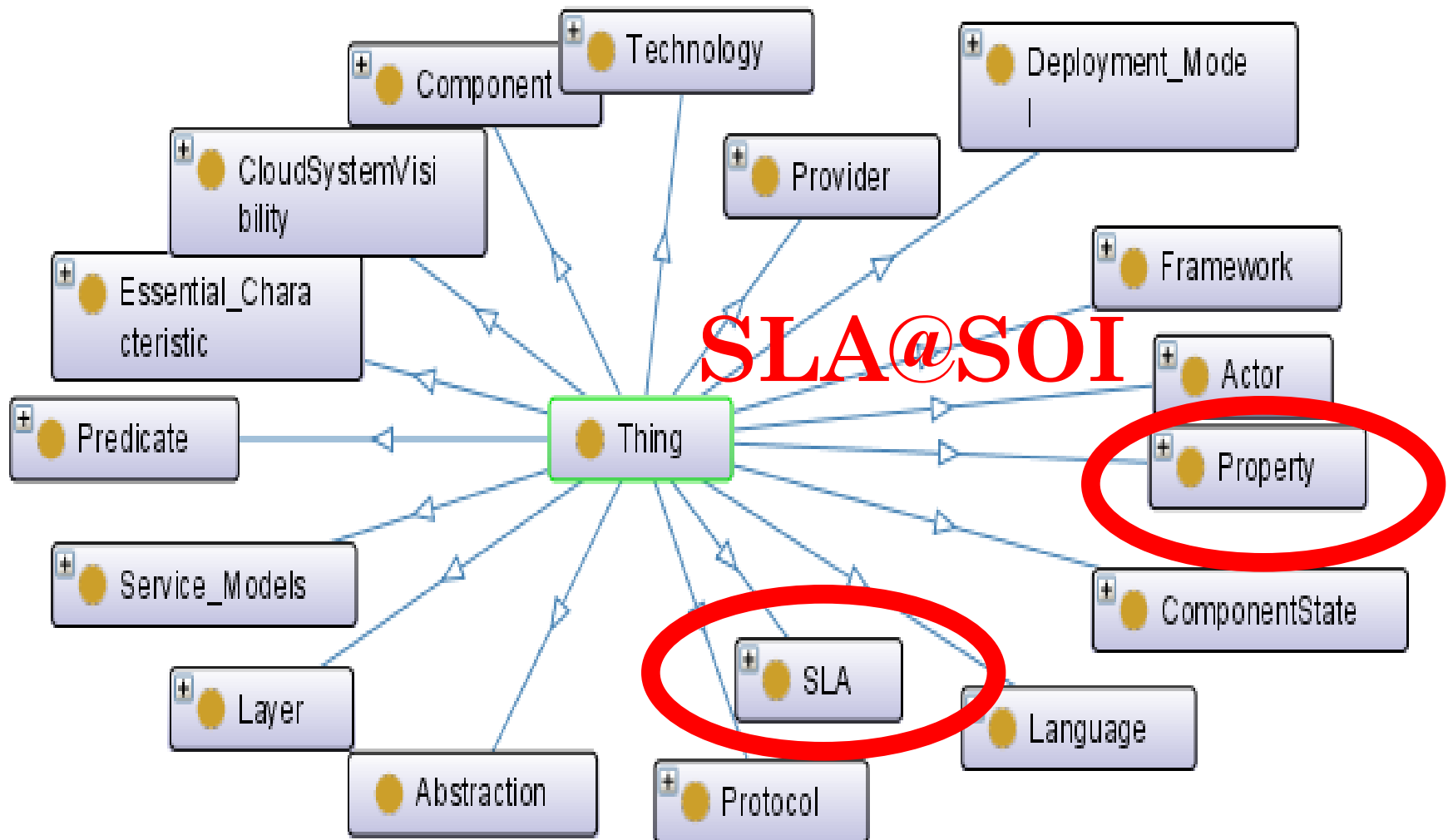
mOSAIC Ontology: Top Level and Standards/Proposals



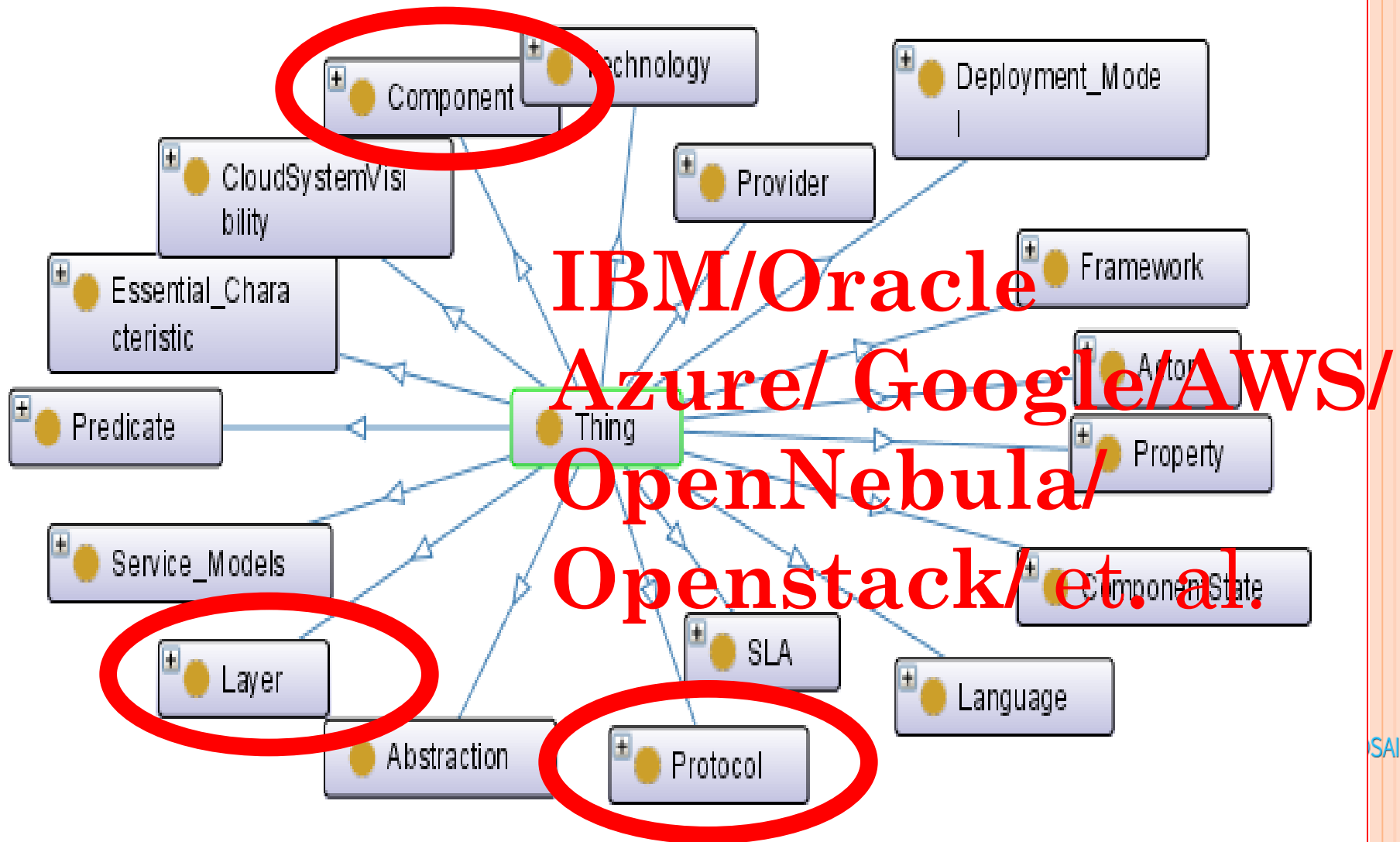
mOSAIC Ontology: Top Level and Standards/Proposals



mOSAIC Ontology: Top Level and Standards/Proposals



mOSAIC Ontology: Top Level and Standards/Proposals



IEEE P2302 – “Intercloud” Standard for Intercloud Interoperability and Federation (SIIF)

**mOSAIC Cloud ontology is being
included in the Standard**



Semantic Engine

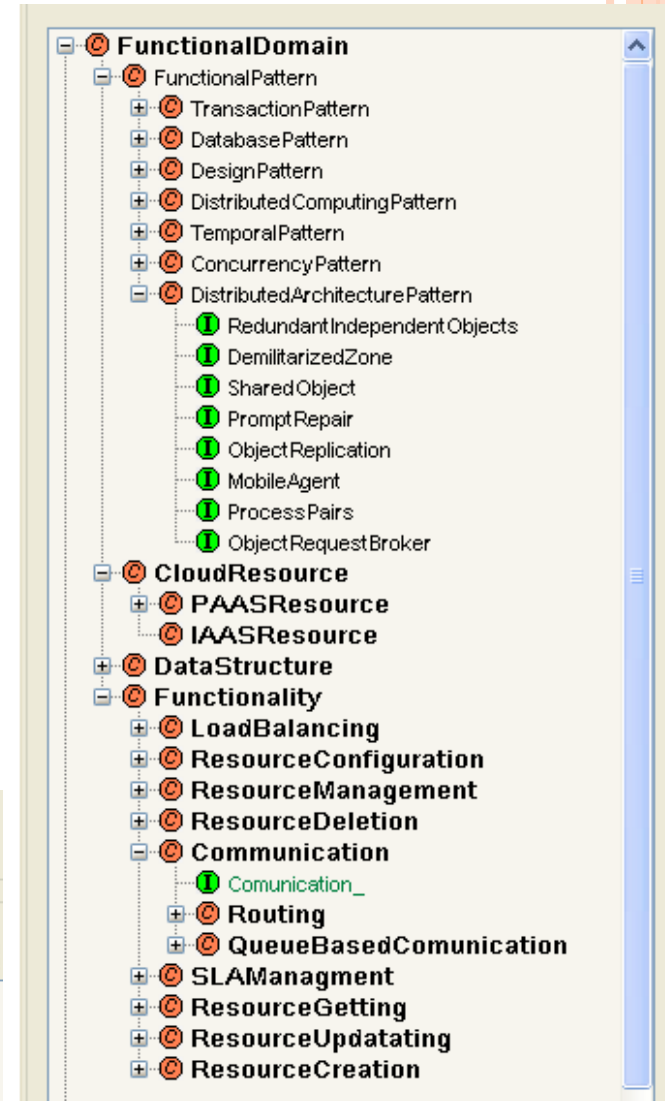
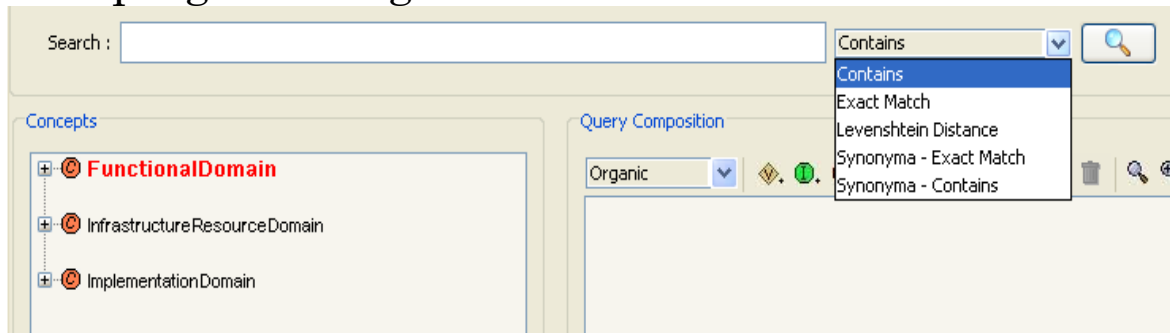
Offers a browsable catalogue of Cloud Services, Appliances and Cloud Patterns, represented in agnostic way.

Maps vendor specific resources, resources configurations, services, appliances and patterns among them and to their equivalent agnostic representation

Offers semantic search and inferencing over resources, services, appliances, Cloud and application patterns

Suggests proper resources' configurations tailored to SL specifications.

Represents the different APIs semantically, vendor agnostically, and independently from programming model



Dynamic Semantic Discovery Service

- Discovers Cloud providers' resources and services,
- Maps and allineates among them and suggests how to compose them;
- Supports the mOSAIC API developer and maintainer to develop new drivers and connectors to wrap and compose the discovered services.

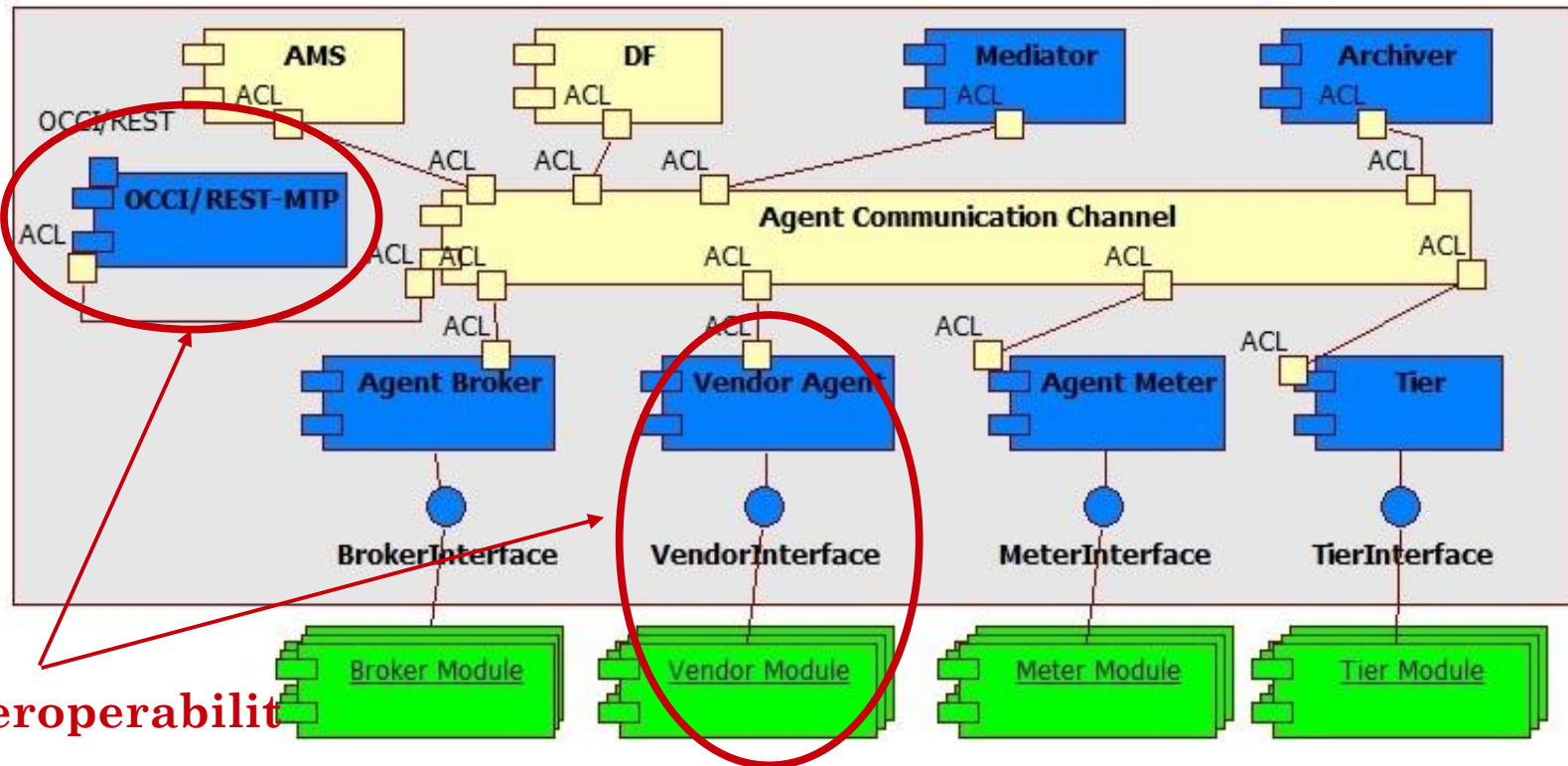
The screenshot displays the DiscoveryService application window with the following components:

- Administration Matching:** Contains tabs for "Matcher", "Mapping And Validation", "Code Filler", and "SimilarityMatrix".
- Source:**
 - Files: StoreData.owl
 - Automated Matching: (icon)
 - Bottom-Up Semantic Browsing: A tree view showing folders for STORE_DATAService, Ontologies, and Wsdl.
 - Source Syntactic Elements: A tree view showing a hierarchy of StoreData, Schema, StoreDataInterface, StoreDataOperation, and StoreDataHTTPBinding. A "Get Reachable Sub-Graph" button is highlighted.
 - Source Semantic Level: A graph showing nodes Storage, Store, Key_Value_Couple, and Store_Data. Relationships include "isSuperClassOf" (Store to Storage) and "Super-Classes" (Store to Store_Data, Key_Value_Couple). A "store_value" relationship exists between Storage and Key_Value_Couple.
 - Count: 81,285
 - Layout: (icons)
- Target:**
 - Files: FunctionalDomain.owl
 - Target Semantic Level: A graph showing nodes store, setData, setdata_1, and eu.mosaic_cloud.connectors.kvstore.BaseKvStoreConnector.set. Relationships include "isSuperClassOf" (store to setData), "hasIndividual" (store to setdata_1), and "implements" (setdata_1 to eu.mosaic_cloud.connectors.kvstore.BaseKvStoreConnector.set).
 - Count: 18,357
 - Layout: (icons)
- Top-Down Semantic Browsing:** A list of URIs. The selected entry is "eu.mosaic_cloud.connectors.kvstore.BaseKvStoreConnector.set". Other entries include "eu.mosaic_cloud.connectors.queue.amq", "eu.mosaic_cloud.connectors.http.HttpGC", "eu.mosaic_cloud.connectors.dfs.DfsCon", "eu.mosaic_cloud.connectors.ca.provisor", and "eu.mosaic_cloud.connectors.kvstore.mer".
- User Validation:** A section with fields for "Source Node" (value: ".1/Wsdl/StoreData.wsdl#StoreDataOperation"), "Target Node" (value: ".connectors.kvstore.BaseKvStoreConnector.set"), and "Validation Value" (value: "1.0"). A "Validate" button is present.



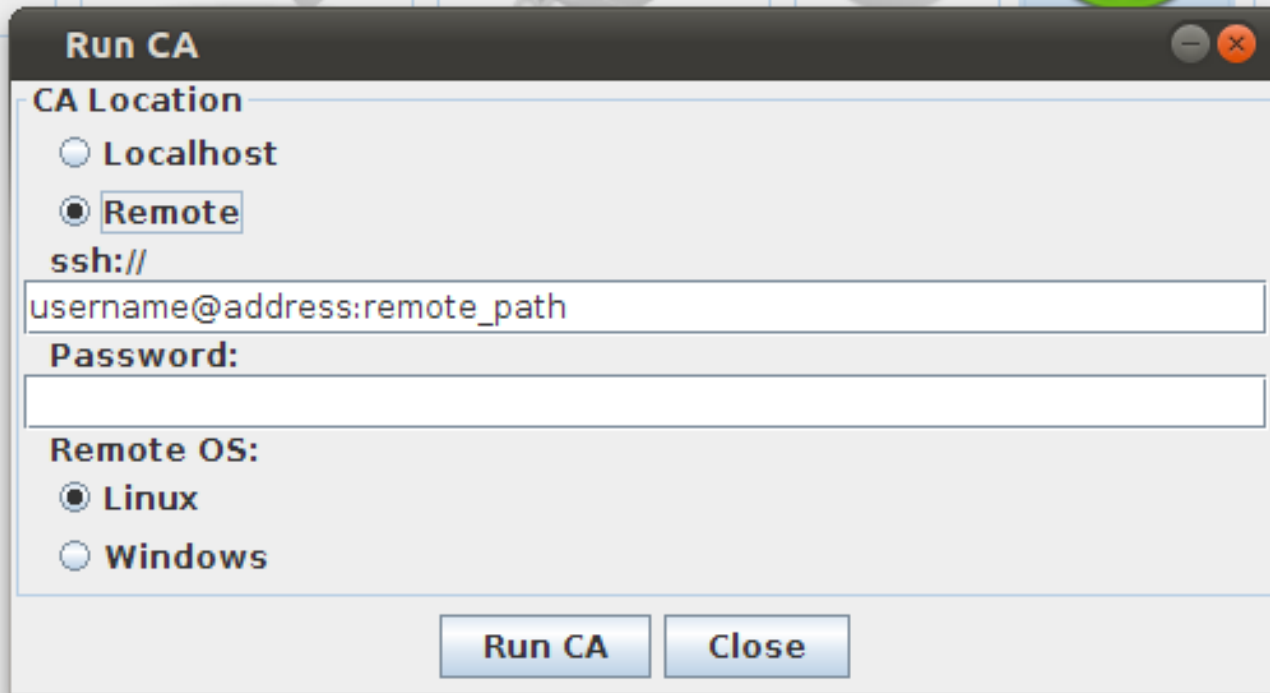
Cloud Agency

Cloud Agency is a multi agent system (MAS) that accesses, on behalf of the user, the utility market of Cloud computing to manage always the best resources configuration that satisfies the application requirements.



Interoperability

Running Cloud Agency through CA-GUI



The image shows a dialog box titled "Run CA" with a standard window title bar (minimize, maximize, close buttons). The dialog is set against a background of a desktop environment with various icons like a magnifying glass, a question mark, and a play button.

Run CA

CA Location

- Localhost
- Remote

ssh://

username@address:remote_path

Password:

Remote OS:

- Linux
- Windows

Run CA Close

CA GUI: Management

CA IP: 127.0.0.1 CA Port: 10001

Cloud Provisioning Management Monitoring Reconfiguration

Management

SLA List Resource

ID	Type	State
stubvendor_h6M2xjQ2y4n5oahA...	compute	null

ID: stubvendor_h6M2xjQ2y4n5oahArtWGN4VwLL618438Wko7_compute1

Action: start

Get Resource Perform Action

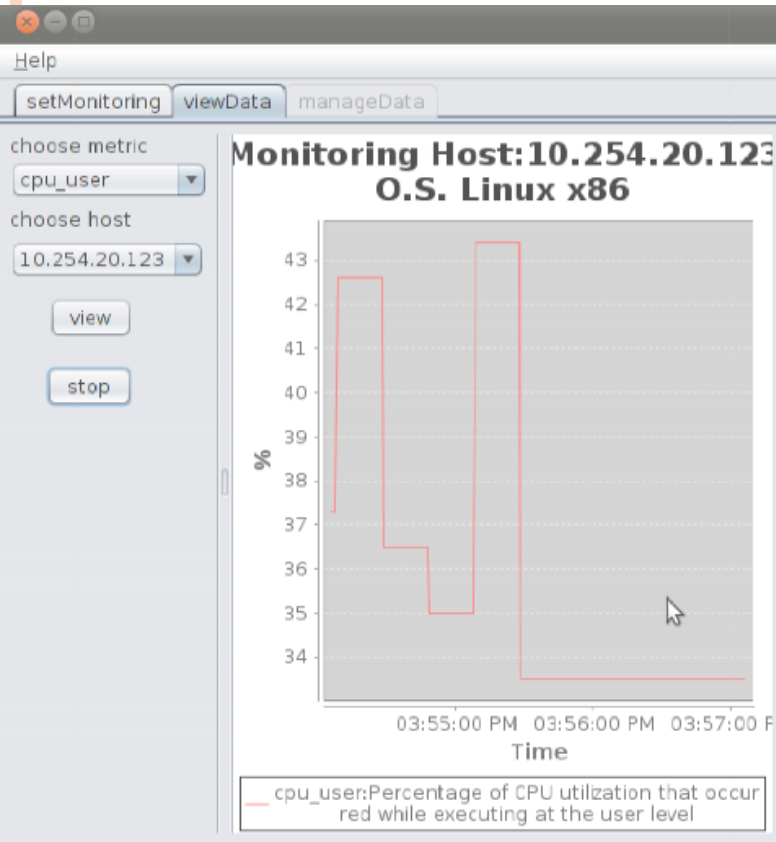
Notification
Content-type: text/occi
Server: CloudAgency OCCI/1.1

HTTP/1.1 200 OK
Content-Type: text/occi
Server: CloudAgency OCCI/1.1

starting/stopping VMs, loading and attaching VM images, deploying and executing applications



CA GUI: SLA Monitoring



Creating triggers on resource parameters

Values aggregation: average

Rule relation: =

% of SLA value:

absolute value:

Verification Mode:

Periodical, with period [s]:

On event from:

Active Rule

Action:

Send event

Active rules:

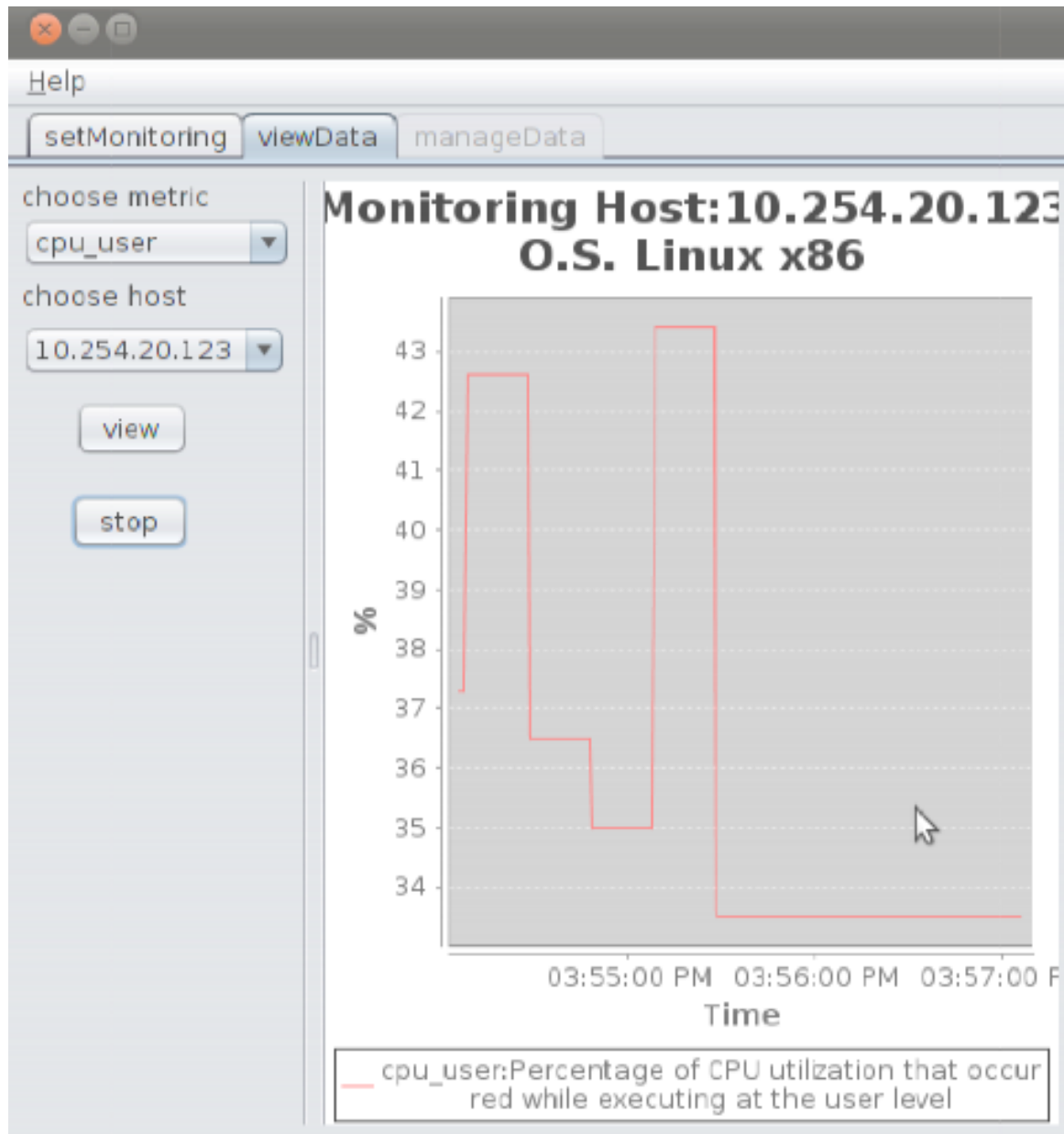
Disable rules:

Executors:

ALL

Visualization of performance indexes

Monitoring the resource



Setting up reconfiguration triggers

Provider: ▼

Resource type: ▼

Parameter: ▼

Rule list:

Add rule

Delete rule

Adding new rules

Values aggregation: average ▼

Rule relation: = ▼

% of SLA value:

absolute value:

Verification Mode:

Periodical, with period [s]:

On event from: ▼

Active Rule

Action:

Send event

Active rules:

Disable rules:

Executors:

ALL

Thanks for your attention!



beniamino.dimartino@unina.it
<http://www.mosaic-cloud.eu>

