# Cloud Computing Interoperability Approaches – Possibilities and Challenges

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## ABSTRACT

The Cloud Computing Interoperability (CCI) is a hot research topic and has been addressed by many scientists, architects, groups etc. A lot of different approaches and possible solutions are published, but there is no accepted standard or model yet. This paper is a survey of the most influential published CCI models and discusses their possibilities and challenges. The accent in this paper is set to analysis of the Software as a Service (SaaS) CCI model based on adapters.

The current state of the cloud computing market and the results of recent Cloud Computing (CC) market surveys are also included in our analysis.

The presented conclusion addresses the increasing trend in the usage of cloud computing and the lack of visible result to achieve cloud computing interoperability. So the next logical step is to create adapters to achieve interoperability at the SaaS level.

## Categories and Subject Descriptors

D.2.0 [**Software Engineering**]: General—*Standards*; D.2.11 [**Software Engineering**]: Software Architectures; D.2.12 [**Software Engineering**]: Interoperability

## Keywords

Cloud computing, interoperability, comparison

## 1. INTRODUCTION

There are different perceptions of the term Cloud Computing Interoperability (CCI) defined by different points of views [13] [10] [15]. This term may be referred as ability of applications running in different clouds to share data, application to be transferred to another cloud solution or having same functionalities and options in different cloud platforms or solutions. Also data and images portability, management and migration among different cloud solutions are not excluded. The interoperability may be defined on every level of the cloud computing service stack: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

In this paper we will use the definition given by Enterprise Interoperability Science Base (EISB) Glossary [2].

Definition 1 (Cloud Computing Interoperability). *Cloud interoperability is the ability of cloud services to be able to work together with both different cloud services and providers, and other applications or platforms that are not cloud dependant. [2]*

[14] is one of the first papers that suggests the need for cloud computing ad CCI and describes possible scenarios for CCI. As cloud computing became more widely used technology, the CCI has been analyzed by more research communities. Yet, there is no unique solution on the horizon.

In this paper we will represent and analyze some of the suggested models for interoperability, analyze the current state of the market and forecast future direction for developments.

Section 2 presents the results from CC surveys and gives overview of the current state of the CC markets and customers opinions. Section 3 presents published CCI models and their current progress and also describes new CCI approach. Section 4 evaluates the presented models.

## 2. CURRENT STATE OF CLOUD COMPUTING MARKET

There are a lot of surveys of the current state of the cloud computing market. According to the Business Web Hosting survey for small and midsized businesses [11] and the

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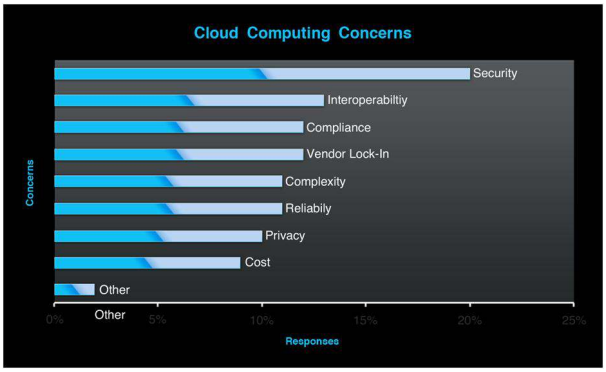


**Figure 1: Results for cloud computing concerns [11].**

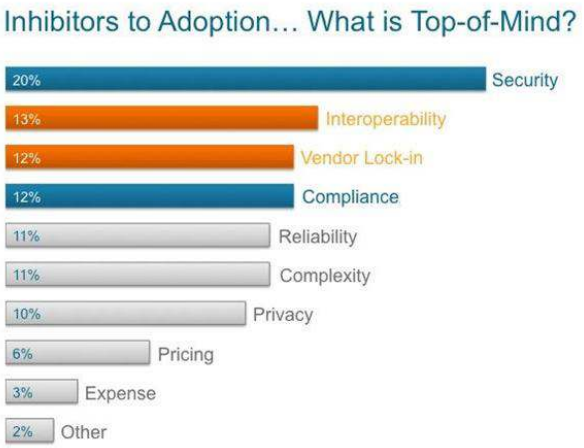


**Figure 2: Results for inhibition to adopt CC [4].**

inaugural North Bridge, GigaOM Pro and 451 Group 2011 Future of Cloud Computing Survey [4] one of the biggest concerns the prevents customers of adopting CC are security and interoperability.

500 customers were analyzed in the Business Web Hosting survey [11]. The inaugural North Bridge, GigaOM Pro and 451 Group have provided a survey on 2011 Future of Cloud Computing [4] by analyzing 417 participants (46% CC vendors and 54% non-CC vendors). The results of both of the surveys about CC concerns are shown in Figures 1 and 2.

As we can see the results are quite similar: security represents 20% of the answers and interoperability 13%.

Also both surveys predict increase of the usage of CC and show high usage of SaaS and IaaS.

The lack of interoperability was introduced by companies when they started to develop adapters in order to achieve transfer of real applications to the cloud. Companies like CloudSwitch and RightScale already made the first step; they have developed tools to enable moving applications to target clouds.

# 3. OVERVIEW OF CCI MODELS

Diferrent models have targeted different layers od the CC stack: [1] addreses all the layers of the cloud, while [5], [3] and [6] target only the IaaS layer. In the following section we will describe these models.

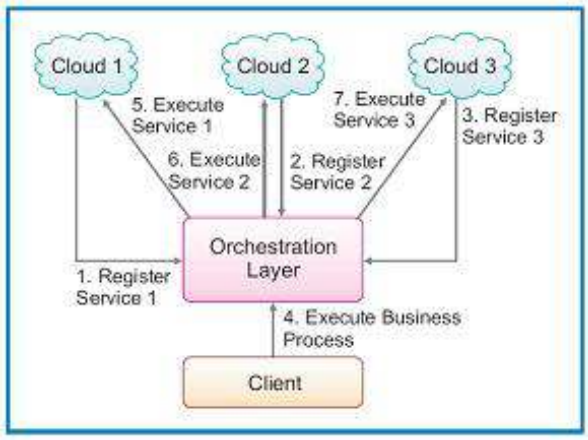


**Figure 4: Cloud orchestration [14].**

## 3.1 Unified Cloud Interface/Cloud Broker

The Unified Cloud Interface Project have goal to create an open and standardized cloud interface for different cloud api's [1]. This model of unified cloud interface (cloud broker) is discussed in [14]. The idea is "*to come up with an abstraction layer that is agnostic to any cloud API, platform or infrastructure*". The unified cloud interface (UCI) should create API for other CC APIs, to serve as common interface, to provide specification and schema for integration with other management models and exchange management information and address Infrastructure as a Service (IaaS) and Platform as a Service (PaaS). This model suggests the usage of semantic web and OWL. The overview of the UCI is shown in Figure 3.

This approach is proposed by a non-profit organization Cloud Computing Interoperability Forum (CCIF). Unfortunately some of the biggest companies in CC have rejected the CCIF approach, so it is unlikely that this model will be widely used.

## 3.2 Enterprise Cloud Orchestration Platform / Orchestration Layer

The solution InterCloud presents a federation of clouds [14]. The source of the idea is to present Internet as a network of networks. In this model different cloud providers can register their cloud services within the orchestration layer (OL) similar to publishing the web services with the Universal Description, Discovery and Integration (UDDI) [5]. [14] suggest "*The orchestration layer can then dynamically select and bind to services based on criteria/algorithms that determine the best cloud service for a particular job based on factors like highest performance, lowest cost or other requirement as specified by the client*". An example of invocation of three different services provided by different CC provider is shown in Figure 4.

Beside the standard CC security issue, this model has a lot of considerations to be solved: limitation of the required service platform support, dealing with delays and latencies due to the OL performance overhead and the data volumes transportation overhead.

Unfortunately this model is also not accepted by the most influential CC providers.

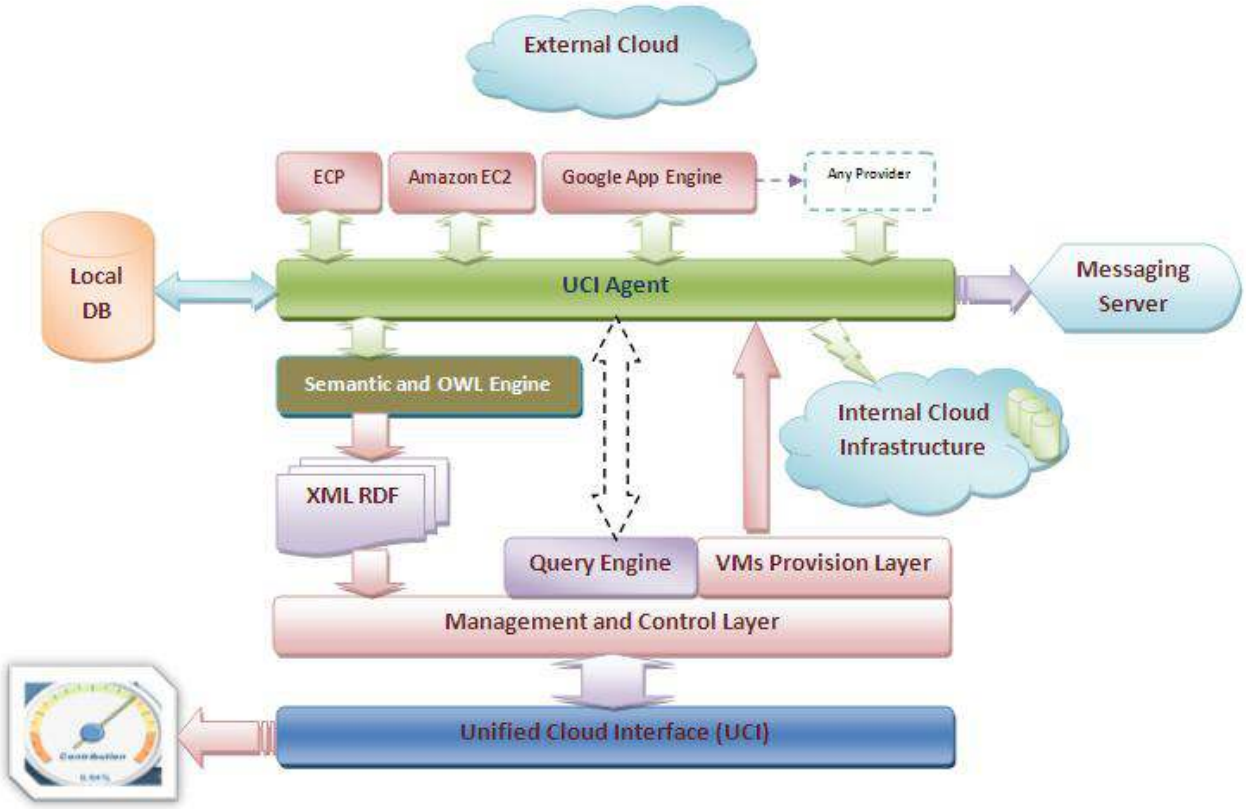


**Figure 3: UCI architecture [1].**

## 3.3 Blueprint for the Intercloud

[3] discusses use cases for CCI including interoperability, inter-cloud protocols and formats for enabling the use cases. Two types of use cases are described: use cases involving a physical metaphor and use cases involving an abstract metaphor. The physical metaphor includes servers, disks, network segments, etc, and the abstract metaphor includes blob storage functions, message queue, email functions, multicast functions, etc.

The first type of use cases is about virtual machines (VM) instantiation and mobility. They include VM mobility transactions, reliable conversations between the clouds, VM transport and VM instantiation formats.

The second type of use cases is about storage interoperability and federation. It includes storage subcontracting of one cloud provider with another and assumes reliable conversation and reliable transport among clouds [3].

[3] suggests clouds of two kinds, one using hypervisors from VMware and another using open source hypervisors such as Xen and KVM from RedHat. "Intercloud Protocols" are tested on these clouds. Figure 5 shows the architecture of Intercloud standards. A set of already established protocols are subject for further research and extension.

This research only shows directions for further standardization and it is only a starting point. It requires a lot of future work and communication among existing CC vendors.

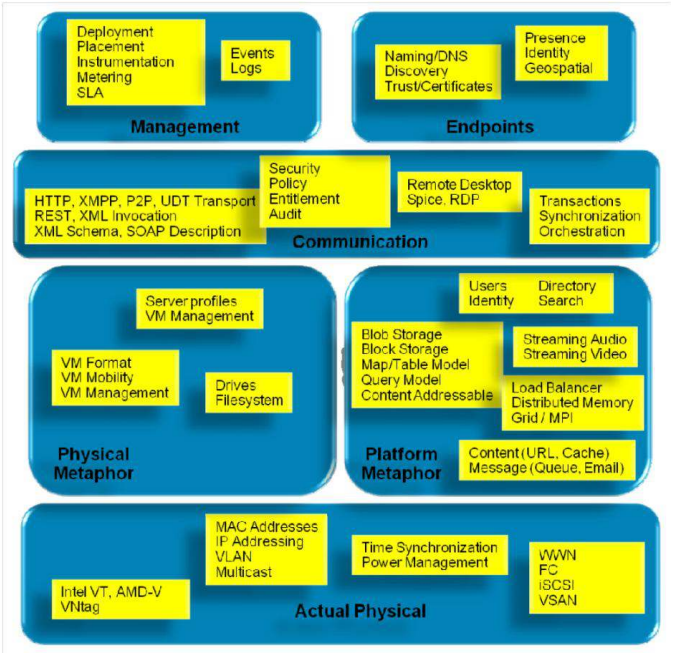


**Figure 5: Architecture for intercloud standards [3].**

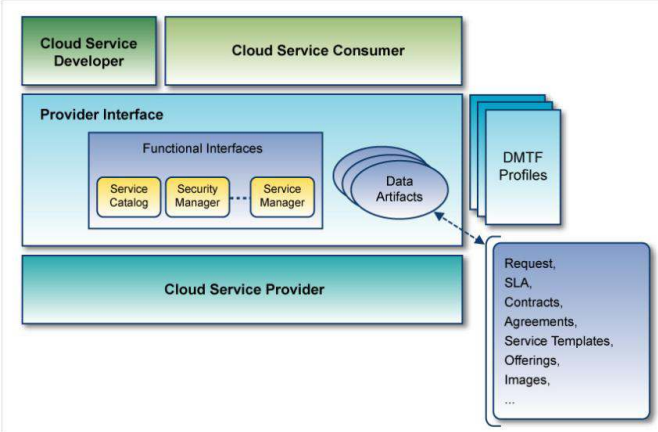


**Figure 6: Cloud service reference architecture [7].**

## 3.4 Management Interoperability for Cloud Systems

In 2009 the Distributed Task Management Force (DMTF) has formed a group dedicated to address the need for open management standards for cloud computing. This group is called "Open Cloud Standards Incubator" and their aim is to develop a set of informational specifications for cloud resource management [6]. Their target is the IaaS interoperability.

This group is promising since the biggest CC vendors like AMD, Cisco, Citrix, EMC, HP, IBM, Intel, Microsoft, Novell, Red Hat, Savvis, Sun Microsystems, and VMware are part of this group.

From 2009 till 2010 this group has created white papers about their vision for interoperable clouds [7], architecture for managing clouds [8] and use cases and interactions for managing clouds [9]. Since then they are working on Cloud Infrastructure Management Interface (CIMI) Model and the work is still in progress.

This group has isolated the cloud management challenges, created scenarios for interaction using interoperable cloud standards, defined cloud service lifecycle and created Cloud Service Reference Architecture [7]. Figure 6 shows the proposed reference architecture.

In [8] they have created more detailed definition of the proposed reference architecture including resource models, security architecture, high-level requirements and gave protocol examples. This group has also defined the management use cases for the lifecycle of a cloud service and the data artifacts used in the use cases [9].

The work of Open Cloud Standards Incubator is still in progress, developing slowly. They are working for almost three years and yet they have not completed their task. And even if they do there is no guarantee that this model will be adopted by other venders that are not part of this group, like Amazon.

## 3.5 Software and Data Interoperability

The interoperability of the Software as a Service (SaaS) layer has not being analyzed as other platforms by researchers. In [12] this question is raised and initially set to the research community in 2010. According to this paper SaaS CCI issue can be summarized into four categories (shown in Figure 7):

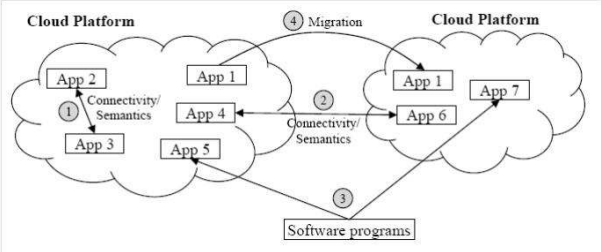


**Figure 7: Types of interoperability between applications in the cloud [12].**

- Interoperation among applications inside a single cloud,
- Applications to exchange information and trigger operations across different cloud environments,
- Software programs to connect multiple cloud environments and to integrate data and applications across clouds in a unified manner and
- Migration of a cloud application from one cloud environment to another.

There are no visible results in this area so far.

## 3.6 Adapters

The software adapters have existed for a long time. They provide service and communication between incompatible software and services; and by definition they provide interoperability. The overall goal is the data exchange.

In the case of cloud computing adapters can provide a new possible solution to the currently nonexistent SaaS standards. The pool of SaaS CSP providers is growing up every day and there are too many software types that can be found in the cloud. It is impossible to create adapters for each type of software. Therefore there are two possible approaches:

- Developing adapters for general world-wide used types of software like CRM, ERP etc...
- Developing custom adapters for specific software.

Our target group is the first one. Most of the general application software deal with similar data but one can expect all this data is differently named and organized. Our goal is to provide fast adapter production for data exchange and extraction of these data types used in common software applications and to cover the four categories of interoperability described by Kumar [12]. The idea is to create a general data and process model that includes the most used service provider in the given class of software and with the use of semantics to create alignment of the data.

# 4. COMPARISON ANALYSIS OF CCI MODELS

Table 1 presents the results of evaluation we have provided in order to compare these models. The methodology consist by measuring the indicators for the following categories:

- **CC stack Layer** - An indicator that tells which layer of the CC stack is addressed in the model (for example, it can specify IaaS, PaaS or SaaS),

**Table 1: Model Comparison**

| Model | CC stack Layer | Details | Realization | Acceptance |
|---|---|---|---|---|
| Cloud Broker | IaaS | Existing draft of requirements and draft OWL Ontology | Demo realization with Amazon EC2 and Enomaly ECP | Rejected by biggest CSP |
| Orchestration layer | IaaS,PaaS,SaaS | General model | Early adopters: Cordys, RightScale and CSC | Not accepted by biggest CSP |
| Blueprint for the Intercloud | IaaS | Only directions | No | No public opinion |
| DMTF CIMI | IaaS | Draft documentation | Expected | Acceptance expected |
| Adapters | SaaS | CSP API or Service required | Some existing realizations, many possibilities | No acceptance nedded |

- **Depth** - An indicator that explains the depth of description to which the model has published the requirements, architectures, how detailed is the model, etc ... (for example, it can be general model specification, directions only, draft documentations, etc.)

- **Realization** - An indicator that presents the existence of demo realization, or initial implementation of the Cloud Service Providers (CSP) or accepted and incorporated by the CSP,

- **Acceptance** - An indicator that shows the possibility of acceptance by the biggest Cloud Service Providers (CSP).

We can conclude that the only solution that can be possibly generally used and adopted by the most of the vendors in the future is the CIMI model by DMTF providing interoperability on the IaaS level. Unlike that, the adapters don't require adoption by the vendors and are probably the only possibility for near future.

# 5. CONCLUSION

The usage of cloud computer is increasing especially in the area of offering infrastructure and software in cloud as a Service (IaaS and SaaS). There are several approaches and research initiatives claiming progress in creation of interoperability in the area of IaaS.

However there is no evidence of progress for setting the interoperability in the area of SaaS. The logical steps lead to creation of general interoperability frameworks for each layer, starting from lowest, and then to expand them. At this moment it seems unlikely for any of proposed interoperability model to be adopted as a standard.

We suggest another solution based on creation of adapters. There are few dominating CC vendors on the market and all of them have created their own different solutions and cannot easily unite their goals in achieving the interoperability. So the next step is to start from the dominating CC models and to create adapters that will ensure interoperability among them. After all, we are still using electrical adapters, when we go abroad, aren't we?

# 6. REFERENCES


[1] Unified cloud, 2009.

[2] Cloud interoperability, 2011.

[3] D. Bernstein, E. Ludvigson, K. Sankar, S. Diamond, and M. Morrow. Blueprint for the intercloud - protocols and formats for cloud computing interoperability. In *2009 Fourth International Conference on Internet and Web Applications and Services*, 2009.

[4] N. Bridge, G. Pro, and . Group. 2011 future of cloud computing survey results, 2011.

[5] Cordys. Now is the time to take the cloud seriouslyy, 2011.

[6] DMTF. Dmtf to develop standards for managing a cloud computing environment, Apr. 2009.

[7] DMTF. Interoperable clouds, Nov 2009.

[8] DMTF. Architecture for managing clouds, Oct. 2010.

[9] DMTF. Use cases and interactions for managing clouds, Jun. 2010.

[10] P. Goyal. Enterprise usability of cloud computing environments: Issues and challenges. In *19th IEEE International Workshops on Enabling Technologies: Infrastructures for Collaborative Enterprises*, pages 54–59, 2010.

[11] B. W. Hosting. Cloud computing attitudes for small and midsized businesses, 2011.

[12] B. Kumar, J. Cheng, and L. Mcgibbney. Cloud computing and its implications for construction it. In W. Tizani, editor, *Computing in Civil and Building Engineering, Proceedings of the International Conference*, page 315. Nottingham University Press, 2010.

[13] K. Oberle and M. Fisher. Etsi cloud - initial standardization requirements for cloud services. In *GECON'10 Proceedings of the 7th international conference on Economics of grids, clouds, systems, and services*, pages 105–115. Springer-Verlag Berlin, Heidelberg, 2010.

[14] A. Parameswaran and A. Chaddha. Cloud interoperability and standardization. Technical Report VOL 7 NO 7, SETLabs Briefings 2009, 2009.

[15] D. Petcu. Portability and interoperability between clouds: challenges and case study. In *ServiceWave'11 Proceedings of the 4th European conference on Towards a service-based internet*, pages 105–115. Springer-Verlag Berlin, Heidelberg, 2011.