Considerations on the Interoperability of and between Cloud Computing Standards

Guilherme Sperb Machado, David Hausheer, Burkhard Stiller
Communication Systems Group CSG, Department of Informatics IFI, University of Zürich UZH
Binzmühlestrasse 14, CH-8050 Zürich, Switzerland

E-Mail: [gsmachado | hausheer | stiller]@ifi.uzh.ch

Abstract

Cloud computing has gaining importance in the recent past due to the conjunction of well-known key features, such as virtualization and pay-by-use, which together form an innovative concept. Even if cloud computing does not have a widely accepted definition, it has been used for many companies to deploy its infrastructures and promote their business. However, the lack of standards seems to be a drawback related to interoperability and optimization issues.

Convenient actions like changing cloud providers, and/or exchange data/information between clouds may be an arduous work for its customers. Therefore, this paper presents major considerations regarding the lack of cloud standards and pointing why this is considered to be a problem. Furthermore, scenarios are discussed, which are desired to make use of cloud interoperability and which are currently initiatives addressing cloud standards issues. This leads to a set of important observations towards a solution solving the interoperability and standardization problem.

1 Introduction

Considerable research has recently been conducted in the area of Cloud Computing. However, no definition of Cloud Computing seems to be widely accepted yet, although this question has already been addressed by several authors [10], [18], [1], [17], and [4]. Cloud Computing has become increasingly important in ICT (Information and Communication Technology) due to the conjunction of key features like self-service, virtualization, pay-by-use (or pay-by-demand), scalability, high availability, and easy dynamic management, which together form an innovative concept that turns clouds into a widely used solution for many organizations.

According to a market-directed poll conducted by [15], a considerable number of organizations are not only considering to use one specific type of clouds, but rather a combination of them. In this way, it is possible to gain the highest benefits from each type of clouds. For example, within the Infrastructure as a Service (IaaS) [1], the use of "public clouds" delivers the best economy of scale, but the shared infrastructure model limits configuration, security, and Service Level Agreements (SLA) specificity. The so-called "internal cloud" has a modest economy of scale due to funding limitations and tends to be less automated. It occurs since it is an on-site solution, and organizations have to take care of the management with funding allocation (which, most of times are scarce). However, the infrastructure – including sensitive data – resides inside the company, providing an enhanced data privacy. In contrast, within the "hosted cloud", a customer can obtain benefits from both worlds, with the comfort of a rented infrastructure in terms of automation, configuration, security, and scalability, and typically with a customized SLA. Nevertheless, costs of hosted clouds are higher due to a full server being dedicated to a specific customer.

In order to arrange the mentioned benefits in an efficient and effective manner, customers may opt to use different cloud types (at the same time) in order to deploy on-production applications, run tests, and build test environments, among other use cases. Customers may also change cloud providers (*i.e.* public or hosted clouds) depending on the best offering and in order to make an optimal choice regarding utilization, expenses, and earnings. However, nowadays it seems unrealistic to accomplish the aforementioned requirements without losing efforts due to the lack of cloud standards. For example, customers need to manage all these different clouds using different APIs (Application Programming Interface), and any change in the cloud environment may lead to application refactoring. For this reason, the need of well-defined standards play an important role towards interoperability and manageability inside and between clouds, with possible impact in the economic aspect as well. Then, customers could take advantage of integrating different cloud providers, combining benefits of each cloud type in order to build solutions that are coherent to their goals: from technical to funding restrictions.

Therefore, this paper presents major considerations regarding the lack of cloud standards, pointing out why this is a problem (Section 2.1), which scenarios are desired making use of cloud interoperability (Section 2.2), a brief discussion toward a solution approach (Section 3), and at the end a related work section inside this research field (Section 4) with preliminary conclusions (Section 5).

2 The lack of Standards

Due to the lack of cloud computing and interfacing standards a set of desired scenarios are outlined to discuss current limitations from the current cloud scene, aiming also at describing benefits employing well-defined standards.

2.1 The Problem

One of the key characteristics that makes clouds different from usual enterprise computing is that the infrastructure can be programmable [16]. In usual enterprise computing environments, physical resources like servers, storage, and network connections should be deployed using human efforts most of times. Nevertheless, in the cloud computing manner developers can describe how these same components are virtually configured or interconnected, how the virtual infrastructure topology are formed, and how they interact to each other, depending on developing needs. In order to accomplish this virtual deployment and management, developers should manipulate an API that is implemented by the cloud provider.

However, cloud APIs are not yet standardized, and what happens nowadays is that each cloud provider has its own specific API for deploying and managing its services. For example, Amazon EC2 [2] API is different from GoGrid [9], even if both offer similar services regarding IaaS. In addition, each cloud provider has its own proprietary solution that tends to lock users into a specific technology. Examples of valuable proprietary solutions are Amazon Elastic Load Balancing [3] and Salesforce Real-time Query Optimizer [8]. When customers instantiate a Load Balance component to manage traffic, and become dependent to this technology, it is not a trivial process to reimplement (and integrate) the same functionality if they migrate to another cloud provider. Unless whether the new cloud provider offers an API that is full compatible to what a load balancer component is able to do.

Taking into consideration that aspects like agility, efficiency, and low associated cost are also key characteristics in cloud computing [1], the lack of standards definitely run against them. The reasons, as mentioned before, is that customers may change providers or combine them in a optimum manner – depending on its needs. In this case, the lack of standardization may bring disadvantages, when the moving, integration, or exchange of resources is required. The main negative aspect is the necessity of refactoring applications to comply with other cloud APIs, which can possibly lead to higher costs, delay of different natures, and risks – thus opposing agility, efficiency, and low costs.

An additional problem covers the necessity of integrated clouds, in the sense that users would move information/applications/servers from one cloud to another without losing functionality; *e.g.*, cloud users can benefit from "federated clouds", which have similar functionalities to scale better with their applications, and distribute sensitive information in an optimized manner. Even for the most prominent problem inside the cloud interoperability subject is the lack of a standardized API, in this case it is also needed to plan for common mechanisms for pricing, accounting, and measuring SLA parameters across cloud boundaries.

2.2 Desired Scenarios

Based on three distinct scenarios selected, the high usefulness related to cloud standards is presented. It is not possible to cover the range of all possible desired scenarios, but it is presented the selection of relevant sample outlines, those which can be possibly done with an employment of standards in various cloud levels.

Scenario 1: The first scenario relies on exporting and importing service configurations on clouds. Suppose that a given company already have a virtual on-production infrastructure deployed in a Cloud Provider CP1. However, such company (as a customer) experienced server performance degradation, which affected the business case negatively. Thus, it was decided to move the entire virtual infrastructure to a new Cloud Provider CP2. With the use of standards for inter-cloud virtual machine exchange, it is possible to export the current virtual infrastructure configuration in a standardized manner, which will permit to import it into a different cloud without refactoring what was consolidated before. This example is based on the IaaS principles, but it can be applied also to SaaS (Software as a Service) where a company can export/import email's configurations for thousands of users.

Scenario 2: The second scenario relies on the management of different resources in different clouds. Suppose that an organization has an e-mail service running in cloud C1, applications in cloud C2, and a a huge storage solution in cloud C3. In addition, the organization runs a server by its own to receive client's requests and process it. According to the business workflow, such server needs to consult data stored at cloud C3 and, depending on some parameters, forward the request to application on cloud C2, which in turn sends e-mails using the e-mail server on cloud C1. Imagine that one of these clouds does modify its API, or due to the purpose outlined in scenario 1 the organization decides to change cloud providers. Consequently, the server managing all resources located on these clouds have to modify its implementation. Naturally, building a solution that would be fully compatible with cloud standards could give much more flexibility and less exposure to high spends due to necessary software modifications.

Scenario 3: The third scenario relies on federated clouds and the capability of accounting its use, monitoring resources, and respect SLAs across boundaries. If an university runs, *e.g.*, simulation approaches in an internal cloud, but would like to move servers on-the-fly (without an availability disruption) to a hosted cloud inside its federation (*e.g.*, a project partner), such a utilization should be accounted across boundaries and SLA parameters respected.

3 Toward a Solution

Stepping toward a commonly and widely adapted solution means that there is a considerable amount of work and research to be performed. However, initially there are key observations collected, which cannot be ignored simply by an approach for developing a new interoperability standard.

The description of desired scenarios in Section 2.2 result in major inquiries that are presented and discussed below. These inquiries are more focused on a strategy point of view regarding cloud standards.

- Amazon, GoGrid, SalesForce, Google, AT&T, and other cloud providers, will possibly not agree with an easy and standardized manner to export/import such cloud configurations. Obviously that cloud providers are not interested to give total freedom to their clients in an straightforward manner in changing providers, and also do not want to open direct "competition" with other companies.
- Each cloud provider offers differentiated services, and want to have special "products" or services to attract more customers. A common standard may regulate them. However, the standard ensures under European regulation a core basic requirement for future software systems, since frameworks need to be accessible from competing vendors as well as customers.

Based on these inquiries, it can be derived that cloud computing needs a common and more basic approach of interacting with its offered services and resources. It does not mean that proprietary solutions will vanish or be limited. Basically, the first standardization shall address *cloud core capabilities* or *cloud core features* (Figure 1). These basic functions inside a cloud, like the management and provision of virtual resources, storage, or network components, reach a central importance level. Thus, on one hand, an extensive research among actual cloud providers has to be done to extract key and more interesting core functions. On the other hand, cloud providers will still have the opportunity to add proprietary functions, but not touching these *cloud core capabilities* and making it clear what are those proprietary values added on its APIs.

When working toward cloud standards, it is also important to take into consideration that, usually, as more the XaaS stack[1] moves up, more the API turns service-dependent. It is more straightforward to come up with standards to the low-level cloud concept (IaaS), than PaaS (Platform as a Service) or SaaS. In this way, efforts have to be undertaken to distinguish which features or common characteristics should be interesting to standardize in each level.

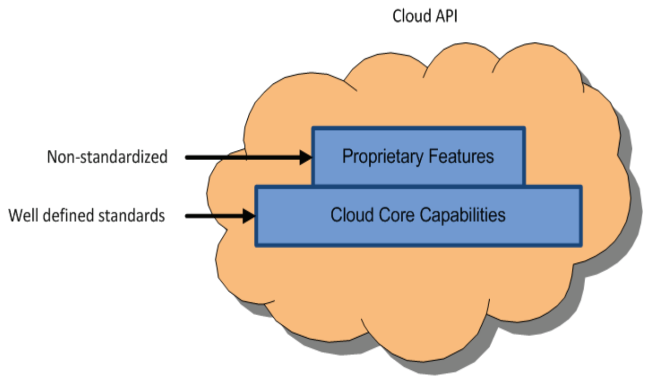

Figure 1: Cloud Core Capabilities as the Base for Cloud APIs

At last, envisaging to respect SLA and accounting across boundaries, standards to build cloud federations are necessary. Some work in this field could be taken from grid computing due to similarities [17]. But still, prior basic concepts should be consolidated first in order to the research on standardization evolve to a higher stage as federated clouds.

4 Related Work

There are some initiatives in the area of standards for cloud computing, but it seems that none is focused on building standards with a defined separation between core and proprietary functionalities in mind. Nonetheless, most of the current work is focusing IaaS manageability [7], [13], but also there are efforts on standardizing virtual resources [6], security [11], data management [14], and interoperability between clouds [5], [12]. Such initiatives are important to a common interface between clouds and cloud features. It is valid to fully describe the following:

- **DMTF's Open Cloud Standards Incubator (OCSI)** focuses on standardizing interactions between cloud environments by developing cloud resource management protocols, packaging for-

1. XaaS is commonly used to express "anything/something" as a service. For example, it is the general term of expressing IaaS, PaaS, or SaaS (Infrastructure, Platform, and Software as a Service). In this case, the meaning of a "XaaS stack" determines an abstract representation, where IaaS, PaaS, and SaaS are those layers, from the low to the highest level, respectively.

mats and security mechanisms to facilitate interoperability [5].

- **The Open Cloud Computing Interface Working Group (OCCI-WG)** develops mainly a practical specification related to IaaS. It focuses on a solution that covers the provisioning, monitoring, and definition of cloud infrastructure services [13]. Seems the most advanced specification nowadays considering IaaS.
- **Cloud Data Management Interface (CDMI):** specifies a functional manner on how applications create, retrieve, update, and delete data elements from the cloud [14].

5 Preliminary Conclusions

Despite of various initiatives related to interoperability and standards in the area of cloud computing, there is still no widely acceptance on a common cloud definition nor standards. This characteristic is considered normal when discussing aspects of a technology in its infancy [16].

However, a fundamental step towards a wide acceptance is the necessity. Customers and cloud providers should to map use cases (scenarios) where the lack of standards turn the process critical. Therefore, such use cases should be quantified in terms of costs envisaging how much resources both customers and cloud providers may save.

Moreover, the distinction of core and proprietary functionalities seems to be the key for the adoption of cloud standards. Not only customers will benefit from this distinction, but also cloud providers which would have the possibility to provide basic standards and provide proprietary solutions on the top of core functionalities/resources. An example related to this fact can be noted in the aforementioned Load Balance component. The cloud provider can offer an optimized way (with a proprietary algorithm) to a better traffic management on virtual machine instances. However, some parameters have to be set. In this case, the income traffic to *domain.com*, port 80, should be balanced using virtual machines VM-1 to VM-*n*, possibly using some other policies. The manner of how to express these parameters must be standardized, and the relation between them. Nevertheless, a separation (clear distinction) of core and proprietary categories may require some heavy effort from both industry and academia.

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