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Architecture and protocol for intercloud communication

Jaime Lloret [a,*], Miguel Garcia [a], Jesus Tomas [a], Joel J.P.C. Rodrigues [b]

[a] Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Universidad Politècnica de Valencia, Spain
[b] Instituto de Telecomunicações, University of Beira Interior, Portugal

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ABSTRACT

A cloud does not have infinite computational and storage resources in its infrastructure. If it saturates, it will not be able to satisfy new requests for service allocations sent by its customers. Clouds should interrelate through networking protocols in order to provide scalability, efficiency and flexibility by using the services and the computational and storage resources of the infrastructures of other clouds. In this paper we describe an architecture and protocol that allows exchanging information, data, services, computing and storage resources between all interconnected clouds. It is highly scalable and permits to add new clouds easily, while tries to balance the load of the nodes involved in the intercloud communication. Our protocol design includes node discovery, authentication and fault tolerance. We show the protocol operation and provide the performance results in a controlled test bench. A comparison of our architecture and protocol with other published intercloud architecture proposals shows the benefits of implementing this new architecture in the real world.

1. Introduction

Cloud computing is an infrastructure that is able to deliver different levels of services, by using many type of platforms and sharing the resources inside of it, to customers outside the cloud (over the Internet). The offered services can be dynamically configured (via virtualization or other approaches) and delivered on demand to the external customers, and it is massively and dynamically scalable. It allows a location/device/host independent computing in which it does not matter where is placed the information and where the computation and processing is taking place, so information and computing is available anywhere and anytime in the Internet.

Cloud computing must be distinguished from grid computing. Although clouds and grids share many common features, such as architecture and technology, they differ in several aspects such as security, programming model, business model, compute model, data model, and type of user applications [16].

One of the main objectives of cloud computing is to provide several standalone services, that currently exist on a personal computer, through a simple web browser [2]. In the very beginning of the appearance of cloud computing, there were few services available. But, along the years this number is increasing and a wide range of services is appearing [28].

There are several works that explain in detail the most important concepts associated with cloud computing and analyze the layered model of cloud computing, which is based on five layers: Cloud Application Layer, Cloud Software Environment Layer, Cloud Software Infrastructure Layer, Software Kernel Layer and Hardware/Firmware Layer [9].

* Corresponding author. Tel.: +34 609549043.
E-mail addresses: jlloret@dcom.upv.es (J. Lloret), migarpi@posgrado.upv.es (M. Garcia), jtomas@dcom.upv.es (J. Tomas), joeljr@ieee.org (J.J.P.C. Rodrigues).

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Cloud computing has several advantages and drawbacks, which provokes proponents and detractors. On one hand, providing services to end-users using Internet helps to improve small and medium enterprises [24]. These companies may provide more cloud-based services and may take larger potential market. In addition, final users will only pay for the used services without having to worry about purchasing the hardware or software required to perform these tasks. Therefore, their potential only depends on their intellectual capabilities and not on their infrastructure. On the other hand, the main observed problem is the high grade of centralization from the organizational and architecture perspective. The centralization of resources was abandoned due to the improvements made by other architectures. Moreover, there are also other problems, for instance: the dependence of the applications proposed by the companies, the services can solve the needs of many end users, etc.

As we can see both sectors are partly right, for that reason in Table 1 we see the main advantages and drawbacks of the services offered by cloud computing [26].

One issue to take into account in cloud computing is its architecture [1]. In most cases it is a centralized architecture with all the benefits and drawbacks of these architectures. From the viewpoint of network topology is not debatable that the centralization of many resources over Internet is a problem, but it lacks of fault tolerance and causes a bottleneck.

One of the most important problems in the cloud computing is the security. It is being studied widely by the scientific community. Subashini and Kavitha explain that the security issues reduce the growth of cloud computing. In [31], they characterized the security threats by the cloud computing service delivery. In order to avoid the security weakness in cloud computing, Zissis and Lekkas propose to introduce a trusted third party solution based on cryptography, specifically Public Key Infrastructure operating in concert with Single-Sign-On and LDAP (Lightweight Directory Access Protocol), to ensure the authentication, integrity and confidentiality of the data and the communication [37]. There are other techniques to increase the security of cloud computing such as using virtualization because it can protect both the integrity of guest virtual machines and the cloud infrastructure components [23].

Many clouds coexist in Internet (Google, IBM, Microsoft, etc.), each one performing its own protocol. There are also appearing new service platforms to take advantage of these clouds (Microsoft Azure, Joyent Accelerators, Google App Engine, Sun Project Caroline, etc.). Some governments are taking advantage of cloud computing benefits [34], and some institutions, such as the University of Westminster, make use of its flexibility and let them to save costs [32]. Each cloud could have different logical topology, although the devices could be in the same physical place.

From the business point of view, cloud computing provide many strengths and opportunities [24], so economic benefits are also obtained. An internetworking between clouds will also increase the benefits to the customer and decrease the economic costs of each cloud because more services and resources will be available to the customers.

Therefore, in this paper we present a new architecture and protocol for intercloud communication which will allow sharing resources, services or data between clouds. It is highly scalable and permits to add new clouds easily, while tries to balance the load of the nodes involved in the intercloud communication. Our protocol design includes node discovery, authentication and fault tolerance. The proposed intercloud architecture satisfies the following objectives:

- Each cloud should be able to work and offer its services without any dependence with other clouds.
- Resources, services and data are shared through the intercloud architecture.
- The intercloud architecture is scalable and able to add new clouds.
- The availability of the resources, services and data should not depend on the customeŕs applications.
- The architecture should be able to support the load given by the traffic exchanged between clouds.

The rest of the paper is structured as follows. Section 2 describes some related works on internetworking between clouds. Section 3 discusses the main design issues to take into account for intercloud communication. Our architecture is described in Section 4. Section 5 shows the analytical models of the proposed architecture. The protocol operation and fault tolerance is detailed in Section 6. Section 7 provides some simulations and a test bench with the performance test of our proposal. A

Table 1
Advantages and drawbacks of cloud computing.

Advantages	• Access to the information and services anywhere
	• Service availability and/or web application 24 h/7 days/365 days
	• Accessibility supported by different technologies, such as PDAs, smart phones, laptops, and notebooks
	• Free and paid services according to the user needs
	• Unsaturation hard disk usage on the computer or application used, because they only need a web browser, and Internet
	• Large and dynamic scalability for companies
	• Higher processing and storage capacity without installing local machines
Disadvantages	• Third parties could access all the information
	• Dependence on the online service features (availability, speed, etc.)
	• The difficulty for end-users to find and select trustworthy or reputable cloud providers/services amongst the numerous available ones
	• In most cases it is a centralized architecture
	• Lose control of the handling, storage and use of this information