The New Cloud Computing Paradigm: the Way to IT seen as a Utility

Carlos Rodríguez Monroy[1], Carlos Almarcha Arias[2], Yilsy Núñez Guerrero[3]

Abstract - In the present competitive environment, companies are wondering how to reduce their IT costs while increasing their efficiency and agility to react when changes in the business processes are required. Cloud Computing is the latest paradigm to optimize the use of IT resources considering "everything as a service" and receiving these services from the Cloud (Internet) instead of owning and managing hardware and software assets. The benefits from the model are clear. However, there are also concerns and issues to be solved before Cloud Computing spreads across the different industries. This model will allow a pay-per-use model for the IT services and many benefits like cost savings, agility to react when business demands changes and simplicity because there will not be any infrastructure to operate and administrate. It will be comparable to the well known utilities like electricity, water or gas companies. However, this paper underlines several risk factors of the model. Leading technology companies should research on solutions to minimize the risks described in this article.

Keywords - Cloud Computing, Utility Computing, Elastic Computing, Enterprise Agility

INTRODUCTION

Currently, companies and other organizations need to reduce their IT costs to improve their profit and competitiveness but at the same time they must increase their efficiency and agility to react when changes in the processes are required. Cloud Computing is the latest paradigm to provide IT services to the organizations considering "everything as a service". These services are delivered through the networks to the users from a pool of shared resources hosted usually by a Cloud service provider. This is the opposite to the traditional IT model where organizations own and manage their hardware and software assets. The benefits from the model are clear, but there are also concerns and issues to be solved in order to spread the use of Cloud Computing by a significant number of organizations in the world.

Mel and Grance (2009) define the model in the following way: "Cloud computing is a pay-per-use model for enabling available, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction".

The interest of users and organizations on Cloud Computing has grown very fast since 2004 until 2011 with some trend to flatness in 2012. This analysis suggests the maturity that this model is reaching.

One of the significant opportunities of cloud computing lies in its potential to help developing countries reap the benefits of information technology without the significant upfront investments that have stymied past efforts. Moving to the cloud enables organizations to not only reduce their IT infrastructure, but also represent a more intelligent use of this infrastructure (Marston et al., 2011).

[1] Carlos Rodríguez Monroy: PhD in Industrial Engineering, Professor and researcher at the Technical University of Madrid (UPM). Coordinator of Doctoral Program in Business Administration. E-mail: crmonroy@etsii.upm.es

[2] Carlos Almarcha Arias: PhD in Industrial Engineering, Associate Professor and Researcher at the Technical University of Madrid (UPM). Management Information Systems professor. Email: carlos.almarcha@upm.es

[3] Yilsy Núñez Guerrero: Business Administration graduate. Doctoral student at the Technical University of Madrid (UPM). Email: yilsy.nunez.guerrero@alumnos.upm.es

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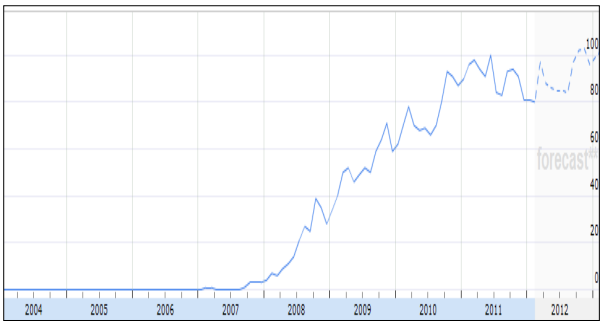

Figure 1. Average worldwide traffic of "Cloud Computing" in all years updated Feb 2012 (Source: Google data base)

CLOUD COMPUTING HISTORY AND DIFFERENT MODELS

Before Cloud Computing became popular other similar models were proposed in the past like the so-called Network Computing in the mid-1990s. This model was too theoretical and did not work simply because the necessary underlying technologies to sustain the services were not sufficiently mature.

Perhaps, the first reference to Cloud Computing was made by Eric Schmidt CEO and Chairman of Google during the Search Engine Strategies Conference on August 9, 2006. Here is a fragment of the comments:

"…What's interesting [now] is that there is an emergent new model, and you all are here because you are part of that new model. I don't think people have really understood how big this opportunity really is. It starts with the premise that the data services and architecture should be on servers. We call it Cloud Computing – they should be in a "cloud" somewhere. And that if you have the right kind of browser or the right kind of access, it doesn't matter whether you have a PC or a Mac or a mobile phone or a BlackBerry or what have you – or new devices still to be developed – you can get access to the cloud. There are a number of companies that have benefited from that. Obviously, Google, Yahoo!, eBay, Amazon come to mind. The computation and the data and so forth are in the servers."

After the conference, the term become generally accepted by other important players in the IT services world like Amazon, who used the same words to describe their new service EC2 launched on August 24, 2006, just a couple of weeks after the Schmidt's speech.

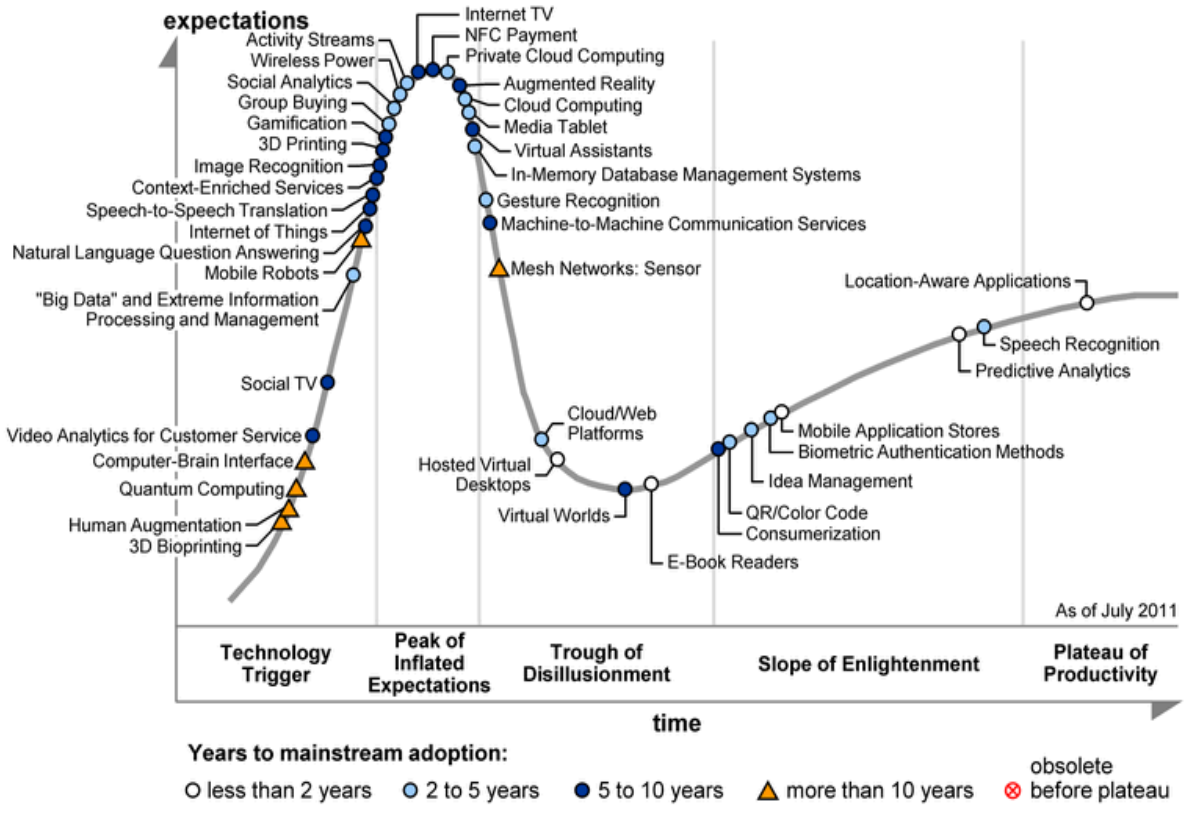

Figure 2. Hype Cycle for emerging technologies. Source: Gartner Group (2011)

According to the Gartner Group (2011) the enthusiasm for a new technology follows a path like the one shown in the Figure 2. After the launch and introduction of a new technology there is a fast ramp where it gains visibility across the market. After that, there is an inflection point where the perception is that the expectations were too inflated. This is followed by a period of time of disillusionment until the market recognizes the real value.

There are three main service types of Cloud Computing:

1. Cloud Software as a Service (SaaS). Use provider's applications over a network

2. Cloud Platform as a Service (PaaS). Provide a computing platform and a solution stack as a service. Usually this solution stack consists of software for application development.

3. Cloud Infrastructure as a Service (IaaS). Rent processing, storage, network capacity, and other fundamental computing resources.

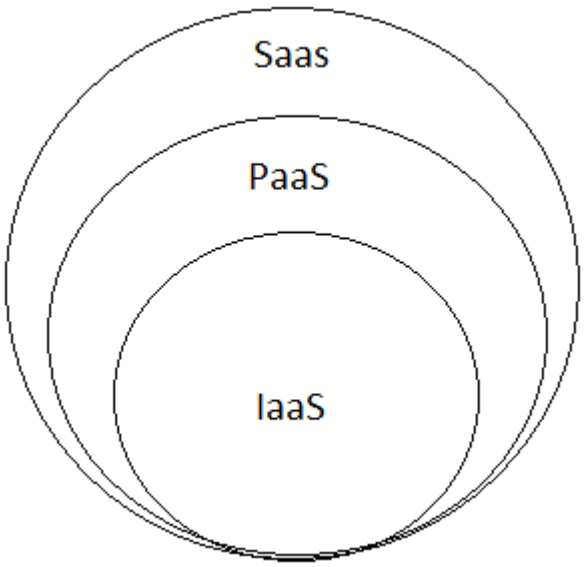

Figure 3. Types of services under the Cloud Computing model. Source: Granneman (2009).

CHARACTERISTICS AND BENEFITS OF THE CLOUD COMPUTING MODEL

The main characteristics of the model are the following:

- On-demand self-service. The services can be activated o deactivated by the users in a simple way through a web portal.
- Ubiquitous network access. The users are able to access the services everywhere. They just need a device with a web browser and an Internet connection.
- Location independent resource pooling. It does not matter where the infrastructure to deliver the Cloud Services is physically located. The location is transparent for the users who receive the services from Internet.
- Rapid elasticity. The contracted capacity can be increased or decreased by the user according to the business needs at any time. This is a key factor to gain agility and synchronize the IT resources to the business needs.
- Pay-per-use. The users pay for the services based on the consumption. This is very different from the traditional model where the organizations had to invest in hardware and software assets. Additionally they had to pay for operational expenses (OPEX) like maintenance contracts and administration costs.

With Cloud Computing, many small and medium companies will be able to access IT services previously inaccessible for them under the traditional model. For example, let us consider an application of CRM (Customer Relationship Management System). Many small companies usually have an insufficient budget to afford investing on the application, servers, network elements plus the expenses to maintain, operate and administrate the new hardware and software. With Cloud Computing any company, large or small, can activate a CRM service online and benefit from this type of applications without making any investment in infrastructure. This means that small and medium companies will be able to compete better with large companies by using similar resources and applications like a CRM.

Large companies will benefit also from Cloud Computing because they will reduce costs and will gain competitiveness. The cost of contracting a new IT service from a cloud service provider is much lower than investing on hardware and software assets.

Finally, agility is another important benefit. When a decision to deploy a new application is made, it usually takes months to establish a budget, select the vendors for new hardware and software, negotiate prices, launch the orders and install and test the new systems. In Cloud Computing the service is provided almost instantaneously when it is contracted with a

Cloud service provider and this enhances enterprise agility.

The advent of Cloud Computing represents such a situation, and the success of this computing paradigm will depend to a large extent on how the regulatory bodies – both national and international – design laws to regulate it (Marston et al, 2011).

There are three types of Clouds:

- Public Clouds. These Clouds are hosted by service providers offering public services to any organization who wants to contract them.

- Private Clouds. Some companies, especially large ones, try to benefit from the Cloud Computing model maintaining control of data and infrastructure. They deploy private Clouds in their own data centers. Deploying this type of clouds the companies have to make investments as well as expenses for maintenance, operations and administration.

- Hybrid Clouds. In this case part of the services is delivered from public service providers and part of the services is provided from a local private Cloud. The criteria to decide the type of Cloud depends mainly on how critical the service is. When the service is very critical or the data are sensitive then the private Cloud should be the choice.

Some examples of real Cloud Computing services are the following:

Cloud Computing services from Amazon

The Cloud Computing services from Amazon include Amazon S3 for storage, Amazon EC2 for hosting and SimpleDB for database. Amazon EC2 (Amazon Elastic Compute Cloud) is a web service that provides resizable computing capacity in the cloud. It is designed to make web-scale computing easier for developers.

Amazon EC2's simple web service interface allows the user to obtain and configure capacity with minimal friction. It provides a complete control of the computing resources and lets him or her run on Amazon's proven computing environment. Amazon EC2 reduces the time required to obtain and boot new server instances to minutes, allowing the user to quickly scale capacity, both up and down, as the computing requirements change. Amazon EC2 changes the economics of computing by allowing the user to pay only for capacity that is actually used. Amazon EC2 provides developers the tools to build failure resilient applications and isolate themselves from common failure scenarios.

Salesforce.com

Salesforce.com is a company focused on CRM solutions (Customer Relationship Management) on demand. Their customers do not have to purchase hardware and software. Just a connection to Internet and they have access to the application without any need of purchasing, installing, configuring and managing hardware and software. They just make a subscription and they have a quick access to the CRM application. The new service can be fully operative in days or weeks instead of the months or even years needed to deploy a CRM application inside a company. When the CRM service is not needed the subscription can be cancelled. Salesforce.com was founded in 1999 by an executive of Oracle, Marc Benioff, pioneer in offering enterprise applications from a website.

HP Cloud Assure

On April 27, 2009 HP announced HP Cloud Assure, a new solution composed by software and services the merging concepts of Storage as a Service (SaaS) and Cloud Computing. According to the market research company International Data Corporation (IDC), the three basic pillars for success in Cloud Computing are security, performance and availability, and these are the areas addressed by HP. The solution includes three applications from the software division of HP but offered as a service through Internet instead of buying software licenses: HP Application Security Center, HP Performance Center and HP Business Availability Center:

- Security: Analyzing networks, operating systems, layers of middleware and web applications. It performs also tests to identify potential vulnerabilities and risks. Therefore, data from providers and consumers is safe.

- Performance: Assuring the Cloud Computing services meet the connectivity and bandwidth requirements of the end user. This helps to control the service level agreements to improve the end user satisfaction.

- Availability: Monitoring the applications availability on the Cloud to isolate potential issues and analyze the root causes of any incident as soon as possible.

Google Apps Engine

This is a tool launched by Google for developers enabling them to run web applications on Google's infrastructure. This will allow startups to use Google's web servers, APIs (Application Programmable Interfaces), and other developer tools to build a web application. Google App Engine is similar to the Amazon Web Services stack, which rolled out at the end of 2006 and has since gone on to be utilized by many startups for their infrastructure needs. But it is not a set of stand-alone services like Amazon's - which includes S3 for storage, EC2 for hosting and the SimpleDB database. Google App Engine is an end-to-end service and bundles everything into one package. It was launched as a beta pilot with 10,000 developers and during the preview period the resources are limited to 500MB of storage, 200M megacycles of CPU per day, and 10GB bandwidth per day.

INHIBITORS AND RISKS FOR THE CLOUD COMPUTING MODEL ADOPTION

The main inhibitors for the Cloud Computing adoption will be the risk factors associated to this model:

1. Service levels – Can the service provider meet the business needs for network and application availability?

Owning and keeping the IT assets inside the company provides much better control of data and infrastructure. In the case of Cloud Computing the users must rely on the service level agreements signed with the service provider.

2. Workloads – Are they suitable for Cloud Computing?

For very heavy workloads, the networks and the service provider infrastructure could be a bottleneck to provide the right application response times.

3. Complexity – Difficult to manage for a Cloud provider?

Again, the Cloud Computing model means more complexity for the service provider. The services have to be activated online and measured for the pay-per-use. On the other hand the pool of hardware and software resources at the service provider side is multitenant. This means that servers, disks, applications, etc. are shared by multiple users and that means additional complexity.

4. Network Latency – Affects end-end service experience

A successful service based on Cloud Computing requires low network latency. If the network is slow the final user experience will not be satisfactory. At the end Cloud Computing is "everything as a service" and the services are delivered through the networks. A poor network performance will impact on the service.

5. Lock-in – How easy is it to migrate from one provider to the next?

Sometimes it can be difficult for a company to migrate a service from one service provider to another. This could be a barrier that makes the companies feel uncomfortable.

6. Regulations – Where does the data reside?

When a company contracts any of the possible Cloud Computing services the data are stored remotely and many times in a foreign country. In some countries there are regulations concerning data management which forbid moving sensitive data out of the country's borders.

7. Security – Who will have access?

When the data are stored at the facilities of the Cloud Computing service provider the user has no control of who has access to the data. He must trust that the Service Provider has the right processes and tools to guarantee data protection.

8. Financial stability – How stable is the provider?

A service provider with a bad financial situation could put at risk the future service continuity forcing a migration to another service provider. This is an undesirable risk for any organization.

The discussion makes it clear that there remains a significant number of challenges that need to be addressed before Cloud Computing becomes robust enough for large enterprises. It is also clear that not all applications are currently ripe for moving to the Cloud. General-purpose applications such as office, e-mail or collaboration technologies are prime candidates, since there are rarely any instances of application requirements in such technologies that are specific only to an organization (Marston et al., 2011).

CLOUD COMPUTING IN EDUCATION

In the current financial crisis, and being challenged by rising needs, educational institutions are facing problems in providing necessary Information Technology (IT) support for educational, research and development activities **(**Microsoft, 2010).

The use of Cloud Computing becomes a necessity and not an option for many universities. This aspect is due to a multitude of factors such as cost increases, the pressure of income increase, students' success, institutional performance and competition in development (Sasikala and Prema, 2010).

The use of the Cloud Computing model by educational institutions can be analyzed from two different points of view:

1. The first one is related to the IT services supporting the normal internal processes like student registration, websites or employees payroll. Traditionally these types of services have been provided with hardware and software infrastructure hosted by the internal IT department and administered by technicians and experts who are normally employees of the institution.

2. The second point of view is regarding the applications needed for educational and research activities. Here we can think of programs for simulation, computer aided design, intensive mathematic calculus or modeling. In this case teachers and researchers are normally in charge of installing and maintaining the educational applications. This means that they must dedicate part of their very limited time to computers administration tasks instead of focusing on their core functions as teachers and researchers.

The integration of computers in education changes the whole ecology of a school. The average school has 1 computer per 20 students, a ratio that computer educators feel is still not high enough to affect classroom learning as much as books and classroom interaction (Gupta, 2012).

Cloud Computing offers the educational institutions the opportunity to concentrate more on teaching and research activities rather than on intricate IT configuration and software systems management. The educational institutions can significantly curtail expense of software licensing and reduce the campus IT staff. The educational institutions without the required hi-tech educational software can utilize it from the surrounding educational institutes which will not only lead to a better utilization of resources but to financial and human resources savings as well (Deka and Dutta, 2012; Gupta, 2012).

The use of Cloud Computing in the case of education has the following features:

- In the Cloud all types of users at all levels can quickly and easily find the resources as well as the corresponding functions that can be centrally controlled.
- Standardization, classification, edition and control by the user. This is required for building the sustainability of the repository.
- All information and data are in the Cloud. There is no need to retain and backup locally.
- Computers improve both teaching and student achievement.
- Computer literacy should be taught as early as possible, otherwise students will be left behind.
- Technology programs support from the business community is badly needed today because schools are increasingly short of funds.
- To make tomorrow's workforce competitive in an increasingly high-tech world, learning computer skills must be a priority.
- Working with computers - particularly using the Internet - brings students valuable connections with teachers, other schools and students, and a wide network of professionals around the globe. Those connections spice the school day with a sense of real-world relevance, and broaden the horizon of the educational community (Deka and Dutta, 2012; Gupta, 2012).

There are certain benefits from Cloud Computing like:

- Lower costs, robust service.
- Institutional branding (school, college or university) as we have domain e-Mail IDs with the school/college/university name as suffix
- Quick & Effective Communication.
- Global collaboration: Collaboration tools lead to collective intelligence and creativity as students may work on their project document at the same time.
- It helps teachers (and students) in organizing their classroom presentations and schedules.
- No maintenance cost.

- Security will be taken care of by the provider.
- Privacy: Google Apps is in compliance with FERPA (Family Educational Rights and Privacy Act).
- Easy to deploy.

However, one must consider that the improvement of Cloud Computing services in education should be analyzed from the point of view of the benefits and the limitations (Table 1).

Table 1. Main Benefits and Limitations of Using Cloud Computing in Education. Adapted from Mircea and Andreescu (2011).

Benefits	Limitations
New technologies more available to students	Lack of confidence
Free software or pay-per-use	Maturity of solutions
Opening to business environment and advanced research	Speed/lack of Internet can affect work methods
Increasing functional capabilities	Standards adherence
24-hour access to infrastructure and content	Risks related to data protection and security and accounts managements
Protection of the environment by using green technologies	Dissemination politics, intellectual property
Access to applications from any location	Security and protection of sensitive data
Support for teaching and learning	Not all applications run in the Cloud

Cloud Computing is a network of computing resources including hardware and software which can be shared to bring to education a variety of options not found in traditional IT models. This model provides also answers to many of the challenges faced today by the educational institutions. Integrating the software and assets owned by an organization with software and services from the Cloud provides an organization with the new choices for balancing system management, cost and security and at the same time helps to improve the quality of service (Gupta, 2012).

Currently many universities and other educational institutions are considering this model for some software applications like ERPs (Enterprise Resource Planning), database management systems or CAD (Computer Aided Design). This will reduce their dependency from the internal IT department facilitating at the same time the access to specific software and hardware resources not available inside the organization.

However, a recent study with respect to using Cloud Computing in higher education, shows that universities may still be found in the phase of ”early adopters” next to other sectors, such as commercial and governmental. The Cloud-based applications will also have to cross the threshold in terms of security and reliability either actual or perceived of their traditional counterparts (Katz et al., 2010; Marston et al, 2011).

Cloud Computing in Education: Examples and Additional Resources

As already explained, Cloud Computing is a valuable tool for its ability to transform education. It should be understood as a service that may be available anytime, anywhere, and be accessed from any device. In order to appreciate its value in this field the following examples are given (Intel Corporation, 2010).

• **Laboratory for Continuing Education in Mathematics in Saint. Petersburg, Russia** This project which is supported by a grant from HP Innovations in Education, connects students with researchers, offering them the opportunity to experience professional research practices while they improve their own technical skills. Students work with researchers in both the scientific and professional fields.

• **Cloud Computing Infrastructure and Technology for Education (CITE)** this project, seeks ways to use Cloud Computing resources to execute scientific research, both in laboratories and in university classrooms.

• **Clarkstown Central School District** uses Google Apps to coordinate curricula and resources in schools and throughout the district. Innovative uses of calendar, shared documents and shared sites make it easy for teachers to follow district curriculum plans, disseminate school-related events, and create and share curricular resources.

• **The TeacherTube** Cloud-based video is a replica of YouTube, but was designed specifically for teachers, schools and home educators. It offers a range of educational videos with various themes.

• **School District in Eagle in Colorado** is implementing a Cloud Computing system that will provide tools for e-mail, word processing, presentations and calendars for the whole district (Intel Corporation, 2010).

CONCLUSIONS

Cloud Computing is a new paradigm where the organizations will receive the IT services from the Cloud through the networks instead of having the traditional infrastructure of servers, software applications, storage and networks inside the institution. This model will allow flexibility and the possibility of pay-per-use model for the IT services. It will offer many important benefits like cost savings, agility to react when changes in processes are required and simplicity because there will not be any infrastructure to operate and administrate. It will be comparable to the well-known utilities such as electricity, water or gas companies.

The model can be used to address tactical problems with which IT continually deals, like resource availability and lack of IT skills inside the organization.

Particularly, in the case of the educational institutions, the Cloud Computing model could help to improve the efficiency reducing at the same time the IT costs. The model could be used not only to support the normal internal processes like student registration or personnel payroll but also to provide applications for teaching and research activities without any need of infrastructure like computers, applications or IT specialists.

This paper has underlined several risk factors and leading technology companies should continue investing in the development of new solutions to minimize the risks mentioned.

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