

Using Cloud Computing for E-learning Systems

PAUL POCATILU, FELICIAN ALECU, MARIUS VETRICI

Economic Informatics Department

Academy of Economic Studies

6 Piata Romana, Secot 1, Bucharest

ROMANIA

ppaul@ase.ro, alecu.felician@ie.ase.ro, mariusvetrici@softmentor.ro

Abstract: - Cloud computing is growing rapidly, with applications in almost any area, including education. E-learning systems usually require many hardware and software resources. There are many educational institutions that cannot afford such investments, and cloud computing is the best solution. This paper presents the positive impact of using cloud computing architectures upon e-learning solutions development. It focuses on the benefits of cloud computing for e-learning solutions and the e-learning project management challenges when this architecture is used.

Key-Words: - Cloud computing, E-learning, Mobile learning, Project management

1 Introduction

During the last years, the nature of the Internet was constantly changing from a place used to read web pages to an environment that allows end-users to run software applications. Interactivity and collaboration have become the keywords of the new web content.

There is no doubt the future belongs to the Web 3.0 (also called the intelligent Web) [1]. This new environment supports the creation of a new generation of applications that are able to run on a wide range of hardware devices, like mobile phones or PDAs, while storing their data inside the cloud.

The need for education is increasing constantly and the development and the improvement of the e-learning solutions is necessary.

Also, the e-learning systems need to keep the pace with the technology, so the new direction is to use cloud computing.

There are several cloud computing services providers that offer support for educational systems. Among them are Amazon, Google, Yahoo, Microsoft etc.

In [2] are presented the main advantages of using cloud computing in schools.

The following sections focus on cloud computing concepts and the benefits of cloud computing for e-learning solutions. Also, the impact on e-learning solutions based on cloud computing project management is analyzed. This is very important for the development of e-learning solutions based on cloud computing.

2 Cloud Computing

The *cloud computing* term was derived from the way the Internet is often represented in network diagrams. Due to the fact it involves the existence of data centers that are able to provide services, the cloud can be seen as a

unique access point for all the requests coming from the world wide spread clients (see figure 1).

Cloud computing comprises of three layers [5]:

- infrastructure as a service (IaaS)
- platform as a service (PaaS)
- software as a service (SaaS)

Depending on the requirements, the customers can choose one or more services provided.



Fig. 1 Cloud computing

Hardware devices (such as regular PCs, notebooks, mobile phones, PDAs or any other similar equipments)

or software applications (like web browsers, for example Google Chrome) can successfully play the role of a cloud client (see figure 2). The customers are renting or simply accessing the needed processing capacity from the data center using the above mentioned client applications. The quality of the service becomes a crucial factor of the cloud computing success.

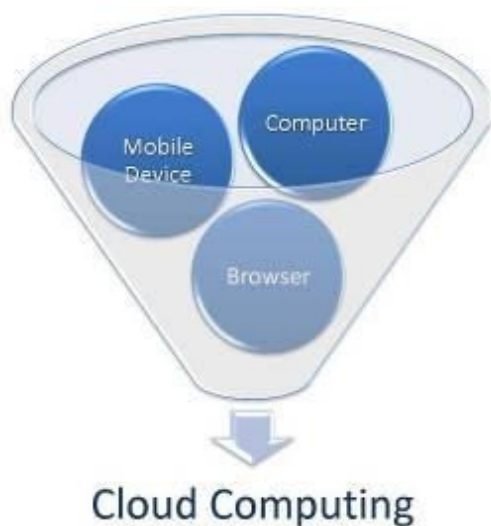


Fig. 2 Cloud computing clients

Cloud computing is by no means different from grid computing. The latter tries to create a virtual processor by joining together a cluster of computers. The aim of a grid computing architecture is to solve large tasks by using the advantage of concurrency and parallelism, while the cloud is focused on collaboration.

Cloud computing becomes very popular because it moves the processing efforts from the local devices to the data center facilities. Therefore, any device, like an Internet connected phone, could be able to solve complex equations by simply passing the specific arguments to a service running at the data center level that will be capable to give back the results in a very short time. In these conditions, the security of data and applications becomes a very major issue.

Cloud computing is widely accepted today due to its key advantages:

- the cost is low or even free in some cases. Also, there are no costs (or very small ones) for hardware upgrades;
- for some applications (like spreadsheets) it can be used even in the offline mode, so when the client goes back online a synchronization process is refreshing the data;
- the strong connection that exists today between the users and their personal computers can be completely broken because a customer can reach the same result by using any Internet connected device having minimum software requirements;

- devices with minimal hardware requirements (mobile phones, for example) could be successfully used as cloud clients;
- in order to become part of the cloud, there is no need to download or install a specific software, only the Internet connection is required;
- the cost of licensing different software packages is moved to the data center level, so there is no need to upgrade the local system when new service packs or patches are released;
- crash recovery is nearly unneeded. If the client computer crashes, there are almost no data lost because everything is stored into the cloud.

Some of the main cloud computing disadvantages are the following:

- the Internet connection speed may affect the overall performances;
- on a long term basis, the data center subscription fee may be more expensive than buying the hardware;
- the service quality is crucial and the need of the backups is critical when speaking about data security.

The major players in the field of cloud computing are Google, Microsoft, Amazon, Yahoo and some legacy hardware vendors like IBM and Intel. Cloud Computing applications are mainly intended to help companies and individuals to stretch resources and work smarter by moving everything to the cloud.

One of the biggest promoters of the cloud computing is Google that already owns a massive computer infrastructure (the cloud) where millions of people are connecting to. Today, the Google cloud can be accessed by Google Apps [6] intended to be software as a service suite dedicated to information sharing and security. Google Apps covers the following three main areas: messaging (Gmail, Calendar and Google Talk), collaboration (Google Docs, Video and Sites) and security (email security, encryption and archiving).

Microsoft is developing a new Windows platform, called Windows Azure, which will be able to run cloud based applications [7].

In 2006, Amazon extended its AWS (Amazon Web Services) suite with a new component called Amazon Elastic Compute Cloud (or EC2), that allows to the users to rent from Amazon processing power to be used to run their own applications [8]. The EC2 users rent out from Amazon virtual machines that can be accessed remotely. The cloud is an elastic one just because the user can start, stop and create the virtual machines through the web service. There are three predefined sizes for the virtual machines that can be rented: small, medium and large, depending on the physical hardware performances.

3 Cloud Computing Benefits for E-learning Solutions

Many education institutions do not have the resources and infrastructure needed to run top e-learning solution. This is why Blackboard and Moodle, the biggest players in the field of e-learning software, have now versions of the base applications that are cloud oriented.

E-learning is widely used today on different educational levels: continuous education, company trainings, academic courses, etc.

There are various e-learning solutions from open source to commercial. There are at least two entities involved in an e-learning system: the students and the trainers.

The students:

- Take online course
- Take exams
- Send feedback
- Send homework, projects

The trainers:

- Deal with content management
- Prepare tests
- Assess tests, homework, projects taken by students
- Send feedback
- Communicate with students (forums)

Usually, e-learning systems are developed as distributed applications, but this is not necessary so. The architecture of a distributed e-learning system includes software components, like the client application, an application server and a database server (see figure 3) and the necessary hardware components (client computer, communication infrastructure and servers).

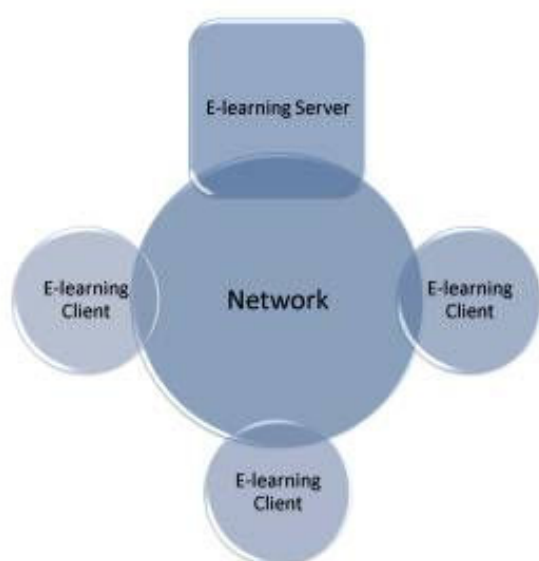


Fig. 3 E-learning system

The client hardware could be a mobile device or a

desktop computer. The client application can be a simple web browser or a dedicated application.

Even with the current hardware and software limitations, mobile devices are supporting multimedia based applications. Compared with desktop applications, nowadays mobile applications, especially multimedia-based applications, have serious limitations due the processing power and memory constraints. Due the fact that the data processing is on the server side, the use of mobile devices for learning is growing fast. Still, the mobile applications need to be optimized to be used for e-learning. In [3] and [17] the m-learning applications characteristics were analyzed.

The e-learning server will use cloud computing, so all the required resources will be adjusted as needed.

E-learning systems can use benefit from cloud computing using:

- Infrastructure: use an e-learning solution on the provider's infrastructure
- Platform: use and develop an e-learning solution based on the provider's development interface
- Services: use the e-learning solution given by the provider.

A very big concern is related to the data security because both the software and the data are located on remote servers that can crash or disappear without any additional warnings.

Even if it seems not very reasonable, the cloud computing provides some major security benefits for individuals and companies that are using/developing e-learning solutions, like the following:

- improved improbability – it is almost impossible for any interested person (thief) to determine where is located the machine that stores some wanted data (tests, exam questions, results) or to find out which is the physical component he needs to steal in order to get a digital asset;
- virtualization – makes possible the rapid replacement of a compromised cloud located server without major costs or damages. It is very easy to create a clone of a virtual machine so the cloud downtime is expected to be reduced substantially;
- centralized data storage – losing a cloud client is no longer a major incident while the main part of the applications and data is stored into the cloud so a new client can be connected very fast. Imagine what is happening today if a laptop that stores the examination questions is stolen;
- monitoring of data access becomes easier in view of the fact that only one place should be supervised, not thousands of computers belonging to a university, for example. Also, the security changes can be easily tested and implemented since the cloud represents a unique

entry point for all the clients.

Another important benefit is related to costs. If the e-learning services are used for a relative short time (several weeks, a quarter, a semester), the savings are very important.

4 Project Management Challenges

This section deals with the impact of employing cloud computing architectures in the field of e-learning software systems development. We analyze the individual influence of the cloud computing model characteristics on the project development process.

4.1 Definitions

A project is “a temporary endeavor undertaken to create a unique product, service, or result” [10]. In [11] we find that “a software development project is a temporary endeavour undertaken to create a unique piece of software.” Considering the two former definitions, we state that a cloud computing based development project is a temporary endeavour undertaken to create a unique system (both hardware and software) that will be running on a cloud computing architecture. High quality cloud computing based development projects deliver the required product within scope, on time and within budget. It is the project manager’s duty to skilfully balance the competing demands for project quality, project duration and cost of resources in order to be able to deliver the system as planned.

4.2 Project management for cloud computing system development

At the top level view, cloud computing based development of e-learning systems follows the same pattern as any other software development project.



Fig. 4 Cloud computing project management process groups

Namely, cloud computing development project

management comprises of the following process groups (see figure 4):

- Project initiation
- Project planning
- Project execution
- Project monitoring and controlling
- Project closing

Subsequent sections of this article will go into great details of the project management process groups.

4.2.1 Project initiation process group

The initiation of an e-learning system development project using cloud computing architecture comprises of developing the project charter and the development of the preliminary project scope statement.

The project charter represents the document that formally authorizes the development project and endows project manager with the authority to employ organizational resources to project activities.

Preliminary project scope statement defines what needs to be accomplished, i.e. the functional specifications of the future e-learning system.

4.2.2 Project planning process group

The very nature of a cloud computing business model and of its technical architecture makes the planning of a cloud computing based project different than any other IT development project. Considering the cloud computing infrastructure will be rented from the service provider, the project manager’s focus moves from choosing the right technology to choosing the right vendor. Instead of concentrating on the computing power of the architecture and the costs of scaling up the e-learning system, the project manager will be looking at such parameters as service availability, data security, backup and contingency plans the cloud computing vendor offers, etc.

The more business oriented and less technical nature of the cloud computing based project activities can be immediately observed in the project scope planning, project work breakdown structure, activity identification and sequencing, activity duration estimation and schedule development. This is because the service provider takes on this initial burden and then offers on-demand virtualized processing power. For project activity duration estimation, one or several of the described techniques [12], [13] can be successfully employed.

Cost estimation and cost budgeting project processes are highly biased because of the cloud computing architecture. The service supplier absorbs up-front costs and spreads the costs over a longer period and over several cloud computing customers. Thus, the initial capital expenditure of the project is converted to ongoing operational expenditure of the e-learning system

maintenance. Table 1 shows the average fees for cloud computing services.

Google App Engine includes a free quota. After this quota is exceeded, the rates from table 1 apply [14].

Amazon EC2 services are charged based on the required resources (small, medium or large) [4].

Microsoft Azzure services are not yet commercially available [6].

Table 1 Average fees for cloud computing services

Provider	Average CPU cost (per hour)	Average bandwidth cost (per GB/month)	Average storage cost (per GB/month)
Amazon	0.11\$	0.12	0.15\$
Google	0.10\$	0.11\$	0.15\$
Microsoft	0.12\$	0.125\$	0.15\$

Using cloud computing instead of investments in datacenters (hardware and software licenses) will result in a shift from capital expenditure (CapEx) to operational expenditure (OpEx).

Quality planning project process involves creating test plans for the future e-learning system. The tests should take into consideration both intrinsic system features and performance testing on the cloud computing architecture.

Human resource planning entails allocating both legacy software development personnel and cloud computing engineers that are aware of the peculiarities of these platforms.

Communications planning means deciding what project processes and tools will be used for timely and appropriate generation, collection, distribution, storage and retrieval of project information. More exactly, this means setting up the reports that have to be generated, their content and frequency. Also, this implies setting up a bug tracking system for recording all the issues that arise during e-learning system development.

Risk management planning project processes need special attention when working with cloud computing infrastructure. It is true that the cloud computing maintenance burden resides solely within the responsibilities of the provider. Even though there are service level agreement items in the contract with the vendor, still Gartner analysts advices us [15] to discuss the following items with our future cloud computing vendor:

- Privileged user access, means asking who has specialized access to data and what are the procedures regarding hiring and management of such administrators.
- Regulatory compliance, means asking whether the vendor is willing to undergo external audits

and/or security certifications.

- Data location, does the provider allow for any control over the location of data.
- Data segregation means making sure that data encryption is available at all stages. Also this implies making sure that the encryption schemes are designed and tested by experienced professionals.
- Recovery, means discussing what happens to data in the case of a disaster, and whether the vendor offers complete restoration. If so, how long does that process will take.
- Investigative support means making sure that the vendor has the ability to investigate any inappropriate or illegal activity.
- Long-term viability, what happens to data if the company goes out of business. Also this implies making sure that the date will be returned in an appropriate format.
- Data availability means asking what are the procedures of moving the data onto a different environment, should the vendor decide to do that.

4.2.3 Project execution process group

Executing the project means directing and managing the project development and performing ongoing quality assurance. For a successful cloud computing based e-learning system to be developed, legacy software development techniques can be successfully employed. That is source control software, build scripts for building the deployment package and automated tests for regression testing. Project criticality analysis techniques [16] can be easily employed in order to enhance the project development quality.

4.2.4 Project monitoring and controlling process group

The monitoring and controlling processes are performed during the entire project lifecycle in order to take preventive and corrective actions so as to meet the established project performance goals. Continuous monitoring gives the project management team insights regarding project health and identifies any areas that might need special attention.

The cloud computing based e-learning systems are no different than other software development projects. More exactly, monitoring and controlling processes are concerned with:

- Assessing project current performance.
- Comparing planned and actual project performance.
- Analyzing, tracking and monitoring identified project risks.
- Provide accurate information regarding project

status report.

- Provide updated project costs and schedule information.
- Manage ongoing feature change requests.

4.2.5 Project closing process group

Project closing involves finalizing all project activities and performing the acceptance and delivery of the final e-learning system. During this stage the project scope is checked against the initial objectives, the e-learning system installation and maintenance is documented, the acceptance testing of the final product is performed and the formal closing of the project is executed.

5 Conclusions and Future Work

The development of e-learning solution cannot ignore the cloud computing trends.

There are many benefits from using the cloud computing for e-learning systems. Also, there are some disadvantages that have to be taken into account.

Using cloud computing for e-learning solutions influences the way the e-learning software projects are managed. There are specific tasks that deal with finding providers for cloud computing, depending on the requirements (infrastructure, platform or services). Also, the cost and risk management influences the way the e-learning solutions based on cloud computing are managed.

A metrics system needs to be developed in order to measure the efficiency of cloud computing based e-learning solutions.

The Academy of Economic Studies from Bucharest uses a e-learning solution based on Moodle and it has its own datacenter that can be in the future a platform for cloud computing.

This paper presents some results of the research project IDEI 2673: *Project management methodologies for the development of mobile applications in the educational system*, financed within the framework of IDEI research program.

References:

- [1] DeCoufle B., The impact of cloud computing in schools, *The Datacenter Journal*, <http://datacenterjournal.com/content/view/3032/40/>, July 2009
- [2] Cena F., Farzan R., Lops P., Web 3.0: Merging Semantic Web with Social Web, *Proceedings of the 20th ACM conference on Hypertext and hypermedia*, HT'09, June 29–July 1, 2009, page 385
- [3] Boja C., Batagan L., Software Characteristics of M-Learning Applications, *Proc. of 10th WSEAS International Conference on Mathematics and*

- Computers in Business and Economics (MCBE'09)*, Prague, Czech Republic, March 23-25, 2009, ISSN: 1790-5109, ISBN: 978-960-474-063-5, pp. 88-93;
- [4] * * *, Amazon Elastic Compute Cloud (Amazon EC2), <http://aws.amazon.com/ec2/>, retrieved on August 2009
- [5] Creeger M., CTO Roundtable: Cloud Computing *Communications of the ACM*, vol. 52, no. 8, august 2009, pp. 50-56
- [6] * * *, Google Apps - www.google.com/a/, retrieved on August 2009
- [7] * * *, Windows Azure Services Platform - www.microsoft.com/azure, retrieved on August 2009
- [8] * * *, Amazon Web Services - aws.amazon.com, retrieved on August 2009
- [9] Pocatilu P., Boja C., Quality Characteristics and Metrics related to M-Learning Process, *Amfiteatru Economic*, Year XI, June 2009, No. 26, pp. 346-354
- [10] Project Management Institute, *A Guide to Project Management Body of Knowledge (PMBOK Guide), Third Edition*, Project Management Institute, 2004
- [11] Vetrici M., Reducing Software Projects Duration using C#, *Informatica Economica Journal*, Vol. VII/No. 1, 2007, pg. 91-95.
- [12] Vetrici M., Software Project Duration Estimation Using Metrix Model, *Informatica Economica Journal*, Vol. XII, no. 47/2008, pp. 87-91.
- [13] Temnenco V., Software Estimation, Enterprise-Wide, *IBM The Rational Edge*, Vol. June 2007, <http://www.ibm.com/developerworks/rational/library/jun07/temnenco/index.html>.
- [14] * * * Billing and Budgeting Resources – Google App Engine – Google Code <http://code.google.com/intl/ro/appengine/docs/billing.html>
- [15] Brodtkin J., Gartner: Seven cloud-computing security risks, *Infoworld*, July 2008, <http://www.infoworld.com/d/security-central/gartner-seven-cloud-computing-security-risks-853>, retrieved on August 2009
- [16] Vetrici M., *Improving software project quality using criticality analysis*, Proceedings of The Ninth International Conference on Informatics in Economy IE 2009, Bucharest, Romania.