An Overview of E-Learning in Cloud Computing

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***Abstract*—E-Learning is the topic related to the virtualized distance learning by means of electronic communication mechanisms, specifically the Internet. They arebased in the use of approaches with diverse functionality (e-mail, Web pages, forums, learning platforms, and so on) as a support of the process of teaching-learning. The Cloud Computing environment rises as a natural platform to provide support toe-Learning systems and also for the implementation of data mining techniques that allow to explore the enormous data bases generated from the former process to ex- tract the inherent knowledge, since it can be dynamically adapted by providing a scalable system for changing necessities along time.**

In this contribution, we give an overview of the current state of the structure of Cloud Computing for applications on e-learning. We provide details of the most common infrastructures that have been developed for such a system, and finally wepresent some examples of e-learning approaches for Cloud Computing that can be found in the specialized literature.

The Electronic Learning, better known as E-Learning, is defined as an Internet- enabled learning. Components of e-Learning can include content of multiple for-mats, management of the learning experience, and an online community of learners, content developers and experts. The study summarized the main advantages, which include flexibility, convenience, easy accessibility, consistency and its repeatability. With Information Technologies (IT), there is a growing trend regarding the re- search and exploitation of this kind of e-Learning platforms. There exist severalinitiatives at different educative levels, from which some examples are the KhanAcademy[1], the Virtual Learning Center of Granada University (CEVUG-UGR) the Open University of Catalonia, the MIT Open Course Ware, or the "Free OnlineCourse" of the Stanford University.

The virtual courses that are supported by the e-Learning approach favors the achievement of a higher impact for the educative framework than those of theclassical attendance group. As an example, in the first edition of the "Machine Learning" course of Stanford[2] more than 160,000 worldwide students were registered. These dimensions affect different issues; on the one hand, the infrastructure provisions that are necessary to give a concurrent service for that number of students clearly exceed the capabilities of a conventional web server. Furthermore, the demand of the teaching resources usually varies in a dynamic and very quick way, and presentshigh peaks of activity. To attend requests during these periods of time without other system services to be resented, it will be necessary to prepare a quite superior infrastructure than that required for the regular working of the learning institution. An alternative would be to provide those services depending on the demand and only paying for the resources that are actually used. The answer to these necessities is the Cloud Computing environment.

Cloud Computing [3, 18] is a computation paradigm in which the resources of an IT system are offered as services, available to the users through net connections, frequently the Internet. It is a model of provision of IT services offered through a catalog that answers to the necessities of the user in a flexible and adaptive way, only billing for the actual usage that is made. Therefore, two of the distinctive features ofthis paradigm are, on the one hand, the use of resources under demand and, on the other hand, the transparent scalability in such a way that the computational resources are assigned in a dynamical and accurate manner when they are strictly necessary, without the requirement of a detailed understanding of the infrastructure from the user's point of view.

With these characteristics, the Cloud platforms arise as accurate alternatives to traditional computer centers. They represent a significate alternative versus the acquisition and maintenance of the computer centers.

Additionally, the e-learning platforms of the large dimensions which wementioned above generate extensive registers of interaction among students-platform-teachers. These data bases contain significate information not defined in a preciseway. Data Mining techniques must be applied to extract this information [23, 17]. Therefore "Educational Data Mining"[3] comes up, being this a discipline whose object of interest is the development of new methodologies to explore the data that are generated in the activity of the educational systems (mainly those with a technological base) and the application of such methods to achieve a better

understanding ofthe behavior of the students, and how to design procedures and material that ease the learning process.

In clear connection with this process we may find the Intelligent Tutoring Sys- tems[4] which are computer-based systems to support the teaching-learning process. Usually, they are intelligent systems able to drive the learning process of the student providing him/her feedback based on the progress of the student and the results of periodical tests. The process of "Educational Data Mining" interacts with anIntelligent Tutoring System by extending and refining its knowledge base. Considering the dimensions and growing capacity of the computational resources (stable storage, memory and CPUs) a Cloud platform is also a natural structure for the implementation of data mining techniques and their application to growing data-sets (Big Data). However, many of the data mining techniques do not have an adequate scalability. This is an aspect that grows in importance and that have attracted the interest of researchers and companies.

In order to overview all these aspects, this contribution is arranged as follows.In Section 2 we introduce the main concepts on Cloud Computing, including itsinfrastructure and main layers. Next, Section 3 presents the features of the e-Learning approach, stressing the advantages of the migration of such a system to a Cloud Computing environment and showing some examples of real applications of this kind. Finally, the main concluding remarks are given in Section 4.

I. BASIC CONCEPTS ON CLOUD COMPUTING

We may define an SOA [15] as an integration platform based on the combination ofa logical and technological architecture oriented to support and integrate all kind of services. In general, a "Service" in the framework of Cloud Computing is a task thathas been encapsulated in a way that it can be automated and supplied to the clients in a consistent and constant way. Any component can be considered as a service, fromentities closest to hardware such as the storage space or the computational time, to software components aimed at authenticating a user or to manage the mailing, the management of a data base or the monitoring of the use of the system resources.

In this section we will give a brief introduction to the Cloud Computing environ-ment, first describing its main features, next by presenting the layers in which this platform is built of, and finally pointing out several technological difficulties that should still be addressed to improve the quality of this paradigm.

II. INTRODUCTION TO CLOUD COMPUTING

The philosophy of Cloud Computing mainly implies a change in the way of solving the problems by using computers. The design of the applications is based upon the use and combination of services. On the contrary that occurs in more traditional approaches, i.e. grid computing, the provision of the functionality relays on this use

and combination of services rather than the concept of process or algorithm. The idea behind this is that grid computing mainly focuses on high performance computing whereas Cloud Computing offers both standard and intensive computation. Additionally, Cloud offers more services than grid computing, i.e web hosting, multiple Operating systems, DB support and much more. Finally, grids tend to be more loosely coupled, heterogeneous, and geographically dispersed compared to convenetonal cluster computing systems. Clearly, this brings advantages in different aspects, for example the scalability, reliability, and so on, where an application, in the presence of a peak of resources' demand, because of an increase of users or an increase of the data that those provide,can still give an answer in real time since it can get more instances of a determinateservice; the same occurs in the case of a fall of the demand, for which it can liberateresources, all of these actions in a transparent way to the user.

The main features of this architecture are its loose coupling, high inter operatively and to have some interfaces that isolate the service from the implementation and the platform. In an SOA, the services tend to be organized in a general way in layers or levels (not necessarily with strict divisions) where normally, some modules use the services that are provided by the lower levels to offer other services to the superior levels. Furthermore, those levels may have different organization structure, a different architecture, etc.

A. Cloud Computer Layers

There exist different categories in which the service-oriented systems can be cluetired. One of the most used criteria to group these systems is the abstraction level that offers to the system user. In this manner, three different levels are often distaingushed, as we can observe in Figure 1. In the remainder of this section, we will first describe each one of these three levels, providing the features that defines eachone of them and some examples of the most known systems of each type. Next, wewill present some technological challenges that must be considered for the development of a Cloud Computing system.

- Infrastructure as a Service (IaaS): IaaS is the supply of hardware as a service, that is, servers, net technology, storage or computation, as well as basiccharacteristics such as Operating Systems and virtualization of hardware resources [8].Making an analogy with a mono computer system, the IaaS will correspond to the hardware of such a computer together with the Operating System that take care of the management of the hardware resources and ease the access to them.
- Platform as a Service (PaaS): At the PaaS level, the provider supplies more thanjust infrastructure, i.e. an integrated set of software with all the stuff that adeveloper needs to build applications, both for the developing and for theexecution stages. In this manner, a PaaS provider does not provide the infrastructure directly, but making use of the services of an IaaS it presents the tools that a developer needs, having an indirect access to the IaaS services and, consequently, to the infrastructure.

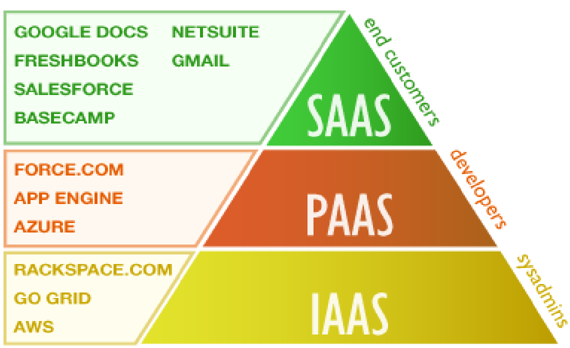

Fig. 1 Illustration of the layers for the Services Oriented Architecture

- Software as a Service (SaaS): In the last level we may find the SaaS, i.e. to offersoftware as a service. This was one of the first implementations of Cloud services. It has its origins in the host operations carried out by the Application Service Providers, from which some companies offered to others the applications knownas Customer Relationship Managements.

B. Technological Challenges in Cloud Computing

Cloud computing has shown to be a very effective paradigm according to its features such as on-demand self-service since the customers are able to provision computing capabilities without requiring any human interaction; broad network access from heterogeneous client platforms; resource pooling to serve multiple consumers; rapid elasticity as the capabilities appear to be unlimited from the consumer's point of view; and a measured service allowing a pay-per-use business model. However, there are also some weak points that should be considered. Next, we presentsome of these issues:

Security, privacy and confidence: Since the data can be distributed on different servers, and "out of the control" of the customer, there is a necessity ofmanaging hardware for computation with encoding data by using robust and efficient methods. Also, in order to increase the confidence of the user, several audits and certifications of the security must be performed.

Availability, fault tolerance and recovery: to guarantee a permanent service (24x7) with the use of redundant systems and to avoid net traffic overflow.

Scalability: In order to adapt the necessary resources under changing demands ofthe user by providing an intelligent resource management, an effectivemonetarization can be used by identifying a priori the usage patterns and to predict the load in order to optimize the scheduling.

Energy efficiency: It is also important to reduce the electric charge by using mi-coprocessors with a lower energy consumption and adaptable to their use.

C. Cloud Computing for E-Learning Tasks

As we stated in the introduction of this work, with the huge growth of the number of students, education contents, services that can be offered and resources made avail- able, e-Learning system dimensions grow at an exponential rate. The challenges regarding this topic about optimizing resource computation, storage andcommunication requirements, and dealing with dynamic concurrency requests highlight the necessity of the use of a platform that meets scalable demands and cost control. This environment is Cloud Computing.

Along this section we will introduce the main advantages and drawbacks to be addressed for e-Learning systems (Subsection 3.1). Then, the significance ofchoosing Cloud Computing for this kind of tools will be stressed (Subsection 3.2). The organization and infrastructure necessary for the virtual platform is described next (Subsection 3.3).

Finally, we will review some of the e-Learning applications that have been already developed within the Cloud Computing platform (Subsection 3.4).

III. CURRENT CHALLENGES OF E-LEARNING SYSTEMS

Among the learning technologies, web-based learning offers several benefits over conventional classroom-based learning. Its biggest advantages are the reduced costs since a physical environment is no longer required and therefore it can be used at any time and place for the convenience of the student. Additionally, the learning material is easy to keep updated and the teacher may also incorporate multimedia content to provide a friendly framework and to ease the understanding of the concepts. Finally, it can be viewed as a learner-centered approach which can address the differences among teachers, so that all of them may check the confidence of their material to evaluate and re-utilize common areas of knowledge [9].

However, there are some disadvantages that must be addressed prior to the full integration of e-Learning into the academic framework. Currently, e-Learningsystem are still weak on scalability at the infrastructure level. Several resources can bedeployed and assigned just for specific tasks so that when receiving high workloads,the system need to add and configure new resources of the same type, making the cost and resource management very expensive.

This key issue is also related to the efficient utilization of these resources. For example, in a typical university scenario, PC labs and servers are under-utilized during the night and semester breaks. In addition, these resources are on highdemands mainly towards the end of a semester, following a dynamic rule of use. The physical machines are hold even when they are idle, wasting its full potential.

Finally, we must understand that there is a cost related to the computer (and building) maintenance, but that the educational center must pay for the sitelicensing, installation and technical support for the individual software packages.

A. On the Suitability of Cloud Computing for E-Learning

E-Learning in the Cloud can be viewed as Education Software-as-a-Service. Itsdevelopment can be performed very quickly since the hardware requirements of the user are very low. Furthermore, as we stated previously, it lessens the burden of maintenance and support from the educational institution to the vendor, allowing them to focus on their core business, also obtaining the latest updates of the system without charges and sharing key resources using Web 2.0 technology.

In what follows, we summarize the consequences and implications regarding thedevelopment of e-Learning services within the Cloud Computing environment, as pointed out by Masud and Huang:

- Accessed via Web: It implies an ease of access since anywhere, any time and any one can access the application, greater demand for Web Development skills.No client-side software needed: Therefore, it has reduced costs for subscriber, as no installation, software maintenance, deployment and server administration costs, and a lower total cost of ownership, reduced time-to-value, fewer IT staff is needed by the institution.
- Pay by subscription based on usage: Which is suitable for Software Model Education market, and can gain access to more sophisticated applications.
- SaaS server may support many educational institutions: Since the applicationis running on a server farm, the scalability in inherent to the system. As student usage grows, the software performance will not degrade.
- All subscriber data held on SaaS server: Very high level of security is neededby SaaS provider in order to gain trust of subscribers and sophisticated multi-tenanted software architecture. The subscriber data is distributed between many providers and it must be integrated in order to gain overview of business, higher demand for system and data integrators.

Finally, several potential values of Cloud Computing for education as stressed by Our and include the following:

- No need for backing up everything to a thumb drive and transferring it from onedevice to another. It also means students can create a repository of information that stays with them and keeps growing as long as he wants them.
- Crash recovery is nearly unneeded. If the client computer crashes, there are al- most no data lost because everything is stored in the cloud.
- Allow students to work from multiple Places (home, work, library ... etc), find their files and edit them through the cloud and browser-based applications can also be accessed through various devices (mobile,

laptop and desk top computers,provided internet access is available).

- Flexibility: Scale infrastructure to maximize investments. Cloud computing al- lows user to dynamically scale as demands fluctuate.
- 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 needsto 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 ofa 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 clientcan 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 placeshould be supervised, not thousands of computers scattered over an extensive geographical area, for example. Also, the security changes can be easily tested and implemented since the cloud represents a unique entry point for all the clients [22].

B. Organization of the Cloud Computing Environment
The architecture of a Cloud Computing platform as depicted in Figure 2 is usually common to most e-Learning approaches on the Cloud. In the first layer we can observe the interface with the Cloud environment, which consists in several management subsystems for determining the current necessities of the user in terms of computational resources, being these the planner for the storage services, the management for distribution of the execution load among the virtual machines, a system administrator to monitor and to initiate activities of each layer, and a security component to ensure the privacy, recovery, integrity and security of user data and transactions, among others. The second layer represents the virtual machines implemented within the system. Finally, the third layer includes all the physical architecture of the system.

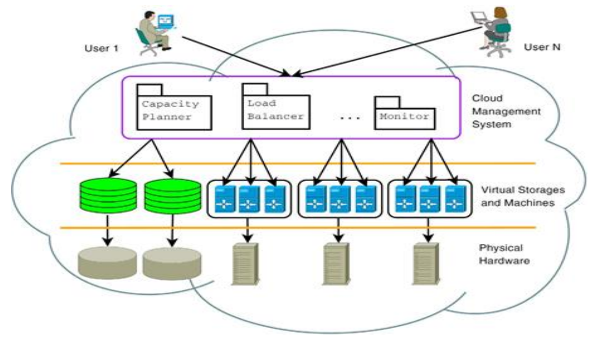

Fig. 2 Overview of a cloud architecture for e-Learning

Additionally, Liang and Yang describe in the functions used in the Cloud IaaS and Saas which must be expected for developing such a system. These features can be observed in Figure 2 and are enumerated below:

From the IaaS perspective:

1. Storage management for the learning system and the users.
2. Load Balance for all learning systems.
3. Scaling management for virtual machines.
4. Backup and Restore for the learning applications.

From the SaaS perspective:

1. Application Registry management for the commercial provides to register their applications.
2. Application Server for managing and deploying the subscribed learning con-tents to the users.
3. Account manage system for the authorized users.
4. Virtual Desktop Deployment for providing the personalized desktop including the subscribed learning contents.
5. Session Management for ensuring the Virtual Desktop used by the authorizeduser.
6. Personalized management for managing the subscription of the favorite learning contents.

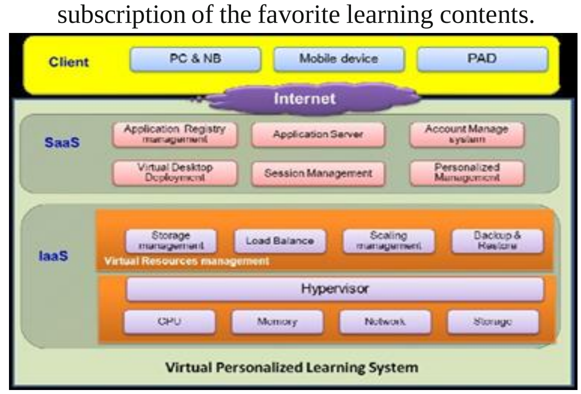

Fig. 3 The Architecture of the Virtual Personalized Learning Environment

C. Applications of Cloud Computing for E-Learning

We must emphasize the necessity on setting the basis for a educationalinformation infrastructure to alleviate the issues enumerated on the previous section. As we pointed out along this contribution, Cloud Computing may promote a new era of learning taking the advantage of hosting the e-Learning applications on a cloud and following its virtualization features of the hardware, it reduces the construction andmaintenance cost of the learning resources.

At the present, the combination of cloud technologies and e-learning has been scarcely explored. Some relevant efforts to use IaaS cloud technologies in education focuses on the reservation of Virtual Machines to students for a specific time frame.

Another example of application that can be found in the specialized literature is Blue Sky, whose architecture has several components aimed at the efficient provision and management of the e-Learning services, being able to pre-schedule resources for the hot contents and applications before they are actually needed, to safeguard the performance in concurrent access, although no details have been found with regard to how this is achieved. On the other hand, Cloud IA [19] is a framework which provides on-demand creation and configuring of VM images so that thestudents are able to have their own Java servlet environment for experimentation, containing MySQL, Tomcat, PHP, and Apache web server. With this approach, students can focus more on developing, deploying and testing their applications in a servlet container.

In the authors present a new service model that enhances the efficiency within a virtual personalized learning environment. This system is intended for sub-scribing the selected learning resources as well as creating a personalized virtual classroom, and allows the learning content providers to registry their applications in the server and the learners integrate other internet learning resources to their learning application pools. Other proposals for personal and virtual learning interact with services that rely on the cloud, such as YouTube or Google Docs.

Finally, we may find some cloud-related works for performing a comparison onthe efficiency of online models versus traditional models. The most represent work is this area is developed, where the authors focused on the impactof supporting technologies or the perceived ease of use and acceleration of the learning process. Furthermore, they analyze the appropriate level of abstraction (i.e., IaaS or PaaS) that should be delivered to students to enable them to focus on the coursetopics.

IV. CONCLUDING REMARKS

In this work we have exposed the main components of e-Learning, focusing on the flexibility, convenience, easy accessibility, consistency and repeatability of this kind of systems. In this manner, an E-learning system is facing challenges of optimizinglarge-scale resource management and provisioning, according to the huge growth of users, services, education contents and media resources. We have settled the goodness of a Cloud Computing solution.

The features of the Cloud Computing platform are quite appropriate for themigration of this learning system, so that we can fully exploit the possibilities offered by the creation of an efficient learning environment that offers personalized contents and easy adaptation to the current education model. Specifically, the benefits considering the integration of an e-Learning system into the cloud can be highlighted as good flexibility and scalability for the resources, including storage, computational
requirements and network access; together with a lower cost considering the pay- per-use billing format and the save in new hardware and machines and software licenses for educational programs.

Finally, we have enumerated several approaches that have been already proposed for addressing e-Learning on Cloud Computing, describing these models and how they take advantage of this environment to enhance the features of the educational system. However, we must stress that these are just initial steps towards an open linefor research and exploitation of e-learning and cloud computing platforms.

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