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Using cloud computing services in e-learning process: Benefits and challenges

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Abstract During the recent years, Information and Communication Technologies (ICT) play a significant role in the field of education and e-learning has become a very popular trend of the education technology. However, with the huge growth of the number of users, data and educational resources generated, e-learning systems have become more and more expansive in terms of hardware and software resources, and many educational institutions cannot afford such ICT investments. Due to its tremendous advantages, cloud computing technology rises swiftly as a natural platform to provide support to e-learning systems. This paper focuses on the research on the application of cloud computing in e-learning. The aim of this paper is to give an overview of the current state and the impact of the use of cloud computing for e-learning. Thus, at first the paper introduces concepts of e-learning and cloud computing infrastructure with their key characteristics. The paper analyzes also challenges facing e-learning systems deployment. In follow the paper considers cloud-based e-learning solutions by focusing on the raisons of the convenience of cloud computing for e-learning. Therefore cloud computing benefits are introduced as a solution for these challenges. Finally, the paper presents some solutions of cloud computing in e-learning and describes the most common architecture adopted. Issues in implementing cloud-based e-learning systems and some potential ways to overcome them are also discussed.

Keywords E-learning · Cloud computing services · Cloud-based e-learning · ICT

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1 Introduction

With the rapid advancements in Information and Communications Technologies (ICT), the popularity of learning on the Internet and construction of e-learning environments is growing rapidly. Today, there are lots of paradigms for getting knowledge or learn through Internet. One of the most promising paradigms for education is e-learning. E-learning refers to the use of networked information and communications technologies and offers a wide range of new opportunities for the development of education and brought profound impact to teaching and learning methods. Today, e-learning has become one of the most popular teaching and learning methods by stretching the spatial and temporal barriers (Dong and Huang 2011).

However, with the increasing access to ICT and the huge growth of the number of users, data and educational resources generated, e-learning systems have become more and more expansive in terms of hardware and software resources (computing, storage …) and many educational institutions cannot afford such investments (Paul and Santhi 2014). Indeed, with the daily rising trend on requirement's dynamic changes in service, e-learning systems deployed in educational institution are facing many issues and challenges of optimizing large-scale resource management and provisioning (Paul and Santhi 2014). On the one hand, a poor or insufficient infrastructure can cause more damage than good to users and the learning experience (Bora and Ahmed 2013). Thus, educational institutions are obliged to evolve their e-learning infrastructure. Nevertheless, the infrastructure provisions that are necessary to provide a competitor service for a large amount of users clearly exceed the capabilities of a simple web server and. This leads to high the costs of the infrastructure establishment and institutions are unable to afford the costs needed.

On the other hand, the demand of the teaching and learning resources (hardware and software resources) usually vary in a dynamic and very quick way and presents high peaks of activity. To attend flexible and dynamic requests of resources, it will be necessary to prepare a quite superior e-learning system than that required for the regular working of educational institutions (Fernández et al. 2012).

To overcome these issues, cloud computing, that has been recently emerging as a key paradigm of the present century, is a new model for hosting resources and provisioning of services to e-learning systems. It provides a convenient, on-demand access to a centralized shared pool of computing resources that can be deployed by a minimal management overhead and with a great efficiency (El-Sofany et al. 2013). Cloud computing rises as a natural platform to provide support to e-learning systems. Today, there is a growing trend regarding the research and exploitation of cloud computing to support e-learning process and many research works has been carried out in the domain of cloud-based e-learning (Huang and Liu 2013; Li et al. 2011; El Mhouti et al. 2016).

This work focuses mainly on the research of the application of cloud computing in e-learning environments. The aim of this work is to give an overview the current state and the impact of the use of cloud computing for e-learning. Thus, the paper presents the cores concepts of e-learning and cloud computing by focusing on e-learning systems challenges and the solutions provided by cloud computing to overcome them. The paper brings forward the benefits that might come as a result of combining the two concepts discussed. The paper gives also some cloud applications solution in e-learning

as well as a look at how incorporating e-learning with cloud computing using a cloud-based e-learning architecture.

The rest of this paper is structured as follows: Section 2 introduce e-learning concept and discusses current e-learning systems challenges. Section 3 describes the core concepts of cloud computing. Section 4 presents the convenience of cloud computing for e-learning platforms. This section discusses also the applications' solutions of cloud computing in e-learning and describes the common cloud-based e-learning architecture. Problems in implementing cloud-based e-learning systems and recommendations to overcome them are discussed in section 5, followed by the conclusion and perspectives of this work.

2 E-learning concepts

2.1 E-learning: Overview

E-Learning is the field related to the virtualized online learning by means of electronic synchronous and asynchronous communication mechanisms, specifically the Internet. It refers to the use of electronic media and ICT in education. E-learning is widely enclosure of all kinds of educational technology in learning and teaching. E-learning is enclosure of, and is widely synonymous with technology-enhanced learning, computer-based training, multimedia learning, computer-assisted instruction, computer-based instruction or internet based training, web-based training, online education, computer-aided instruction, virtual education, m-learning, virtual learning environments and digital educational collaboration. These other alternative names dwell on a specific component, aspect or delivery method (Sneha and Nagaraja 2013).

Computers are the basic equipment used in the e-learning process. Different kinds of educational software created and verified by domain specialists and educators allows the implementation of the principles of education, which are the individualization of the trainings and teaching by examples.

Technical capabilities make possible a visualization of knowledge as well as the alignment of both the pace and structure of the education content to the individual recipient's perception (Orzechowski 2007).

There are many types of training using e-learning techniques. For example, (Schulmeister 2003) distinguishes two types of training: a type using e-learning between individual (type A) and a type called group training (type B), closely related to the form of materials (Fig. 1).

According to Schulmeister, individual trainings (type A) is person-to-standardized content interaction, whilst person-to-person interaction (type B) is the acquisition of knowledge in interaction with members of specific communities of practice.

The evolution of the Web to Web 2.0 has given birth to e-learning 2.0. The influence of new practices on the Web has resulted in a new array of services, which can be collectively termed "e-learning 2.0". Figure 2 shows the different forms of e-learning.

Today, and with the current digital age, e-learning has become a necessary instrument in educational environment, allowing the creation of learner-centered learning and offering new more flexible learning methods.

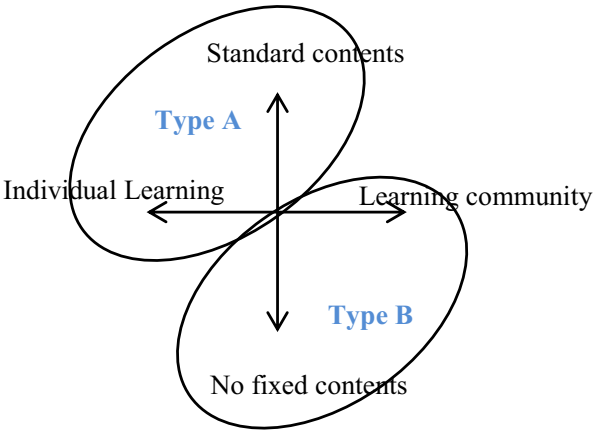

Fig. 1 E-learning types (Orzechowski 2007)

2.2 E-learning systems

An e-learning system is a software application, system or platform for flexible learning. Its aim is the realization of learning process theory: organization of contents and resources, delivery of educational courses and training programs, tracking, documentation and administration tasks. In academic field, the first e-learning systems were really only set up to deliver information to learners but as we entered the 70s e-learning started to become more interactive.

E-learning systems constitute learners tracking, synchronous and asynchronous communication tools, assessment techniques and collaboration spaces (Sneha and Nagaraja 2013). The structure of an e-learning system is shown in Fig. 3.

Typically, e-learning systems provide facilities for managing the learning experience, communicating the intended learning experience and facilitating tutors' and learners' involvement in that experience. The learning experience needs to be communicated via syllabi, complete course content or copies of visual aids/handouts, plus additional resources, links to resources in libraries and on the Internet. Easy authoring tools or standard office software used for authoring should be available to aid this (Sneha and Nagaraja 2013). The learning experience is facilitated typically via self-assessment quizzes and communications tools such as e-mail, forum, threaded discussions and chat rooms. To allow all of this, the systems should provide differential access rights for instructors and learners (roles). All the various functions and resources

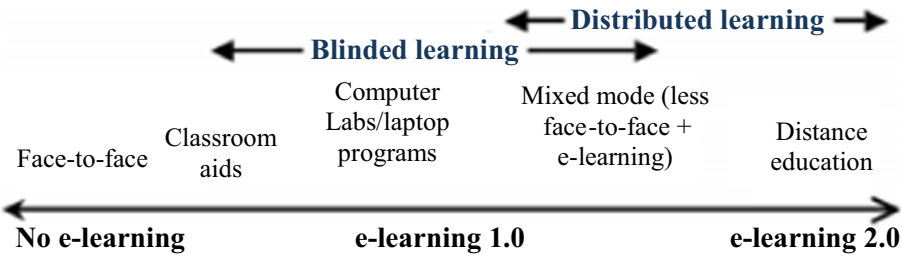

Fig. 2 Different forms of e-learning

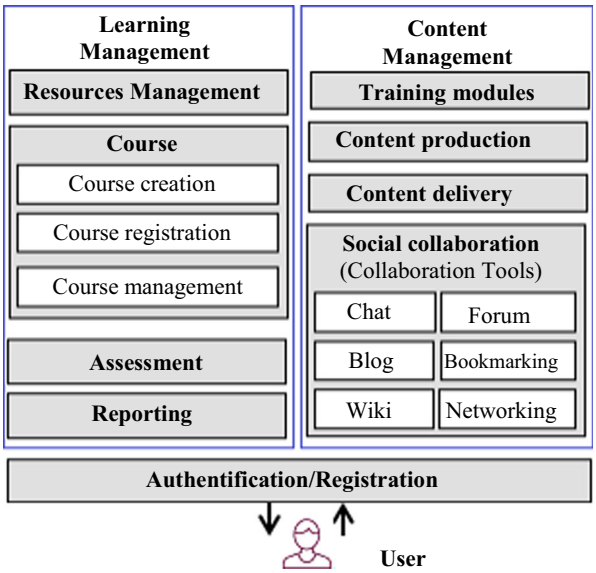

Fig. 3 Components of an e-learning system

need to be capable of being hyperlinked together within a consistent interface (Gaeta et al. 2011; Blas et al. 2012). From the earliest Internet-based learning systems, people started exploring the possibilities of the worldwide web as a means of supporting learning. The earliest systems which satisfied the 'consensus view' of -learning systems elements began to appear and included systems such as WebCT and Lotus Learning Space. During this period, systems were developed which took a pedagogically focused view of e-learning.

There is a plethora of kinds of e-learning systems. The most used systems are LMS (Learning Management Systems), LCMS (Learning Content Management System), VLE (Virtual Learning Environment), etc. There are free systems such as open source software that by definition are open source. Of course there are also commercial e-learning systems.

Recently, various e-learning systems have been developed and are currently available. We distinguish different kinds of projects working on virtual learning environments. Among e-learning systems developed, we can mention: WebCT (Web Course Tools), Virtual-U (Virtual-University),. LRN, Moodle, Sakai, etc. (Sneha and Nagaraja 2013).

2.3 E-learning systems trends

In recent years, rapid evolutions of web technologies are introducing new opportunities in the development of e-learning systems used in higher education. In this sense, e-learning is emerging as a dynamic, interdisciplinary and international field of research. If conventional e-learning systems were based have been used to organize and publish learning materials, the tendency for the new emerging e-learning systems focuses on how technology can facilitate the

sharing and creation of academic knowledge and expertise through peer interaction and group learning processes (Resta and Laferrière 2007).

Current e-learning systems for higher education are based on a learning strategy that embodies the application of new technologies and where several students interact with each other in order to achieve their common goals. They use the collaborative environment supported by the computer network to carry out the collaborative learning, in the form of group work, between teachers, tutors and students, based on their discussion, cooperation and communication (Wang et al. 2005), using the various interaction tools (Fig. 4).

E-learning systems for higher education are based on Web 2.0 and emerging trends in e-learning that are built around collaboration, which assumes that knowledge is socially constructed. They are based on creating and sharing of information and academic knowledge with others using social media tools like blogs, wikis, social bookmarking and social networks to support collaborative approach to learning (Rupesh 2009).

2.4 Current e-learning systems challenges

It is obvious that the Web-based e-learning systems offer several benefits over conventional classroom-based learning. If the popularity of e-learning and e-learning systems is growing rapidly, it is because these systems bring learners from different geographical areas together and create a notion of a single classroom environment which helps them and theirs teachers to share academic knowledge and exchange experiences (Gamundani et al. 2015).

However, providing active e-learning, to the masses on gigantic scale to meet the ever-changing requirements of the educational institutions and also to meet the learner's

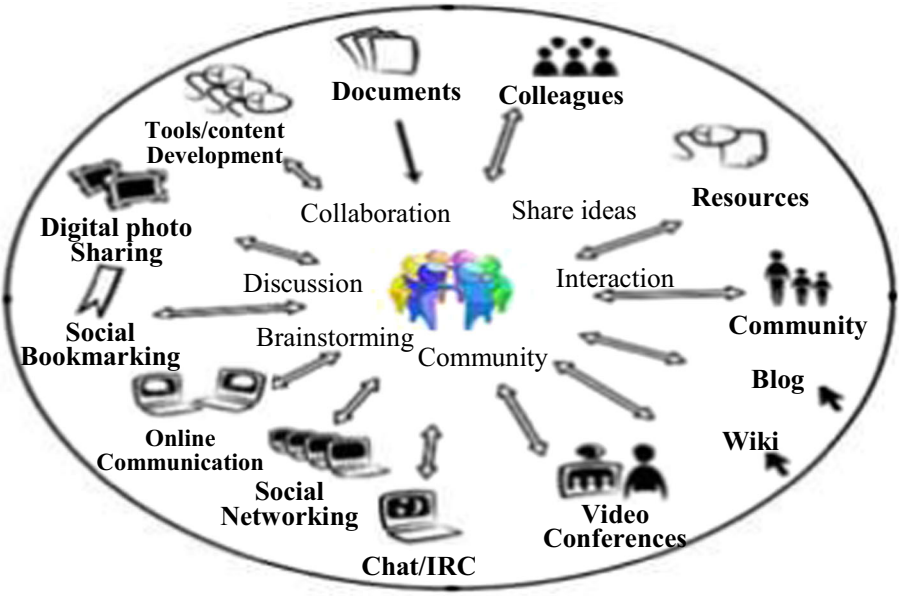

Fig. 4 E-learning system trends

special requirements and tastes, is not possible through the conventional e-learning systems that are not scalable dynamically and do not fully utilize the resources. With the exponential growth of knowledge at an ever-increasing rate, the e-learning raises significant challenges. These challenges, which concern pedagogical, technical and organizational issues, must be addressed and resolved prior to the full integration of e-learning into the academic field.

In this context, the review of some earlier works (Guoli and Wanjun 2010; Kerres and Witt 2003; Karim and Goodwin 2013) done in this field shows that the most important challenges facing educational institutions are related to the efficient utilization of e-learning systems resources. These challenges concern also the keeping pace of the rapid increase in the size and variety of data in these systems. Thus, e-learning systems are still weak on scalability at the level of their infrastructure. In an e-learning system, several resources are deployed and assigned just for specific tasks, which implies to add and configure new resources of the same type when receiving high workloads. This makes the cost and resource management very expensive (Fernández et al. 2012).

Indeed, with the huge growth of the number of users (learners, trainers ...), services offered, contents and resources made available by educational institutions, e-learning systems dimensions grow at an exponential rate. The challenges regarding this emerging evolution, which concern the computing resources optimization and storage and communication requirements, highlight the necessity of the use of a platform that meets scalable demands and cost control.

Also, reference (Sife et al. 2007) clearly points some key challenges related to the pedagogical, technical and cost implications of e-learning technologies availed. The challenge of storage facilities is a hindrance for hosting e-learning systems that support multimedia content as pointed by (Gamundani et al. 2013).

Finally, it is important to understand that, in an e-learning system, there is a cost related to the hardware resources maintenance (computers, servers, data centers, computing centers...), but also software resources. In that case, the institution must pay for the site licensing, installation and technical support for the individual software packages (Kwan et al. 2008).

3 Cloud computing concepts

3.1 Definition

Cloud computing has been recently emerging as a compelling paradigm of the present century for managing and delivering services over the Internet. Cloud computing is defined as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell and Grance 2011).

Cloud computing technology has evolved through several phases over the years, which include grid and utility computing, application service provision, and software as a service. Figure 5 illustrates the main phases of evolution of the concept of cloud computing.

As a new promising paradigm, Cloud computing has been recently emerging as a compelling paradigm of the present century, for managing and delivering services over the Internet. Cloud computing can offer utility-oriented IT services to users based on a pay-as-you-go model. It can also make good use of economies of scale, and dynamically deliver/configure almost any ICT related services on demand (Peng et al. 2011).

The five essential characteristics of cloud computing are: 1/ on-demand self-service: customers can request and manage their own computing resources; 2/ broad network access: it allows services to be offered over the Internet or private networks; 3/ resource pooling: customers draw from a pool of computing resources, usually in remote data centers; 4/ rapid elasticity and 5/measured service.

3.2 Services

In terms of services, there are many services provided by the cloud computing. The three mains service models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) (Fig. 6).

In a SaaS model, a pre-made application, along with any required software, operating system, hardware, and network are provided. In PaaS, an operating system, hardware, and network are provided, and the customer installs or develops its own software and applications. The IaaS model provides just the hardware and network; the customer installs or develops its own operating systems, software and applications (Patel and Kumar 2013).

3.3 Deployment models

There are four deployment models that together categorize ways to deliver cloud services. Figure 7 describes each of these four models.

Cloud deployment models are mainly distinguished by the size, proprietorship and access:

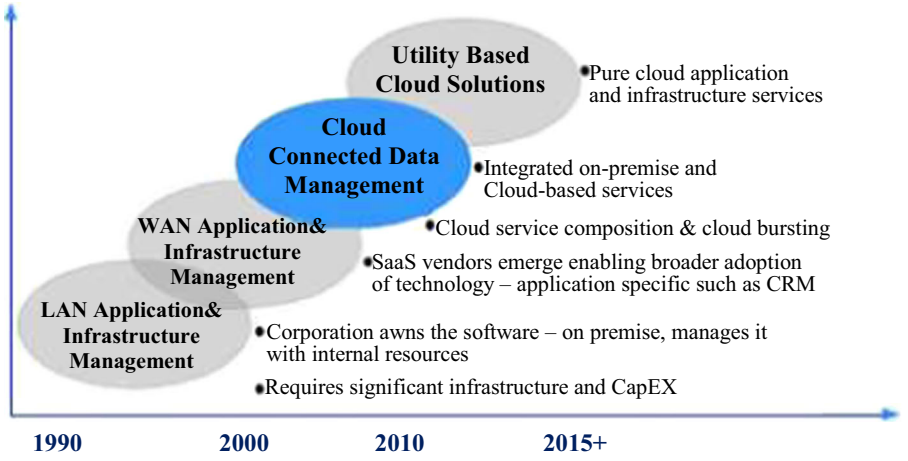

Fig. 5 The cloud computing evolution

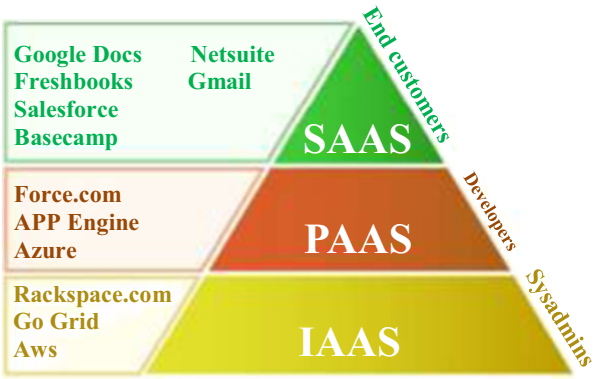

Fig. 6 The layers for the services of cloud computing (Patidar et al. 2012)

- private cloud: provisioned for exclusive use by a single organization. It may be owned, managed, and operated by the organization;
- community cloud: provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns;
- public cloud: the cloud infrastructure is provisioned for open use by the general public;
- hybrid cloud: the cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities.

4 Cloud-based e-learning systems

As we have identified above, there are many challenges and issues facing deployment of e-learning systems. On the other hand, cloud computing is growing rapidly with applications in almost any area, including education.

This section introduces the implications and reasons for the move towards e-learning based on cloud computing services. Then, the benefits of cloud computing in e-learning will be stressed. Finally, we will review some of the applications of e-learning that have been already developed using cloud computing and we will describe the common architecture of the cloud-based e-learning environments.

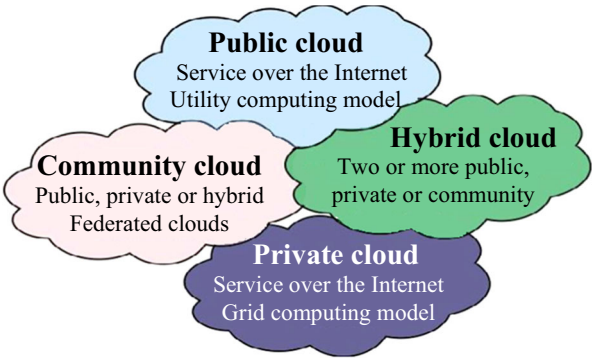

Fig. 7 The cloud deployment models (Bora and Ahmed 2013)

4.1 The reasons for the convenience of cloud computing for e-learning

Today, cloud computing has become an alternative and attractive model for delivering ICT services with which most other technologies would like to be incorporated with. In this sense, much research has conducted and has been oriented towards cloud computing applications and its possibilities. E-learning for is one of the technologies of interest in cloud computing for various reasons.

In the first place, educational institutions using e-learning systems and where the use of computers is increasingly intensive (online labs, computing centers, data centers …) are seeking to provide free or low-cost alternatives to expensive and exclusive tools. In this sense, cloud computing paradigm has promoted the growth of e-learning systems with its pay as you go model: users can use computer resources anywhere, anytime, simply on demand and only pay for the usage thereof. This model is adapted to all scales of budgets and requirements. Thus, by developing usage of Internet and computer networks, cloud computing was introduced as one of the best and economical option to the needs of educational institutions. Instead of adopting expensive and complex hardware and software resources, cloud-based e-learning can be used with less expensive costs.

On the other hand, cloud computing plays a big role in education industry and has a great potential to make significant changes in e-learning systems used by educational institutions. Cloud computing has been adopted in e-learning to increase the efficiency and availability of such e-learning systems. Due to the scalability and cost reduction, cloud services allow implementing easier, faster and less expensive e-learning solutions.

In addition, cloud computing brings for educational institutions a new type of business model where the services that are provided become computer resources. By choosing cloud computing, educational institutions can develop their services and use resources in a flexible manner in the cloud. When users need more resources to their e-learning system, it is no need to install software or purchase hardware, but these resources are automatically transferred to user, which constitutes a cost-effective platform to respond the educational needs.

Moreover, cloud based e-learning supports the creation of a new generation of e-learning systems which are able to run on a number of hardware devices, while storing data in the cloud. Also, cloud computing provides a natural platform to support e-learning systems and this by enabling the implementation of data mining techniques that becomes important when large databases are being used so that meaning can be extracted from data (Fernández et al. 2012).

Also, the use of cloud computing in e-learning allows managing the educational and technical tasks better. By using cloud computing, educational institutions become responsible for the content creation, content management and content delivery, while the cloud providers are responsible for constructing as well as management of the e-learning system (Sharma and Rana 2011).

Finally, cloud computing responds to the purpose for which e-learning systems were created in educational institutions: collaboration, interaction and exchange between learners and teachers. Thus, e-learning based on the cloud is a new model that enhances productivity in a virtual learning environment and provides a learning environment where learners could share educational resources and actively collaborate.

4.2 Benefits of e-learning on the cloud

The implementation of cloud services in e-learning provides various opportunities and benefits for users. (Bora and Ahmed 2013) reported that cloud computing can contribute to the improvement of e-learning systems using three types of aspects: 1/Infrastructure: deploy an e-learning solution on the provider's infrastructure; 2/Platform: implement an e-learning solution based on the provider's development interface; 3/Services: use the e-learning solution given by the provider.

Hence, by detailing these three aspects, the key benefits of e-learning based on the cloud are (Masud and Huang 2011; Ouf and Nasr 2011):

- Cut-down cost of ICT investment: e-learning systems require sophisticated resources of which educational institutions cannot afford the huge investments. By using cloud computing, cloud infrastructure is pooled to consuming institution (Benta et al. 2014) and these institution have to pay only for the resources they use. Thus, there are a lower maintenance issues, a lower hardware requirements, a lower software and ICT Infrastructure costs.
- Scalability: cloud computing allows to educational institutions to scale theirs services as according to their demand.
- Centralized and unlimited data storage: a large part of applications and data is stored into the cloud. This makes the data and educational resources management easy to handle. Also, cloud offers an almost unlimited storage capacity.
- Data accessed via the Web: the data access is easy since anywhere, any time and any learner/teacher can access the application.
- Accessibility: cloud computing services can be accessed through heterogeneous systems.
- No user-side software needed: this allows reducing costs for educational institutions, as no installation, software maintenance, deployment and server administration costs, which leads to a lower total cost, and a fewer ICT staff for the institution.
- Virtualization: the concept of virtualization allows the rapid replacement of a compromised cloud located server without major costs or damages. It is possible to integrate a new clone of a virtual machine so the cloud downtime is expected to be reduced substantially.
- Easy monitoring: the monitoring of data access is easier because only one place should be supervised, not thousands of computers distributed over the world. Also, since the cloud represents a unique entry point for all academic users, the security changes can be easily tested and implemented (Wheeler and Waggener 2009).
- Improved improbability and data security: it is extremely difficult for a hacker to identify where is located the computer that stores wanted data (learners' profiles, learners' notes, results, files) or to find out which is the computer he needs to attack in order to get data desired. In addition, data in the cloud is automatically duplicated so unlike desktop computing, a computer crashing in the cloud doesn't destroy the data, which will still be available from other computers in the cloud.
- High availability: cloud computing can automatically detect the node failure and exclude it without affecting the normal operation of the e-learning system (Hossain and Huang 2012).

- Backup and recovery: if a user's computer crashes, there are almost no data lost because everything is stored in the cloud (Madhumathi and Ganapathy 2013).

4.3 Applications' solutions of cloud computing in e-learning

Nowadays, the applications of cloud computing solutions in e-learning environments have been scarcely explored. These applications have been of interest of many educational institutions and researchers. Various examples of cloud applications in e-learning have been discussed. This section continues to mention some of them.

As a first example, (Oladimeji and Folashade 2016) have designed in 2016 a cloud based e-learning framework for Ladoke Akintola University of Technology Open Distance Learning (LAUTECH ODL) using computer science and related courses as a case study. The proposed system addresses the cloud services in a new dimension and each layer in the cloud-based architecture specifies the essential components needed to construct an academic cloud in an open distance learning environment. Also, a way of implementing the framework has been described.

On its side, (Dong et al. 2009) have presented BlueSky, an e-learning framework embracing cloud computing. It's about a cloud-based architecture that has several components devoted to the efficient provision and management of the e-learning services. The architecture is able to preprogram the necessary resources for the demanding contents and applications before they are actually needed. It improves the availability, performance and scalability of e-learning systems.

Another example of application of cloud computing in e-learning is CloudIA system developed by (Sulistio et al. 2009). CloudIA is a framework that delivers on-demand creation and configuring of Virtual Machines images so that learners are able to have their own Java servlet environment for experimentation. The framework allows learners to focus more on the development, deployment and test of their applications in a servlet container.

Ivica et al. (2009) has proposed StartHPC, a system for teaching parallel programming at MIT. StartHPC is developed on the basis of a virtual image of Amazon EC2 which is used to create the class cluster. In this cloud-based system, learners and teachers were allowed to focus on the parallel programming concepts in OpenMPI and OpenMP without being distracted by non-related.

Liang and Yang (2011) propose a new service model that improves the effectiveness within a virtual personalized learning environment. The presented framework is devoted for the subscription of the selected learning resources as well as the creation of a personalized virtual classroom. It allows the educational content providers to registry their applications in the server and the learners integrate other resources to their learning application pools.

Yang and Zhu (2010) has developed an Opensource software for e-learning based on cloud computing technology. Authors have implemented the EduCloud platform to deploy their e-learning environment on a public cloud, based on IaaS and SaaS in order to overcome resource limitation and lack of scalability.

Tian et al. (2010) has devoted their work to manage a virtual Cloud lab's resources allocation, with the ability to deploy the proposed virtual lab on a public or private Cloud. The implemented virtual cloud lab allows enhancing resource utilization and

sharing. Authors have designed and implemented the framework to manage PaaS in virtual computing labs.

Finally, (Gamundani et al. 2013) proposes a system architecture based on distributed resources which provided by users' computers. In addition to the elastic characteristics of cloud computing, the system provides the high scalability by supporting the coordination of distributed resources of the node to the central computer system. Other works can be found in (Fernández et al. 2012; Jain and Chawla 2013; Masud and Huang 2012).

4.4 Typical architecture of the cloud-based e-learning systems

In education field, the cloud computing infrastructure can be pooled to e-learning systems in different ways. However, in most cases, this combination takes into account educational institutions' demands in terms of resources virtualization, centralized data storage, low cost of running, scalability, flexibility and availability of e-learning systems.

Thus, the cloud-based e-learning architecture is usually common to most e-learning approaches on the cloud (Fernández et al. 2012). This architecture includes, in addition to the cloud management system, all hardware and software computing resources and services offered by the cloud to engage in e-learning. The typical architecture of cloud-based e-learning systems is shown in Fig. 8.

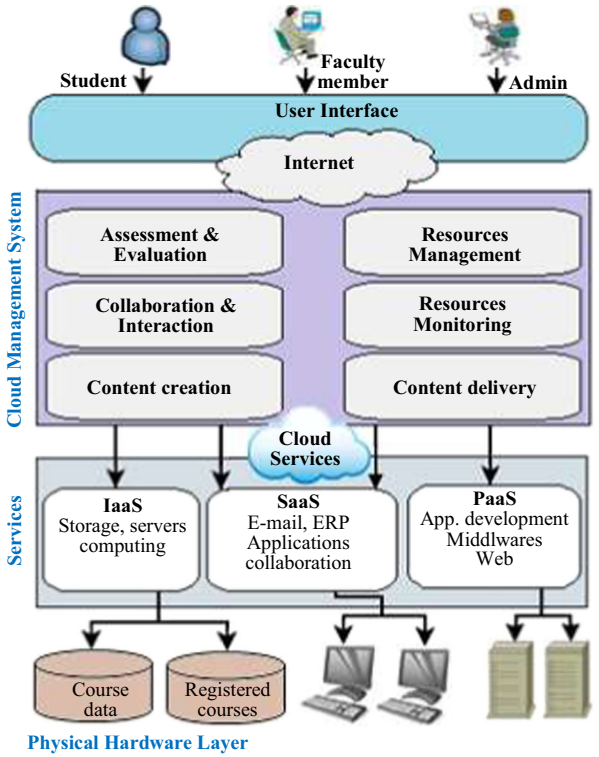

Fig. 8 Common architecture of the cloud-based e-learning systems

The architecture of e-learning systems based on the cloud is divided into three main layers. The first layer is the Cloud Management System Layer. It represents the interface of e-learning system with the cloud environment. This layer consists in several management subsystems which allow the integration of e-learning practices in the cloud computing model. Rather than having to install course design and management software, actors involved can simply use their Internet browsers to upload content, create new courses and collaborate between them.

The second layer represents the virtual machines implemented within the system and which deliver cloud services. It delivers three types of cloud services: SaaS, Paas and IaaS. Users use software via the Internet. They do not need to purchase software and hardware nor to maintain or upgrade them.

Finally, the third layer is the Physical Hardware Layer, which includes all the physical architecture of the system. This layer represents the information infrastructure and all resources used. It represents also for learners the basic computing power like physical memory, CPU ... The physical host pool is dynamic and scalable. This means that new physical host can be added in order to enhance physical computing power for cloud middleware services.

5 Discussion and recommendations

As we stated in this work, cloud-based e-learning architecture has many advantages over traditional e-learning architecture. In education field, providing e-learning solutions using cloud computing can be easier to maintain and update, can reduce costs and offer benefits to end users in terms of security and compatibility.

Indeed, cloud computing services are quite appropriate for supporting e-learning systems, in order to fully exploit the possibilities offered, and this by creating efficient learning environments that offer easy adaptation to the current e-learning model, a model based on collaboration and social interaction. Users and experts in the field claim that some of the most promising trends of modern e-learning systems will be the Web with cloud computing.

However, despite the convenience of cloud computing approach to tacking limitations of e-learning, we must stress that cloud computing technology is not free of risks and concerns. Some challenges, related to cloud technology itself, must be addressed before there is full integration of cloud computing in the university context. The implementation of e-learning solutions based on cloud computing needs to overcome these challenges.

One of the major challenges of using cloud computing concerns the connectivity weakness because cloud-based e-learning systems require fast and reliable Internet access, and the low speed connections reduce the efficiency of the provision of e-learning services. Thus, to ensure consistency and availability for educational institutions that have campuses dispersed in various sides, the low Internet throughput is one handle to tackle before a practical implementation of the cloud-based e-learning solutions.

Another challenge that must be resolved before the implementation of cloud-based e-learning solutions is related to the cloud privacy, security and confidence that remain unclear. Indeed, privacy and security issues continue to be the biggest concern that

slows down the adoption of cloud computing in e-learning practices. This issue of security, which is related to the multi tenancy nature and resource and data outsourcing, is still not convinced by many users. Educational institutions and actors involved are always concerned about the storage and the processing of their sensitive data and critical applications deployed on the cloud. Users continue to pose many questions about where are their data located, who manages their data, who uses their personal data, but also, what will be the fate of their data in case of cloud-based e-learning system failure.

Thus, the future work in cloud computing and its applications in almost all area, especially in education, must focus on developing mechanisms and approaches that are able to address its privacy and security issues. In this context, strict rules and norms are to be enforced so that the users will feel secured to use cloud computing.

6 Conclusion and future works

In conclusion, ICT are being used increasingly by educational institutions to provide efficient learning services using e-learning systems. These institutions face a wide range of challenges in implementing these systems such as costs, data storage, software and hardware resources, and a lack of technical resources. Cloud computing rises swiftly as a natural platform to provide support to e-learning systems and it is the core technology of the next generation of e-learning.

In this paper, we focused mainly on the application of cloud computing in e-learning. The research study gave an overview of the concepts of e-learning and cloud computing with theirs structure, benefits and challenges, and presents the impact on using cloud computing for e-learning.

The research shows that cloud computing has tremendous effects on the education modes and cloud-based e-learning systems are emerging as an attractive method for providing e-learning services. Cloud-based e-learning systems can reduce costs due to lower requirements of hardware and software and offer more powerful functional capabilities to end users. Cloud-based e-learning systems are also easier to deploy across multiple locations as they are centrally administered.

In addition to the potential advantages of using cloud computing, this research has discussed the cloud limitations that should be considered. These limitations are related to issues surrounding the security of the cloud, as well as the low speed of Internet connections that reduce the efficiency of the provision of e-learning services.

As part of the continuity of this work, we are working on the design of a cloud-based e-learning environment dedicated to the collaborative production of e-learning contents as learning objects. The objective of the framework is to improve collaborative learning. On the other hand, further research will be devoted to the aspects of security, privacy and confidence in cloud based e-learning.

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