U-Lab Cloud: A Ubiquitous Virtual Laboratory Based on Cloud Computing

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***Abstract*— This paper describes a proposal of U-Lab Cloud, a ubiquitous virtual laboratory based on Cloud Computing. This environment will provide hardware and software resources dynamically, making it possible to increase the resources as needed. The environment will be adapted to the user's context and will consider the individual characteristics of each student, such as connection speed, device type and cognitive style of the student.**

Keywords- u-learning; laboratory virtual; cloud computing.

I. INTRODUCTION

The use of virtual laboratories is essential for acquiring practical skills [1]. These laboratories allow students to perform simulations and practice theories without the need of a physical laboratory, because the construction of such laboratory requires high investment costs and adequate infrastructure. Moreover, others difficulties found are: the need of exclusive use of these resources and its quick obsolesce. [2]. In this scenario, it is necessary to provide an accessible environment that meets the individual characteristics of each student. According to Piovesan [3], U-learning environments provide access to educational resources with full mobility and an adaptation system to the computational context of students. Facing the need of providing a personalized educational environment to the context of the students, this work aims to provide the U-Lab Cloud, a ubiquitous virtual laboratory. Its objective is to identify variables of the user context, such as the student's cognitive profile and connection speed. With the identification of these characteristics, the U-Lab Cloud will indicate what type of content presentation is the most appropriate for that student, then U-Lab Cloud will dynamically provide the software and hardware resources available from a Cloud Computing environment.

Some analysts predict that by 2020, most of the world's digital data will be handled, monitored and/or stored in clouds - if not throughout their whole life cycle, at least in part of it [4]. Thus, Cloud Computing emerges as a technology model that allows access to the network in demand, in favor of configurable shared computing resources (e.g., networks, servers, storage, applications and services) [5]. Most existing solutions for U-learning, based on Cloud Computing, implement some models of cloud services without integration with a learning service [2][6][7].

Therefore, this work aims to integrate the latest technology trends, ubiquitous computing and Cloud Computing, in order to present the same potential in educational settings, given the diversity of available platforms, operating systems and patterns.

II. CLOUD COMPUTING

Cloud Computing is based on surveys of virtualization, shared computing, "grid computing" and more recently, networks, the web and software services [7]. Cloud Computing is defined as "a computer model with the ability to allow, in a ubiquitous and convenient way, the access to shared and configurable computing resources" [8]. One of the advantages of using cloud services is the reduced concern of the loss of data or the intrusion of a virus [9]. The use of virtualization and cloud technologies provide versatile management of computing systems, because it can be easily deployed, scaled, replicated and updated in any of the levels of the Cloud Computing [1].

Cloud Computing is an emerging computing model in which users can have ubiquitous access to their applications [10]. According to Dey [11], it promotes the idea of ubiquitous exchange of information anytime and anywhere by the use of transparent, intelligent and integrated computer technologies. This way, Cloud Computing can be used to support ubiquitous environments. However, the implementation of a ubiquitous, scalable and reusable educational Cloud Computing architecture still faces big challenges in the areas of technology advancement and better practices [9]. Although several studies address Cloud Computing in Education [1][12], the lack of a systematic description during the development of the Cloud Computing platform is noted, because most papers discuss only techniques, types of services and others.

Among many characteristics of Cloud Computing, according to [1] using this technology allows the management of versatile computing systems, because it can be deployed, scaled, replicated and updated easily in any of the levels of the computing cloud. To Liang and Yang [9], one of the biggest advantages of using cloud services is the reduced concern about data loss or the intrusion of viruses. Cloud computing is an emerging computing model that the users can have ubiquitous access to their applications from any connected device [10]. When analyzing the computational cloud model, one realizes that one of its biggest benefits is the

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flexibility that it provides to the user. Therefore, the user needs to have in his computer device only a browser installed to access the desired application, without the need for installing software or even performing updates.

Another potential of Cloud Computing is the possibility of sharing data and conducting collaborative work practices that facilitate working in educational settings. For example, to centrally store all data in one place with the same format, it excludes the need for conversions and adaptations.

In addition, large financial investment to use Cloud Computing in institutions is not necessary, since this infrastructure requires little computational resources, i.e., it can be used by computers with simple hardware (personal computers). Spending on software license is not necessary because by joining this alternative you have the possibility of using open source operating systems, which can be installed for free with no restrictions on the number of machines.

So, it was estimated that the use of this new paradigm of computing can bring many operational and financial benefits. However, there are some significant obstacles when using Cloud Computing. A major disadvantage of using this model points to data security and asks whether it is possible to maintain total security in data traffic. The unavailability of service can be another obstacle to the success of this computational model, since it is necessary to connect to the Internet to access certain data.

III. U-LEARNING

The term Ubiquitous Computing has emerged in the 90s, initially proposed by Mark Weiser. This concept promotes the idea of the exchange of information anytime and anywhere through the use of a transparent, intelligent and integrated way of computer technology [13]. Yahya et al. [14] describes the technological developments, especially the expansion of computing and communication abilities of small electronic devices as responsible for the progress of electronic-learning (e-learning) to mobile learning (m-Learning) and m-learning to the ubiquitous learning (u-Learning). So, the u-learning automatically adapts resources and content according to the preferences and needs of students at any time and place, observing the characteristics, context and available resources [3][15].

In [7], Ubiquitous computing environments are defined as "an area that incorporates a set of embedded systems (computers, sensors, user interfaces, and service infrastructure) that is reinforced by technological computation and communication." The ubiquitous computing environments allow learning the right thing, at the right place and time, and in the right path [3]. Piovesan [3] complements that the u-learning environment allows "access to educational resources with full mobility and adapting the system to the computational context of the students".

A feature of Ubiquitous Computing is the sensitivity to the context. In [11], a definition of context is any information that can be used to characterize the situation of entities that are considered relevant to the interaction between a user and an application.

To Pernas et al. [15], sensitivity to context refers to everything that occurs around the user, and that influences how it interacts with the environment and with other people. According to Dey [11], context-sensitive computing should be aware of the state of the user and its surroundings, and must modify their behavior based on this information.

IV. RELATED WORKS

Cloud Computing proposes the integration of various technological models for the provision of hardware infrastructure, platforms of development and applications as a service [6]. The virtualization is one of the prerequisites for the realization of Cloud Computing [5]. Therefore, it allows the execution of multiple virtual machines (VMs) on a single physical machine. Among the many advantages of Cloud Computing applications with focus on teaching, one can mention scalability, centralized storage, flexibility, accessibility and low costs [16]. Cloud Computing is an infrastructure that has been explored in educational environments [1][5][15][16][18][19]. It is important to highlight that for the proper choice of the Cloud Computing platform, some aspects need to be considered: the Information Technology infrastructure and the most appropriate service model type to be implemented in the educational institution. An application can use one or more types of service, including: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) [17].

For example, Wenhong et al. [16] proposes a framework for managing PaaS in a virtual laboratory based on Cloud Computing that implements user management, resources and accesses, but it approaches the subject in general and does not focus on the needs of an educational system.

In [18], an infrastructure solution is presented in a private cloud that addressed a combination of three service models (IaaS, SaaS, PaaS); it was developed in the University of Hochschule Furtwangen (HFU). This solution allows the creation of Virtual Machines from choosing an image and software packages by the user. Similarly, Vouk et al. [19] describes a Virtual Laboratory with a Cloud Computing solution; it was developed by the North Carolina State University (USA). It enables students to reserve VMs according to their needs, choosing from basic images or images with specific applications. This platform is being used by a large number of users and currently uses a service (SaaS) model, providing a variety of specific applications for different areas of study.

In [1], a system based on Cloud Computing and virtualization directed to the engineering education was presented. This virtual laboratory provides hardware and software resources, where practical work from VMs can be developed.

The problems mentioned during the implementation were related to network communication and the creation of VMs on OpenNebula. Similarly, Wang et al. [12] provides a laboratory for network administration, implemented with the integration of VMware and Lab Manager, having as main characteristic the flexibility of resources.

Comparing with the mentioned works, the U-Lab Cloud differs from them because it will provide an environment adapted to the peculiarities of the students, for example, cognitive profile, the device they will be using and their connection speed. Another difference is that the U-Lab Cloud will provide students a ubiquitous environment and may be accessed from any device with an Internet connection, but without the need to make downloads or install applications.

V. PROPOSAL

The proposal of this paper is to supply from a platform of Cloud Computing the U-Lab Cloud, a ubiquitous virtual laboratory.

Among several factors that motivated this work, one of them is the problems faced by students when they fail to download certain materials, because they are using a low speed connection. This barrier discourages students, making them give up from seeking access to the materials. So, the proposed environment aims to get information from the user's context, such as: the connection speed to the cognitive style can create a user's profile. Then, it will provide the presentation of the content, adapted to each user's particularity.

Another particularity of this environment is that it will supply dynamic hardware and software resources, making it possible to increase or decrease these resources as it is needed for use.

The Cloud Computing is divided in three layers: IaaS, PaaS and SaaS [17]. So the proposed architecture for the U-Lab Cloud will approach the model in layers of services, as it can be visualized in Figure 1.

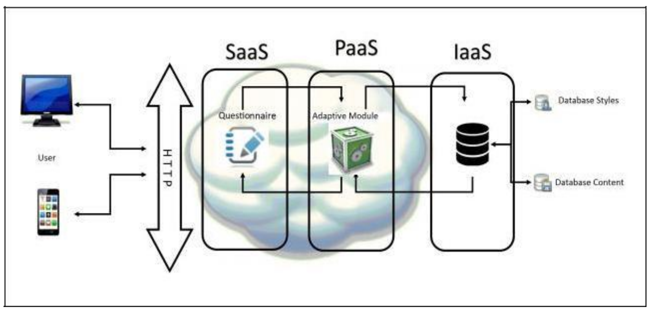

Figure 1. Architecture of U-Lab Cloud.

The SaaS layer is the most superficial one of this environment; it will provide the interface for the student. It will be available over Internet and it will be able to be accessed from any device with a Web browser. In this layer, students will have access to the provided applications, the adapted content and the proposed activities.

For the intermediate PaaS layer, it is suggested an Adaptive Module that will do the treatment of the student's information context. This is how it is going to work: first, it will be collected preferences from the student through the answering of a survey. Then the connection speed of the device that the student is using will be collected. After that, the Adaptive Module will determine the context style of the user, based on the connection speed and the materials that were chosen.

Finally, the Adaptive Module will communicate with the Database (DB) stored on the IaaS layer, and it will adapt the presentation of the content in the U-Lab Cloud, according to each student's context.

U-Lab Cloud will allow students to use the most recent software versions, independently from the hardware they have, because it will provide these resources in a dynamic way. So, if the number of users get higher, it will be possible to increase these resources as needed, without the concern of the physical infrastructure. To provide this environment, after performing a performance analysis which will be done with very similar hardware machines, a Cloud Computing platform will be selected.

Students will be able to access the U-Lab Cloud by any technology device that has an Internet connection that has a very minimal requisite: only a Web browser. It will be used in the desired time, from anywhere, from any device, making this approach ubiquitous.

VI. METHODOLOGY

To develop he U-Lab Cloud, five distinct steps were scheduled. The first is characterized by the construction of the theoretical framework, where we will seek to study the main concepts that will be used in its development. The second step also involves the implementation of a private cloud on a platform of Cloud Computing; the Eucalyptus version 3.4.2 with CentOS was used. Eucalyptus was chosen for providing open source versions and presenting the initial requirements for the context of this work.

The installation of this platform will be held on the network server located in the Network Group and Applied in the IT Laboratory that is located at the Federal University of Santa Maria in the city of Santa Maria, Brazil. This server has an Intel Core2 Quad Q9300 2.66 GHz processor with 4 physical cores of 8 GB of RAM and one hard drive with the capacity of storing 750GB with CentOS operating system. For the third stage of this work, it is planned to build the U-Lab Cloud, as well as the insertion of objects and Computer Networks related to teaching activities. The development of this stage involves the installation of Moodle [20], OpenSim [21], Sloodle [22] and WampServer [23] platforms.

Moodle was chosen because it is open source and is the virtual environment used at this university. OpenSim is the tool that makes the creation of the graphical interface of the virtual laboratory and it was chosen because it is open source, stable and allows the integration with the Moodle version. Sloodle will be used to integrate Moodle with OpenSim, and it allows the inclusion of activities on the topic of Computer Networks which is available to students through the U-Lab Cloud. Finally, the WampServer was used to create a local server.

In the fourth stage of this work, U-Lab Cloud will be validated in the discipline of Computer Networking, with students from the Computer Science Course of this institution. The fifth stage includes a statistical analysis that will be performed with data collected during the validation process.

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VII. CONCLUSION

The lack of physical laboratories at the institutions made the virtual laboratories arise as a complementary alternative to practice theories. Several works using virtual laboratories and Cloud Computing were evidenced but most of them had static characteristics.

The difference of this proposal is that it will be considered the variables from the student's context, because these particularities influence directly in the teaching and learning process.

With this work, it is intended to provide a ubiquitous environment, based on the principles of Cloud Computing and virtualization. These technologies will be selected after the realization of performance tests using almost homogenous machines. This work has presented the proposed architecture for the development of U-Lab Cloud, describing the service layers that it will approach.

With the fulfillment of U-Lab Cloud, it is intended to supply scalability, availability and ubiquity to students and teachers. With the completion of this study, it is intended to demonstrate the viability of the Cloud Computing infrastructure platform in the educational environment, as well as the advantages in using it.

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