SOFTWARE ARCHITECTURE IMPLEMENTATION BASED ON OPENSIM

D. Fernández-Avilés, D. Contreras, J.C. Salazar

Universidad Politécnica de Madrid (SPAIN)

Abstract

One of the objectives of the European Higher Education Area is the promotion of collaborative and informal learning through the implementation of educational practices. 3D virtual environments become an ideal space for such activities. On the other hand, the problem of financing in Spanish universities has led to the search for new ways to optimize available resources.

The Technical University of Madrid requires the use of laboratories which due to their dangerousness, duration or control of the developed processes are difficult to perform in real life. For this reason, we have developed several 3D laboratories in virtual environment. The laboratories are built on open source   platform   OpenSim.

In this paper it is exposed the use of the OpenSim platform for these new teaching experiences and the new design of the software architecture. This architecture requires the adaptation of the platform to the   needs   of   the   users   and   the   different   laboratories   of   our   University.

We will explain the structure of the implemented architecture and the process of creating and configuring it. The proposed architecture is decentralized, each laboratory is housed in different an educational   center.

The architecture adds several services, among others, the creation and management of users automated, communication between external services and platforms in different program languages. Therefore, we achieve improving the user experience and rising the functionalities of laboratories.

Keywords: OpenSim, Virtual Lab, Software architecture, 3D application.

1   IMPORTANCE OF NEW TECHNOLOGIES IN EDUCATION

The Spanish university education has been affected, first, by the size of the student population and the resources available, and secondly, by new horizons that ICT discloses [1], [2]. The dominant trend for last years was the increasing number of students, as well as, reducing the number of teachers. As a result, resources and classrooms available for the preparation of the laboratories have been exceeded. In this context, new technologies provide several virtual or simulated solutions [3] that solve the above problems and, not least, incorporate new educational and operational features:

- Allow the realization of teaching practices through the Internet, anytime, anywhere.

- Encourage autonomous work of the student facilitating customization of the learning process.

- Encourage the active participation of students, which allows millions of people around the world are connected by sharing knowledge in collaborative spaces.

- Allow offering practices that in real life would be very difficult to carry out for safety in the handling of equipment and materials (radioactive material, nuclear, electrical or biological material) or the cost of the necessary equipment.

- Improve accessibility of university practices.

2   VIRTUAL LABORATORIES

Consistent with the previous section and as a result of the work of Educational Innovation Project, GridLabUPM was created in 2010. This platform hosts a number of virtual laboratories, where users can make real teaching practices of the different colleges of the Technical University of Madrid.

The platform is built on open source software OpenSim [4], which manages the 3D virtual worlds. The programming language used to provide functionality to objects in the virtual world is Linden Scripting Language. On the other hand, users require a client application, which is used as a viewer and shows the user the graphical representation of the virtual world. This type of application allows users to connect to the virtual world, we recommend using Firestorm [5]. Entering the GridLabUPM, users appear in a central region of welcome, consisting of buildings, a virtual meeting point and a region of tutorial. The main objective of this region (see Fig. 1) is that new users will adapt to the management of the virtual environment.

Figure 1. Central region

Nowadays, thirteen laboratories have been completely developed in the following areas: electronics [6], biotechnology, physics, chemistry, biology, robotic, agroforestry, continuum mechanism [7] and industrial. Ten laboratories are under exploitation.

Due to the large number of laboratories and users, which are increasing, the demand for improvement and expansion of laboratories with new functionalities and content teachers and OpenSim own limitations, we developed a software architecture that supports the new requirements of platform.

3   SOFTWARE ARCHITECTURE IMPLEMENTATION

This new architecture is based on the default architecture of OpenSim and adds a number of improvements in the form of services that increase the functionality of the laboratories and the services offered to users.

3.1   Default architecture OpenSim

This section describes the configuration options selected to configure OpenSim, we will call default architecture to this configuration and was used in the early years of use of the platform. Fig. 2 shows the default architecture.
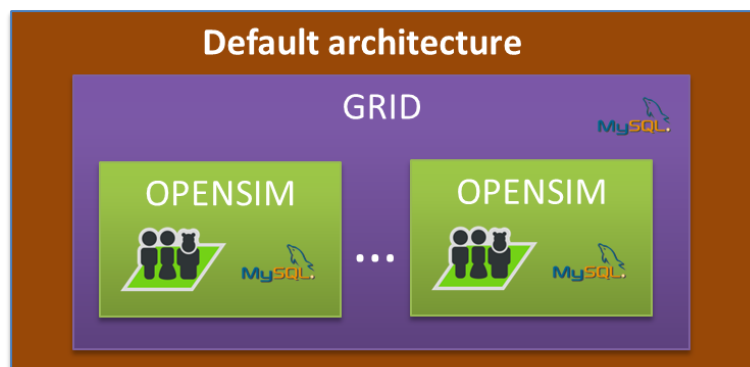

Figure 2. Default architecture

3.1.1 OpenSim

OpenSim operates in Grid mode, in which laboratories are hosted on different servers running an instance of OpenSim and which are connected via the Internet to a central server that manages all laboratories. The architecture is, therefore, decentralized.

3.1.2 MySql

OpenSim uses a MySQL database to store all information in the virtual world, both the central server and distributed servers run a separate instance of MySQL.

3.2 New architecture

This section describes the new features or services incorporated into the GridLabUPM. We have to distinguish between two types of services (see Fig. 3). Some services are more general and connect to the central server, serving all laboratories and other services connect directly with each individual laboratory.
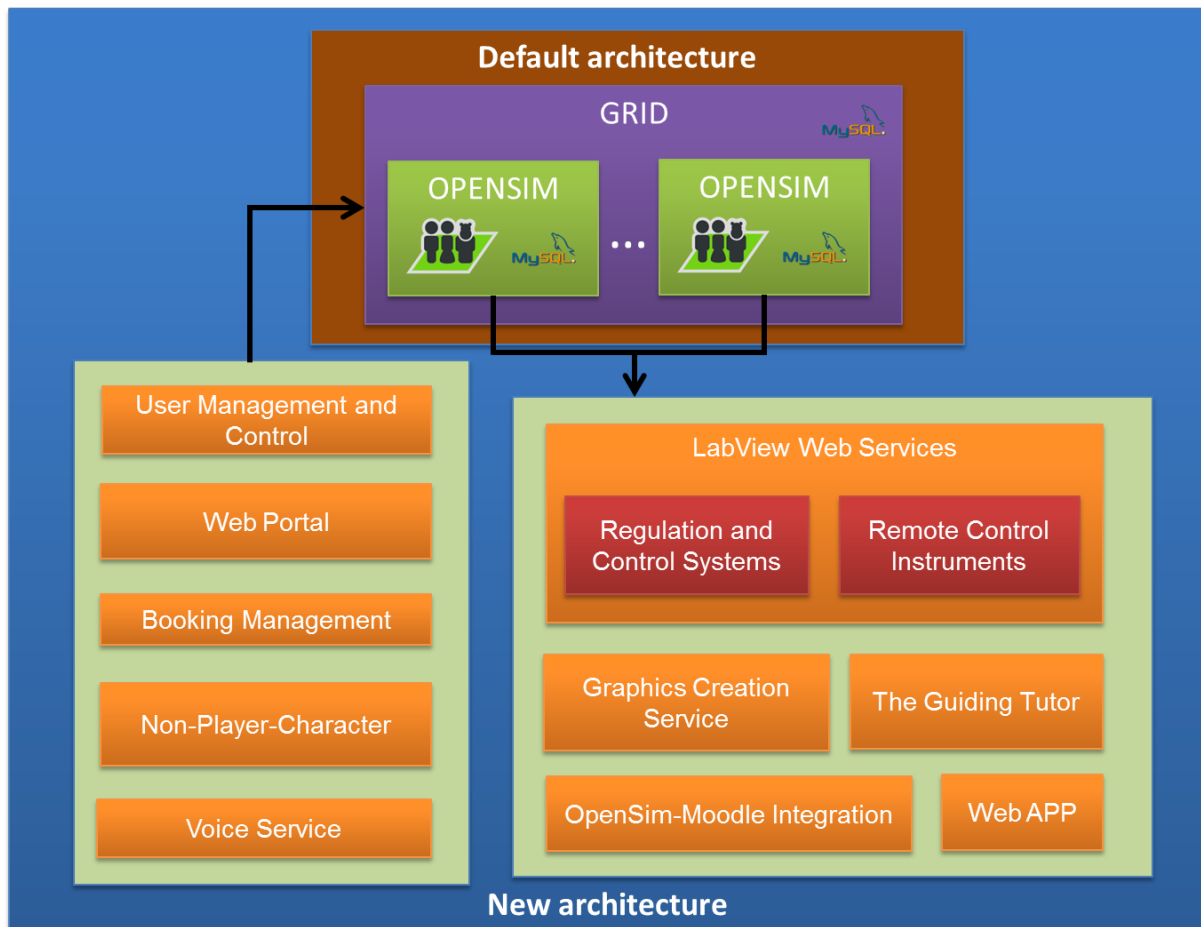

Figure 3. New architecture

3.2.1 User Management and Control

One of the hardest problems we found was user management (create and delete users and modify personal data). OpenSim is prepared to perform these actions from its own console, so we need to create an automated service for these actions. As a result, we have developed a PHP web application that facilitates the management of these actions. This application is integrated in the web portal and the platform Moodle [8] allowing user to management easily your account. Others services show users connected, the last connection, the number of laboratories and your names, and the data and statistics of the central server and distributed servers.

3.2.2   Web Portal

To achieve more visibility of laboratories, we created a web portal [9] that presents all the project information. Specific information about laboratories, GridLabUPM and 3D viewers can be found. Furthermore, there are manuals about viewers, access and configuration to GridLabUPM, handling in the virtual world, descriptions of virtual practices and video tutorials.

Furthermore, web portal allow creating users and do surveys about GridLabUPM. In addition, there is a section where developers can access and download 3D objects and scripts used in the laboratories.

3.2.3   Booking Management

One of the important services in a laboratory, both real and virtual, is a booking system. For this reason, we have developed a PHP application in which next properties are defined: permitted days, schedule available, maximum number of reservations, whitelist (users that do not need to book) and number of available seats. The booking panel is accessible both from practice room in 3D world and a web browser.

3.2.4   Graphic Creation Service

In the realization of the laboratories is usually necessary the data representation (or data sets) in a graph. For this, we have developed a service using the 'Google Chart API' tool [10] that allows us to create graphs in image format (.png) or embedded in a web.

This service developed in PHP, consists of two parts. The first, receives the properties to the graphs: axis values, graphs type, number of graphics, color, number of lines, the points size and the data to represent. The second part is communicating with the Google Chart API to create the graph. When the graphic is created, it is embedded in a web accessible from 3D environment and users can zoom and take data to treat outside the GridLabUPM.

3.2.5   LabVIEW Web Services

Developing certain laboratories we have found it difficult to model some behaviour due to the limitation of Linden Scripting Languages. This language has many functions, but not comparable to other more versatile programming languages. For this, we have developed a web service by LabVIEW [11] from National Instruments. Through http requests from OpenSim we communicate with two services:

- Regulation and Control Systems

For model, identification and control of physical systems in some virtual practices, depending on the configuration selected, practises of simple or complex systems can be implemented: first order linear equations, second order linear equations or higher order.

- Remote Control Instruments

The user has available the management of real instruments and set of analog circuits with which they can interact changing settings and taking measures to check the operation of these circuits. The architecture, that allows controlling of the real equipment from GridLabUPM, is shown below on Fig. 4.
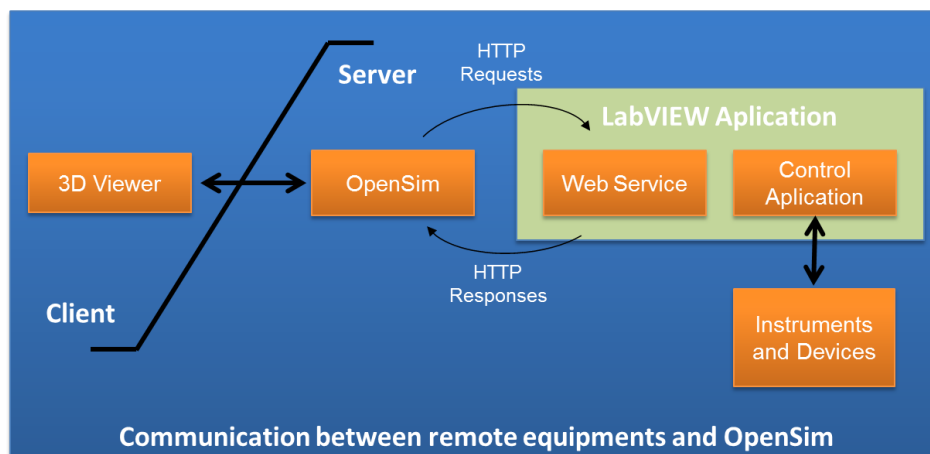

Figure 4. Communication between remote equipments and OpenSim

The configuration of equipment and circuits of each user is sent to the web service created in LabVIEW via http requests. The configuration of equipment and circuits of each user is sent to the web service created in LabVIEW via http requests. This web service is responsible for the management and control of the real equipment. The web service receives the data and performs in real equipment and circuits and returns the result (analog measurements, waveform, among others) to be represented in 3D laboratories.

3.2.6 Voice Services

OpenSim allows the integration of an external voice service to facilitate communication within the virtual environment. For this purpose, one of the most used programs is FreeSwitch [12]. FreeSwitch is open source. For this reason, we have chosen to include FreeSwitch to GridLabUPM.

3.2.7 Non-Player-Character

Non-Player-Character is a character that is controlled by the computer. We have included this type of character in the virtual world with different functionalities aimed at users: to guide within the virtual environment, to help a user when he feels lost, to follow a user through the virtual world, to welcome new users and to perform simple actions in the virtual environment (such as a walk and greet whoever who is) imitating who are users. These capabilities have been developed in Java.

3.2.8 The Guiding Tutor

The Guiding Tutor [13] has been included in several laboratory practices, especially in procedural practices in which the actions have a very strict order in its process. Using this component increases the complexity of developing laboratories but improves considerably your functionality, and their pedagogical function for users.

3.2.9 Web App

The main objective of the creation of this application is the capability to perform actions in the virtual world without the need to connect through a 3D viewer, therefore, without graphical interface. Users can connect to the virtual laboratory, perform certain actions and consult information from any device using web browser. The principal advantage is that users can connect to OpenSim from a mobile device, due to there are no 3D viewers with quality and free to connect to OpenSim for mobile devices. It is built in Spring [14].

3.2.10 OpenSim-Moodle Integration

This service is only available for students of Technical University of Madrid. We have developed a system that allows passing the qualification of the virtual practice of the student from the virtual world to the Moodle platform automatically.

4   CONCLUSIONS

We have created a new enhanced software architecture based on default architecture of OpenSim. This new architecture provides a set of new services for the users and improves GridLabUPM. However, we will continue doing improvements: developing new services and features, doing a gamification study and optimizing available resources of servers with the purpose to improve educational processes.

REFERENCES

[1]   Jong, T., Linn, M.C., Zacharia, Z.C. (2013). Physical and virtual laboratories in science and engineering education. In Science, vol. 340 no. 6130, pages. 305-308.

[2]   Balamuralithara, B., Woods, P.C. (2009). Virtual laboratories in engineering education: The simulation lab and remote lab. In Computer Applications in Engineering Education, vol. 17, no. 1, pages 108-118.

[3]   Darrah, M., Humbert, R., Finstein, J., Simon, M., Hopkins, J. (2014). Are Virtual Labs as Effective as Hands-on Labs for Undergraduate Physics? A Comparative Study at Two Major Universities. In Journal of science education and technology, vol 23, no: 6, pages: 803-814.

[4]   OpenSimulator. In: http://opensimulator.org/wiki/Main_Page/, visited on December 2014.

[5]   Firestorm. In: http://www.firestormviewer.org/, visited on January 2013.

[6]   Carpeño, A., López, S., Arriaga, J. (2014) Using Remote Laboratory eLab3D for a Broader Practical Skills Training in Electronics. In 11th International Conference on Remote Engineering and Virtual Instrumentation (REV), 2014 IEEE, pages 98-99.

[7]   Gonzalez, B., Mosquera, J.C., Ramírez, J.A., Fernández-Ordoñez, D., Fernández-Avilés, D. (2014). The virtual room as an opportunity to support collaborative learning in the area of knowledge of continuum mechanics. In 7th International Conference of Education, Research and Innovation, 2014, pages 1764-1768.

[8]   Moodle. In: https://moodle.org/?lang=es, visited on January 2015.

[9]   Laboratorios Virtuales UPM. In: http://serviciosgate.upm.es/laboratoriosvirtuales/, visited on January 2015.

[10]   Google Chart. In: https://developers.google.com/chart/, visited on January 2015.

[11]   NI LabVIEW. In: http://www.ni.com/labview/esa/, visited on January 2015.

[12]   FreeSWITCH. In: https://freeswitch.org/, visited on January 2015.

[13]   Rico, M., Ramirez, J., Riofrio, D., Berrocal-Lobo, M., and de Antonio, A. (2012). An architecture for virtual labs in engineering education. In Global Engineering Education Conference (EDUCON), 2012 IEEE, pages 1-5.

[14]   Spring. In: https://spring.io/, visited on January 2015.