Future Generation Computer Systems 48 (2015) 46–59

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

Cloud E-learning for Mechatronics: CLEM

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HIGHLIGHTS

- We have designed and developed a new customized cloud platform for e-learning.
- We have designed and developed a new cloud framework to model mechatronic devices.
- We have evaluated the system with users and teachers in the field.
- The proposed system is the first cloud based e-learning system for mechatronics.

ARTICLE INFO

Article history:
Received 1 May 2014
Received in revised form
8 October 2014
Accepted 25 October 2014
Available online 4 November 2014

Keywords:
Cloud computing
Mechatronics
E-learning
Remote virtual laboratories
Community
Ecosystem

ABSTRACT

This paper describes results of the CLEM project, Cloud E-learning for Mechatronics. CLEM is an example of a domain-specific cloud that is especially tuned to the needs of VET (Vocational, Education and Training) teachers. An interesting development has been the creation of remote laboratories in the cloud. Learners can access such laboratories to support their practical learning of mechatronics without the need to set up laboratories at their own institutions. The cloud infrastructure enables multiple laboratories to come together virtually to create an ecosystem for educators and learners. From such a system, educators can pick and mix materials to create suitable courses for their students and the learners can experience different types of devices and laboratories through the cloud. The paper provides an overview of this new cloud-based e-learning approach and presents the results. The paper explains how the use of cloud computing has enabled the development of a new method, showing how a holistic e-learning experience can be obtained through use of static, dynamic and interactive material together with facilities for collaboration and innovation.

1. Introduction

Mechatronics combines the disciplines of electronics, mechanics and computer science. The fusion of techniques from these disciplines enables fantastic technological advances with many practical applications. Example application areas include the medical field and increasingly intelligent industrial automation with sophisticated use made of highly-calibrated sensors and complex control systems. A workforce with relevant skills is essential if the potential of these technologies is to be realized. Highly trained individuals with relevant skills in mechatronics will be increasingly sought after by emerging industries in the new technological and information age.

Heightened by the growth and vision of the Internet of Things [1,2], a need has been identified in Europe for vocational skills

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http://dx.doi.org/10.1016/j.future.2014.10.033
0167-739X/

development in the area of mechatronics [3–5]. The objective of the EU Leonardo project in CLoud E-learning for Mechatronics (CLEM) is to develop an infrastructure for e-learning based on cloud services which will contribute to satisfying this need [6]. The approach of CLEM is to develop a method and exemplar to enable learning providers to create and deliver suitable courses in mechatronics, tailored to local requirements, in a scalable and sustainable way.

Training, and in particular, vocational education and training (VET) has in recent years gained an important status on the European social and political agenda. Demands for a highly skilled workforce for the European economy are challenges for the teacher and training community. Continuing professional development (CPD) of teaching staff and trainers is a key element in meeting the demands of industry for highly skilled workers. Skilled educators are needed to train the workforce. This project has resulted in an interactive resource base in mechatronics which is tuned to the needs of VET teachers and hosted in the cloud. This provides a new and dynamic method of teaching through which teachers and trainers can impart industry-ready knowledge and develop relevant skills.

The emerging technologies of cloud computing and service-oriented computing, allow resources to be interoperable and shareable. This enables the facilities and materials for e-learning to be modelled as services and managed in the cloud. The advantage of this is that the users can obtain their required services without being concerned with technical issues. In addition, teaching materials can be easily composed to meet the users' requirements. Teaching or training materials developed in this way become accessible and sharable.

Many educational programmes display a trend towards increased cooperation, not only between different departments in the same organization but also among the many different organizations involved in national VET systems. These include schools, training institutions, companies and local and central government. Often, cooperation takes the form of what we have called bottom-across coordination, with individual teachers cooperating directly with teachers, researchers, administrators and policy-makers outside their own organization. This trend is embraced in CLEM which provides the means of community building and resource sharing.

CLEM is designed to be a platform to allow e-learning resources that can be interoperable and sharable in the e-learning community, but trainers have different requirements and preferences to meet their student background and training purposes. The number of students can be various in classes or courses, so the system should be flexible to accommodate their requests by providing their required sizes or numbers of resources. In addition, the resources exist in heterogeneous forms such as hardware (e.g. CNC machines, Motors, Servo and 3D printers), programs to control the hardware, and multi-media such as video clips, animation and slides due to the multi-disciplinary nature of the discipline of mechatronics. This is compounded with the dispersed locations of the resources, learners and trainers.

In this paper we describe the approach taken in order to deliver the CLEM objective and present our results. The paper is organized as follows. Section 2 reviews the state of the art in e-learning and virtual laboratories. Section 3 presents CLEM. Section 4 evaluates CLEM as a cloud platform while Section 5 provides a user evaluation of the system. Section 6 analyses related literature on cloud e-learning, pointing out the innovative nature of CLEM. Section 7 concludes the paper.

2. Related work in e-learning

E-learning is becoming very important in higher education as a means of reaching wider audiences as well as a convenient way to supplement traditional learning. Students like to see learning materials online as well as being presented in a classroom as it gives them more opportunity to learn and greater location freedom. Various principles for e-learning have emerged, an important one being the development of a community of enquiry [7]. A community of enquiry is the idea of groups of learners and instructors communicating or collaborating in order to increase understanding or solve a problem. This idea is better supported in e-learning rather than traditional learning because of the ease with which communications can be made in an online setting. An online community of enquiry can be supported through a cloud infrastructure, which is the approach taken in CLEM. Another important development in e-learning has been the provision of virtual or remote laboratories [8].

The idea of virtual laboratories in science and engineering has prevailed for some time now, ever since computers became very networked and ubiquitous. In 1986 National Instruments launched LabView (Laboratory Virtual Instrument Engineering Workbench) which is a software platform for interfacing to laboratory instruments enabling control and visualization. Many different types of instruments and buses are available for inclusion. In 2000, Ertugrul provided a review of virtual laboratory implementations that had been created using LabView [9]. He described the basic structure of a virtual laboratory as being a device under test which can be controlled electronically. Various sensors gather data from the device. The data can be captured and analysed remotely. The analysis results can determine control commands which can be sent to the device via a control interface. The experimenter can decide which control instructions to send or what environmental factors to change depending on feedback. The experimenter can also set hypotheses and test these by analysing the data that is gathered. Ertugrul's review describes industrial and education applications in various areas of engineering and science.

One of the main advantages of virtual laboratories used in education is that learners can have access to laboratory equipment and data that we would otherwise be beyond reach, because of cost, time, distance or rarity. Ertugrul observed that the roles of teachers and students were changing and that new methods of learning were still to be discovered. Since then there has been much further effort and interest in virtual or remote laboratories in both education and industry. For instance, in 2003, Bistak and Zakova discuss organizing tele-experiments for control education [10]. The paper describes the authors' experiences in building remote laboratories. It also illustrates the various architectures for providing real experiments via the internet.

In 2005, Martin and Munoz [11] describe a distance learning course on virtual laboratory implementation for high school science teachers. The simulation environment used to implement the virtual laboratories in this case was Easy Java Simulations (Ejs), an open-source tool for teachers who do not need complex programming skills and which enables easy building of interactive visualizations based on mathematical models. The intended audience was high school teachers who wished to make use of interactive simulation in their classes. The course gives the skills to design and implement virtual laboratories for educational purposes using Ejs.

Remote control of experiments via Matlab was presented in 2006 [12] and in 2008 Zilka, Bistak and Kurcik described a hydraulic plant remote laboratory [13]. The authors discussed the means in which the hydraulic system could be integrated into a virtual laboratory. In 2009 Rojko described a system for e-training in mechatronics [14]. The system consisted of standard modules in the form of static learning material and also a virtual laboratory which was made through LabView. More recently Chaos et al. [15] have used EjS, Matlab and LabView to create virtual and remote laboratories. The Digital Systems and Media Computing (DSMC) laboratory of the Hellenic Open University (HOU) has created