Experiments in Collaborative Cloud-based Distance Learning

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***Abstract*—Mobile devices have revolutionary changed the process of multimedia consumption in distance learning systems and provide flexible user-oriented experience. M-learning systems typically include different kinds of multimedia resources helping learners to be more interactive and interested in collaboration. The proposed multi-tenancy group collaboration within the cloud-based learning platform (as a main contribution of this paper) provides easy and simple access to the cloud-based Platform as a Service (PaaS) model and delivers improved interactive tools for distance learning. This collaborative and interactive cloud-based learning environment that students are using to develop and deploy intelligent multimedia content resources has been subjected to quality of experience (QoE) estimation. Using the Questionnaire for User Interaction Satisfaction (QUIS) as estimation tool, the system has provided an effective collaboration environment between the students and the professor, by continuous interaction in the multi-tenant cloud environment.**

Keywords - distance learning; cloud computing; quality of experience; collaborative group learning.

I. INTRODUCTION

Traditional university applied teaching requires the professor to be present in the classroom to provide scaffolding and collaboration with students aimed to complete all assigned tasks that they are facing. The process of dissemination of the multimedia content in distance learning systems is a challenging task and requires more than just simple static HTML-based websites. With the introduction of the Web 2.0 technologies in distance learning context, we are facing a new era in the practice of e-learning [1]. L. Wan [1] has proposed a framework that consists of Web 2.0 tools, e-learning 2.0 application and e-learning 2.0 learning modes. Recent distance learning systems are directed to provide on-line collaborative tools, which are using Web-based e-learning architecture [1].

The multimedia material that is used in collaborative distance learning environment should be adjusted according to the mobile device capabilities, student domain knowledge level, interaction style and skills [2]. There have been several distance learning systems, like in [3], that propose a decentralized and distributed adaptive architecture, which would bring the possibility to support collaborative activities for sharing resources between students with their mobile devices in constantly changing conditions. Challenges in distance learning systems exist in the process of delivering individualized content according to student's particular learning needs, by using several technologies to ensure maximum collaborative learning tasks [4]. Taking into consideration the results from research by I. Jung [4], we have concluded that *interaction* is an important dimension in evaluating the quality of e-learning.

Mobile devices provide an interactive and user friendly interface that was investigated in mobile video retargeting and location-based systems [5], as well as in mobile health care applications [6]. Especially interesting is mobile multimedia computing because it is a computationally intensive task on mobile devices limited by battery and computing power [5]. Modern m-learning [7] applications are complex because they deliver learning content usually as multimedia material, which combines texts, pictures and video/audio files. Because of the limited mobile resources, algorithms designed for mobile multimedia systems need to be lightweight or when Internet access is available, part of the computing tasks to be offloaded in the cloud where more resources (such as computing, memory, and relevant data) are available. The existing research by C. Ciurea and P. Pocatilu [7], proposes m-learning applications and mobile learning processes inside a virtual university campus that have the great potential to enable innovative and effective distance learning techniques. Some of the positive benefits of using cloud computing architectures in distance learning systems development for m-learning systems are presented in [7], [8] and [9]. M. S. Fathi et al. [9] presented and developed the concepts and potential of innovative collaborative tools, such as Context-Aware Cloud Computing Information Systems, in order to ensure the delivery of applicable and reliable information to enhance the collaboration of the parties within the construction supply chain and project stakeholders.

The main contribution of this paper is the advantage of using the multi-tenancy group collaboration in cloud-based learning platform (CCLP) during distance learning processes in order to provide increased quality of e-learning. It will be estimated by the quality of experience (QoE) analysis conducted with a group of university students. We propose our collaborative cloud-based learning platform to provide easy and simple access to the cloud-based Platform as a Service (PaaS) model, in order to provide improved interactive tools for distance learning application.

This paper is organized as follows: Section II presents our proposed architecture of collaborative cloud-based architecture. Section III presents a case study for distance m-learning of a database course. Section IV gives overview on the results from the QoE estimation model. Finally, Section V concludes the paper.

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II. COLLABORATIVE CLOUD-BASED ARCHITECTURE

M-learning systems typically include different kinds of multimedia resources helping learners to be more interactive and interested in collaboration. The proposed collaborative cloud-based architecture for distance learning system uses Platform as a Service (PaaS) [11] cloud model that comes with integrated developer tools, database management system and Web server. This platform provides multi-tenant environment where users can work on different operating systems from mobile devices, and that way students and professors can access the cloud-based platform simultaneously from any location, at any time. The proposed collaborative cloud-based architecture is given in Figure 1, where different layered components in distance learning environment are illustrated.

Collaborative cloud-based architecture consists of three main parts: user interface layer, network layer and cloud-based multimedia delivery system. Mobile clients (smart phone, tablet and laptop) are members of the *user interface layer* that provide various access points for accessing our cloud-based system. The *network layer* is responsible for daily operation of the platform and monitoring Quality of Service (QoS). Networks are the main means to deliver the multimedia content through a variety of protocols (LTE, WiMax, WiFi, GSM, EDGE, etc.). The third component of this architecture is based on the cloud computing model and is composed of hardware (infrastructure) layer, virtualization layer, platform layer and multimedia service. The cloud management server uses the request broker agent that collects the users' requests for multimedia content and, depending on the estimated user profile and context-aware conditions, the adaptation agent is delivering the appropriate multimedia content to the user. The proposed cloud-based technologies provide high interactive environment (on a single or a group of users' level) as a basis for delivery of personalized and adapted multimedia content.

Using this cloud-based architecture, the student can work on their application independently and efficiently without additional problems with software installation and compatibility issues.

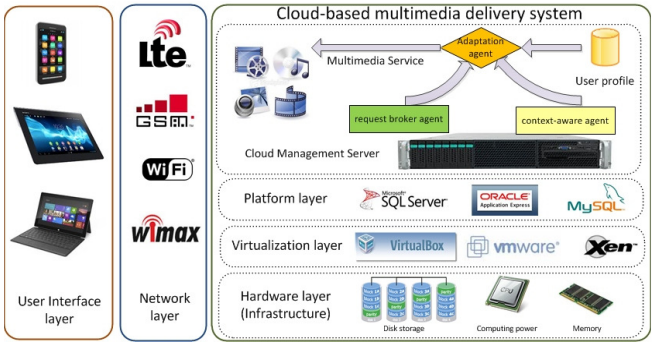

Figure 1. Collaborative cloud-based architecture.

The cloud provides ease of transfer of multimedia content between the students, using mobile devices, and the university distance learning portal. Students have the main developer role, they are creating database objects, and they write SQL request queries and develop Web-based applications. The professor has a supervision role, but also very important interactive possibilities based on PaaS cloud model. The learning process starts when mobile users enroll to the Web 2.0 university distance learning portal, then locate the link to PaaS cloud model learning platform. This way, the student has direct access from his personal mobile device to the remote Database Management System (DBMS) and he/she is able to send the SQL query to the cloud and receive results on his mobile device. Using the proposed cloud-based architecture, professors can monitor the students' progress and can provide scaffolding and propose more efficient solutions or can interactively support the error debugging in the application development progress.

III. CASE STUDY – DISTANCE M-LEARNING OF A DATABASE COURSE

The proposed collaborative cloud-based learning platform has been demonstrated to the students using the Web 2.0 university distance learning portal, see Figure 2. We have created a distance learning course for learning the database course by using the ORACLE database. The course covers the Entity Relations (ER) – real world modeling techniques that provide basic knowledge for designing relational database systems, see Figure 3. Our case study provides interactive communication with real database problems that students need to handle.

In order to conduct QoE estimation in our case study using the university distance learning system, the students were split into two teams: control and experimental groups. The first control group was subjected to regular distance learning course for SQL query data manipulation, and on the other hand, the second experimental group of students has been provided with collaborative cloud-based learning platform - APEX.

Figure 2. University Web 2.0 distance learning portal.

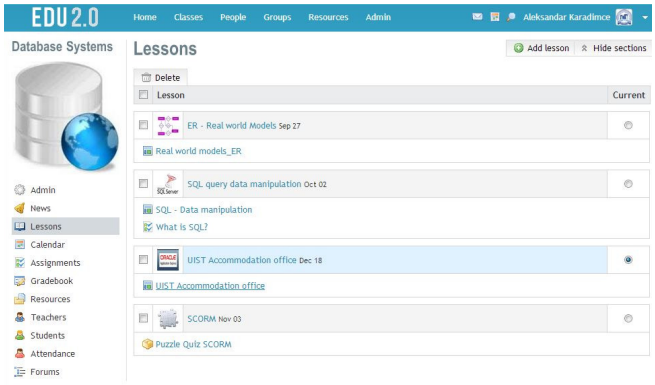

Figure 3. List of lessons for the course Database systems.

For the purpose of this case study, both lessons where available for learning on the Web 2.0 university distance learning portal under the database course in the section Lessons, see Figure 3.

A. *Control group of students*

The control group consisted of 15 students who have been offered a guided instructors' video and audio course that is explaining the process of constructing correct SQL data manipulation queries, see Figure 4. This course presented an existing database to the control group of students, where using video and audio guidance have been given scaffolding for SQL query development process. For this part of the research we have used only multimedia streaming services, without any help from cloud computing technology in order to deliver the instructions to the control group of students that were using mobile devices.

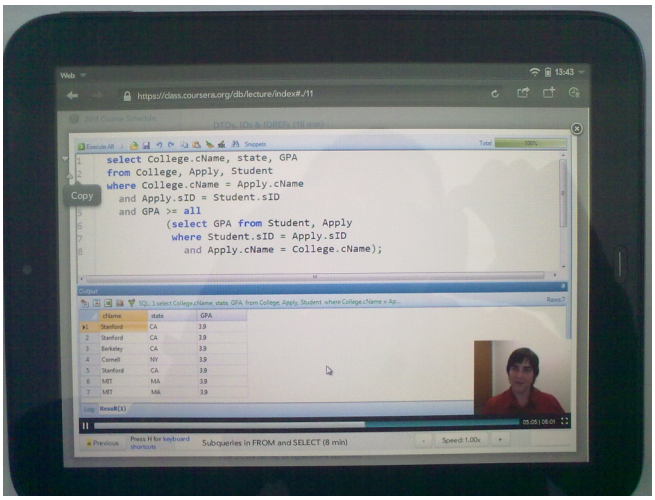

Figure 4. Course presented to the control group of students.

B. *Experimental group of students*

Using the proposed collaborative cloud-based learning platform, we have delivered customized interactive learning course for the experimental group of 15 students. Oracle APEX [10] is a collaborative learning environment for processing Web-based SQL requests, and offers a platform for fast, reliable development and running Web applications. Oracle Application Express (APEX) is a rapid Web application development tool for the Oracle database, which relies on Web browser in order to gain hardware independence. Using mobile devices to access this platform, students are able to learn how to build SQL queries and incorporate different types of items and shared components in the Web-based application [10]. Their learning effort was completed with developing a Web-based application "UIST accommodation office" (see the mobile screenshot in Figure 5) that was created from the proposed cloud-based platform. This system has provided an effective collaboration environment between students and professor, by continuous interaction in the multi-tenant cloud environment.

The database Web application was developed for the needs of the University Accommodation Office. It contains information about students, accommodation room types, lease agreement types, invoices and student flats inspections. Using this Web-based application, all the users can easily see their status of acceptance in the University Accommodation Campus. To estimate the benefits of this innovative collaborative cloud-based PaaS model for distance learning, we conducted a quality of experience (QoE) analysis for both university student groups.

IV. RESULTS FROM THE QOE ESTIMATION MODEL

Mobile devices have revolutionary changed the process of multimedia consumption in distance learning systems and provide flexible user-oriented experience. Today, there is a growing trend to estimate the user satisfaction of video, audio and interaction level with the collaborative distance learning systems. These collaborative and interactive environments that students are using to develop and deploy intelligent multimedia content resources have to be subjected to estimation using a QoE model. The QoE estimation, according to the International Telecommunications Union (ITU) has been defined as "the overall acceptability of an application or service, as perceived subjectively by the end-user" [12]. This requires subjective perception of the end-users and indicates the importance of the context in which a system is being used, as well as the expectations that users have about the system [12].

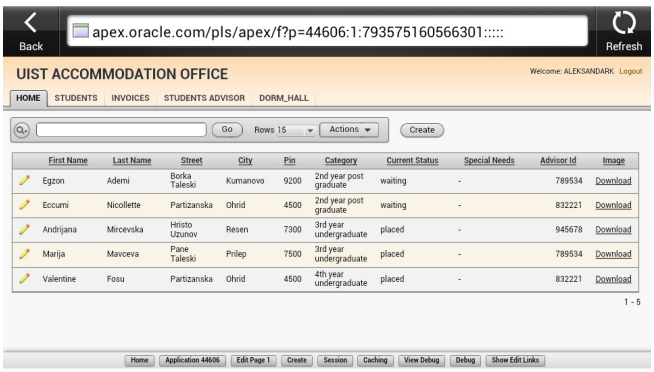

Figure 5. Course presented to the experimental group of students.

In our case study, of distance M-learning of database course, we have used rating scale for subjective evaluation of the student's opinion, as required. The aim of Questionnaire for User Interaction Satisfaction (QUIS) is to measure users' satisfaction with the human-computer interface and involves users' satisfaction to examine the relationship with the users' knowledge [13]. Students from both groups, control and experimental, were therefore required to respond to 22 questions, using a 9-point response rating scale. Scores were recorded so that a high score denoted a factor which was highly satisfactory, and a low score indicated a more negative response. This questionnaire provided a qualitative approach of the QoE that is applied to obtain the details of the participants' interaction with mobile device interface based on the individual experience. The QUIS questionnaire presented observations from the students overall reaction to the software, mobile screen, software terminology and system information, process of learning and system capabilities [13].

We have conducted our survey for QoE evaluation model in order to measure the quality of achieved learning. Distance learning systems should be supported with increased interaction using multi-tenant mobile cloud computing environment. The QUIS survey questions were answered by both of the groups consisted of 15 students, control and experimental groups, which participated in the database course.

The results from the control group of students that participated in regular distance learning course for SQL query data manipulation are given in Figure 6. We can conclude that control group of students have demonstrated better results from 12% to 14% percentage response for the values 6-7 on the 9-point rating scale.

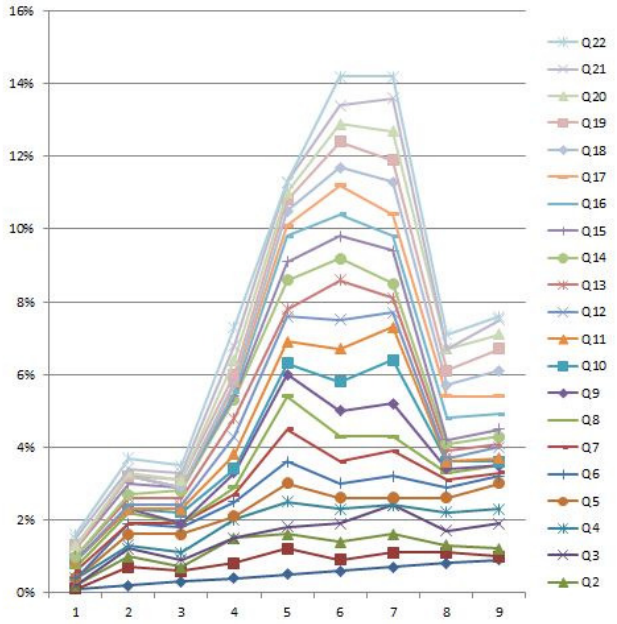

Figure 6. Results from the control group of students.

On the other hand, the experimental group of students participated in the course with *collaborative cloud-based learning platform* and created the mobile application UIST Accommodation Office. The analysis of the QUIS questionnaire completed by the students that participated in this group is given in Figure 7. From that chart we concluded that experimental group of students have demonstrated better results from 15% to 20% percentage response for the value of 8 on the 9-point rating scale.

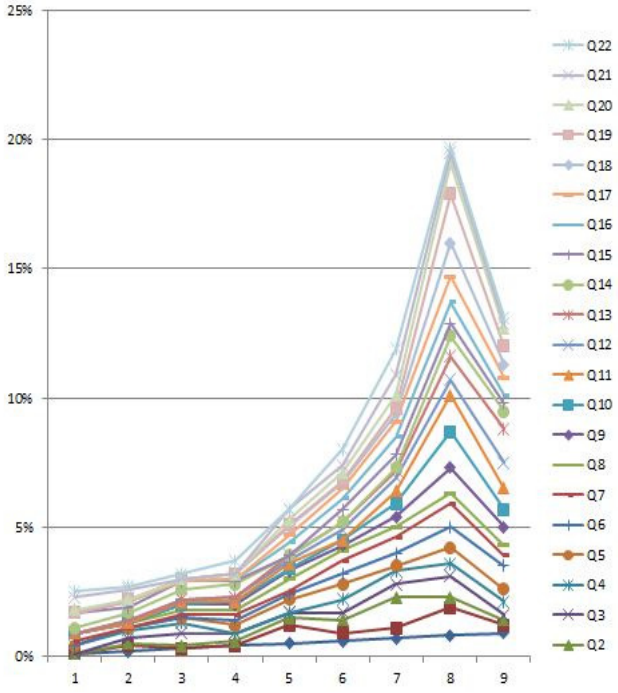

Figure 7. Results from the experimental group of students.

This research examines individuals' performance with mobile device interface according to QoE estimation model in order to confirm the consistency of this research. Comparison of the results from the QUIS survey completed by the two groups of students has allowed us to conclude that the group of students that was using collaborative cloud-based learning platform had increased overall attention and provided educational benefit in the process of learning. It is obvious that the cloud-based learning platform, using the benefit of the multi-tenancy collaboration, had provided higher interaction between professor and students.

V. CONCLUSION AND FUTURE WORK

The proposed collaborative cloud-based architecture enhances the importance and the benefits of collaborative and interactive knowledge in distance learning systems. This proposed system is based on the PaaS cloud model, which comes with integrated developer tools, database

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management system and Web server. That way, students and professors can access the cloud-based multi-tenant platform simultaneously from any location in any time. We have understood the advantage of using multi-tenancy group collaboration in cloud-based learning platform through the quality of experience (QoE) analysis conducted with a group of university students. The QoE model for evaluation was done using the QUIS in order to measure users' satisfaction with the human-computer interface and student's satisfaction that leads to improved distance learning.

In addition to the benefits from the proposed cloud-based collaborative environment, in our future work, we plan to provide an intelligent decision rules algorithm for adaptation of the multimedia content based on the user request, profile and context.

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