E-Learning on the Cloud

Mohammed Al-Zoube

Princess Sumaya University for Technology, Jordan

Abstract *Cloud computing technologies have changed the way applications are developed and accessed. They are aimed at running applications as services over the Internet on a scalable infrastructure. Many applications such as word processing, spreadsheets, presentations, databases and more can all be accessed from a web browser, while the software and files are housed in the cloud. Educational institutions can take advantage of cloud applications to provide students and teachers with free or low-cost alternatives to expensive, proprietary productivity tools. Browser-based applications are also accessible with a variety of computer and even mobile platforms, making these tools available anywhere the Internet can be accessed. This paper presents a cloud computing based solution for building a virtual and personal learning environment which combines a wide range of technology, and tools to create an interactive tool for science education. The proposed environment is intended for designing and monitoring of educational content as well as creating a platform for exploring ideas. The system allows exchange of educational content and integrate different pedagogical approaches to learning and teaching under the same environment.*

1. Introduction

Recent advances in computing, multimedia, and communication technology provide an opportunity to build a self growing, unit sharing virtual environment for teaching and learning. At present, it is common to access content across the Internet independently without reference to the underlying hosting infrastructure. This infrastructure consists of data centers that are monitored and maintained around the clock by content providers. Cloud computing is an extension of this paradigm where the capabilities of applications are exposed as services. These services enable the development of scalable web application in which dynamically scalable and often virtualized resources are provided as a service over the Internet [7,24]. Providers such as Amazon, Google, IBM, Microsoft, and Sun Microsystems have begun to establish new data centers for hosting Cloud computing applications in various locations around the world to provide redundancy and ensure reliability in case of site failures. Since user requirements for cloud services are varied, service providers have to ensure that they can be flexible in their service delivery while keeping the users isolated from the underlying infrastructure.

Cloud computing technologies enable institutions that do not have the technical expertise to support their own infrastructure to get access to computing on demand. Cloud computing makes it possible for almost anyone to deploy tools that can scale on demand to serve as many users as desired. Service providers enjoy greatly simplified software installation and maintenance and centralized control over versioning; consumers can access the service anytime, anywhere, share data and collaborate more easily, and keep their data stored safely in the infrastructure. To the end user, the cloud is invisible; the technology that supports the applications doesn't matter. For many institutions, cloud computing offers a cost-effective solution to the problem of how to provide services, data storage, and computing power to a growing number of Internet users without investing capital in physical machines that need to be maintained and upgraded on-site.

Educational institutions are beginning to take advantage of existing applications hosted on a cloud that enable end users to perform tasks that have usually required site licensing, installation, and maintenance of individual software packages [20, 21]. Many applications such as word processing, spreadsheets, presentations, databases and more can all be done inside a web browser, while the software and files are housed in the cloud. In addition to productivity applications, services like YouTube, Google Docs and Spreadsheets, as well as a host of other browser-based applications, comprise a set of increasingly powerful cloud-based tools for almost any task a user might need to do especially in elearning applications. Furthermore, it is very easy to share content created with these tools, both in terms of collaborating on its creation and distributing the completed work. Applications like virtual office, spreadsheets, databases, and social software can provide students and teachers with free or low-cost alternatives to expensive, proprietary productivity tools. Browser-based applications are accessible with a variety of computer and even mobile platforms, making these tools available anywhere the Internet can be accessed.

The purpose of this paper is to present a cloud computing based solution for building a virtual and personal learning environment which combines a wide range of technology, and tools for education. The proposed environment is intended to support formal and informal lifelong learning, and to enable mashup of various learning services and applications. The rest of this paper organized as follows: Section 2 gives an overview of virtual and personal learning environments and their classifications based on their pedagogical approach. Section 3 briefly describes current methods of building mashup PLE. Section 4 presents the proposed cloud-based elearning system. Section 5 presents some related work. Finally, Section 6 ends this paper with conclusion and future work.

2. Virtual and Personal Learning Environments

Virtual Learning Environments (VLEs) are electronic platforms that can be used to provide and track elearning courses and enhance face-to-face instruction with online components. Primarily they automate the administration of learning by facilitating and then recording learner activity. VLEs have evolved quite differently for formal education and corporate training to meet different needs. The most common systems used in education are Blackboard [8] and Moodle [10]. VLEs are the dominant learning environments in higher education institutions. Known also as learning management systems (LMS) and course management systems (CMS), their main function is to simplify course management aimed for numerous learners. The content within VLE is developed by teachers, which are mainly experts of a special domain. VLEs provide an easy to use system for flexibly delivering learning materials, activities, and support to students across an institution. For the administrator, a VLE provides a set of tools which allows course content and students to be managed efficiently and provide a single point of integration with student record systems. For the tutor, a simple set of integrated tools allows the creation of learning content without specialist computer skills, whilst class administration tools facilitate communication between tutor and individual learners.

One major drawback of existing VLEs is that it is content-centric. Many instructors simply move all their teaching materials to the system. The materials are presented uniformly to all learners regardless of their background, learning styles and preferences [18]. Nowadays, we are seeing the trend in education that emphasis on learner-centric learning. A learner-centric learning places learner at its heart. Learners are expected to actively engage in the learning process to construct their own learning. Thus they have more responsibility for their learning. Instructors are still responsible for learners' learning, but they play the role of "facilitator" who guides the learning process instead of being the sole information provider. A learner-centric learning will give learners a deeper and richer learning experience, as there is greater participation and involvement in the learning [3].

In the last few years a new wave of web technologies such as blogs, wikis, and social software, known as Web 2.0, has become a major technology that supports content publishing over the Internet [1,26]. Web 2.0 allows people to create, publish, exchange, share, and cooperate on information in a new way of communication and collaboration. Applying Web 2.0 technologies to elearning can enhance interactive communication and collaboration among participants and learners who either possess related learning resources, or can help to discover and obtain the resources, or are willing to exchange and share the resources with others in the Web-based learning. In Web 2.0, learners can read and write to the Web, in which learners become the consumers and producers of learning resources. Thus, Web 2.0 provides a learning environment have the potential to fundamentally change the nature of learning and teaching, through the creation of learner controlled learning web. This kind of environment is named Personal Learning Environment (PLE) [19].

Adoption of PLEs as the platform for elearning is motivated by several reasons. The most important is that PLEs help learners control and manage their own learning. This includes providing support for learners to set their own learning goals, manage their content and communicate with others in the process of learning, and thereby achieve their learning. A PLE also permits learners to join into groups and provides a suitable environment to practice social skills. Furthermore, PLEs can provide support for lifelong learning that is mainly informal and occurs over the life of the learner. Nevertheless, it has not been proven yet if PLEs can enable the growth of reflective skills, and thus enable the growth of self directed learner [18].

PLEs can be classified based on their architecture, client/server e.g. PLEX [5], or web-based with loosely joined or tightly joined web services, e.g. ELGG [9]. A second approach is based on their platform. For example, VLEs systems like Moodle and Blackboard have an architecture that supports a rich facility for extension points for PLEs' components [17,2]. Social software like Facebook includes a number of APIs that enable developer to produce a learning context as simple as building a Facebook entry for a class and then associating a number of Facebook applications with the context [6]. A more discerning classification approach of PLE's is based on their pedagogical approach. In the following, we will present three pedagogical approaches of PLEs.

2.1. Self-regulated pedagogical approach

This kind of PLEs represents a set of loosely joined services that are utilized by a learner, usually a skillful user of the Internet, to set and achieve his learning goals. Loosely joined services will ensure modular development of the system and make it so easy to build a PLE that is continuously evolvable to meet user needs. The PLE is very much learner controlled and suited to self-directed learning. For example, user can use Google Docs as web-based office where he can share documents with peer learners and for collaborative report writing. Also, learner can use YouTube to share educational videos, Google Calendar to set goals and timetable, etc. In fact, Google Apps for education resemble this kind of PLEs. Social software based PLEs, such as ELGG which is social software especially built for elearning, provide self directed pedagogy where user can be a member of a social network of common learning goals, get peer assistance and exchange information with other peers. Personalized home pages, like iGoogle or myYahoo, offers an environment where the user can glue up all components of his PLE in canvas view.

2.2. Self-regulated and teacher-led pedagogical approach

This pedagogical approach supports both formal and informal lifelong learning and strives to facilitate empowerment of both learners and teachers, while producing personalized learning experiences. The already in use VLEs that covers the social aspects of online learning is the most suitable platform for this PLE. Current VLE systems have architecture to flexibly expand these systems in order to add features where this social collaboration can take place within a learning context. The Moodle VLE is one example that is developing rapidly and contains the affordances necessary for this model of eLearning. However, a major shortcoming is these mechanisms for extension are proprietary and users cannot themselves extend these VLE systems.

2.3. Self-regulated, teacher-led, and personalized pedagogical approach

Besides the formal and informal learning support, this PLE provides personalized pedagogical assistant to the learner such as recommendation of material, common interest learners, and adaptive path personal learning. Systems that provide personalized pedagogical aids could improve the quality of instruction while reducing the demands of an instructional designer. This smart PLE able to learn the habits of an individual user, remember those habits, and make the user's experience less repetitive and fixed. The iClass project is an open learning system which aims to establish a framework that delivers a personalized, adaptable and adaptive learning experience in a collaborative environment for learners [12]. iClass includes a number of services and an adaptive intelligent system exploiting the potential of ICT to support a personalized, flexible, learner-centered approach, for facilitating personalised eLearning experiences.

3. Mashup Personal Learning Environments

In the context of self regulated learning, a common feature that should be supported by all learning platforms is to enable user to shape his PLE. This means a learner can choose the applications and services that constitute his PLE, be able to add new applications, whether from the set of pre defined tools or own ones, arrange the learning tools according to the basis of a grid layout, and be able to integrate data from different resources to produce a new service. Such a solution is called mashup PLE [22].

Building a mashup PLE can be achieved in different ways depends on what to mashup be it data or application functionality. The simplest method for data mashups is using syndication, and widgets for applications and services mashups. Rich Site Summary standard (RSS) is one of the primary ways PLEs bring together data from distributed remote systems and aggregate or manipulate that data to provide a useful new service. RSS allows content creators to syndicate their writings and use RSS feed readers, such as Google Reader [11], to search web pages' content, and subscribe to RSS feeds to let the content come to them.

On the other hand, application mashups can be achieved by implementing the applications as a widgets, then glue these widgets together using suitable widget container. A widget is a portable application, typically implemented using HTML, JavaScript and CSS, which can be run in a wide range of platforms and performs a specific function, usually obtaining content from one website and displays it on another website [13, 23]. Widgets can offer a relatively low-cost method for exposing some types of institutionally managed services, such as timetabling, support services, and libraries, to be offered through personal systems. Thousands of widgets exist and may be found on download pages at places like Yahoo! and Google.

Currently, many learning management systems such as Moodle and Blackboard provide their own mechanisms to enable third party widgets to be incorporated by users [17, 2]. However, each system has a different API, and widgets must be developed for each one using the native programming platform of the system. To overcome this shortcoming a number of initiatives to standardize widget platforms have emerged such as the W3C's Widget specification initiative [12] and the Google Gadget platform. Google

Gadgets and OpenSocial APIs is an effort promoted by leading web development companies (Google, Yahoo, and MySpace) to manage and deploy social widgets on different social network platforms or personalized websites such as iGoogle.

Another approach for mashup PLE that provides adaptation mechanisms for learning environment construction and maintenance proposed in [25]. The Learner Interaction Scripting Language (LISL) and its prototypical implementation Mash-UP Personal Learning Environments (MUPPLE) is a platform for creating, managing, maintaining, and learning about learning environment design. The LISL allows experienced users to describe their learning activities efficiently and create their learning environment based on these activities. However, the utilization of iframes in this approach causes problems in cross domain scripting and MUPPLE still lack important functions, especially in the area of regulating collaboration and privacy.

4. Cloud-Based Personalized e-Learning System

This section presents a web-based elearning system that utilizes various social tools, smart agents, and interactive environments of Web 2.0 and available in cloud. The main components of the system are shown in Figure 1. The system has three major functionalities that are designed to support lifelong formal and in formal learning. The first one is a web-based course management system (CMS), which is managed by the web server. The second is a PLE where various web-based services and applications are utilized with iGoogle as a portal to these applications. The third is the smart agents which consist of a personalized learning path generation system and test generation engine.

The system has two models for personalization, assessment-based personalized learning and personalized space. Collaboration is achieved via Learning Service, which provide specific collaboration services for learners. Although the proposed system integrates personalization and collaboration in the learning environment, users have the option of switching off the personalization so the learning space can act as a collaborative environment. One major issue is the extra overhead required by instructors to set up the relationships between learning content upon addition of learning content into knowledge base. The underlying architecture of attaching assessment questions to each learning topic together with the relationships among learning content make it possible to easily and automatically generate quiz to assess learners' understanding of a particular learning topic.

The system functionality is implemented using C# and ASP.NET. Microsoft Language Integrated Query (LINQ) and the .NET client libraries, provided by Google, are used to interact and manipulate the data retrieved from the cloud services. In the following subsection, more details will be given for each component in the system.
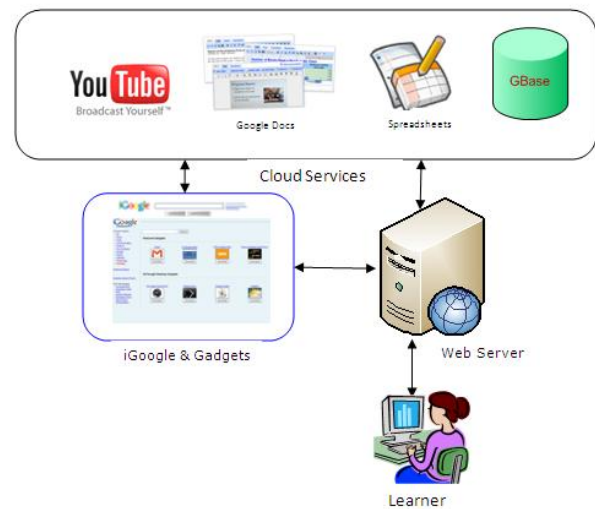

Figure 1. The main components of the system

4.1. The Web-Based CMS

The main objective of the CMS is to provide the formal learning for registered learners where they can access course materials, provided and maintained by teachers. The course contents, which could be documents, presentations, or videos, are hosted in Google Docs and YouTube. Google Docs is a web-based word processing application that allows users to create, view and share documents, presentations, and spreadsheets over the Internet. Each document has a creator, who determines who is allowed to access the file, either as a viewer (with read-only rights) or a collaborator (who can change the file). Because Google stores all of the files and content centrally, collaboration and document management become far simpler than when distributing files to multiple people and keeping track of different versions.

On the other hand, if the lesson is a video then it can be hosted in YouTube web site. YouTube allows users to post videos, watch those posted by others, post comments in a threaded-discussion format, search for content by keyword or category, and create and participate in topical groups. It also offers an open access to key parts of the YouTube video repository and user community, via an open API interface and RSS feeds. YouTube is increasingly being used by educators as a pedagogic resource. Many educators believe that the act of creating content is a valuable learning exercise, helping develop a deeper understanding of the subject matter and the tools used to create that content.

The CMS maintains an XML file of the lessons URLs which are arranged according to each subject graph. A teacher can add a subject to the by adding an entry to the XML file with the corresponding lesson

titles and URLs. The Docs API also enables full-text search over the documents, and hence, it is more convenient for students to search for specific information in the lessons. Figure 2 shows the CMS page with the available courses and lesson from Google presentation.
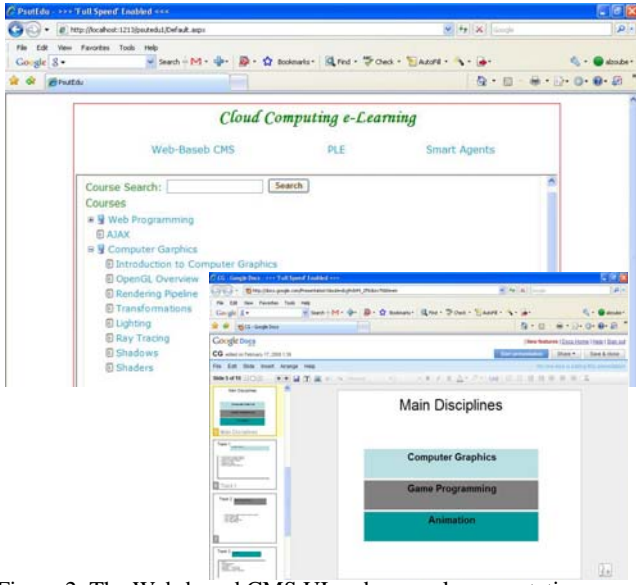

Figure 2. The Web-based CMS UI and a sample presentation hosted in Google Docs.

4.2. The PLE

PLE can be implemented in different ways as described in section 2. In our system iGoogle and gadgets are exploited as platform for learner to use whatever available gadgets he likes or build his own to set and achieve his learning goals. For example, a learner can choose Google Docs gadgets to access his own documents, Instant Messenger to send and receive messages, To Do gadget to set learning goals, etc. Figure 3 shows an example after the learner has logged to his iGoogle page.

Figure 3. The PLE implemented with iGoogle and Gadgets

One of the interesting gadgets in the PLE is the Personal Learning Network (PLN). PLN is a collection of resources that can help learning. This includes family and friends, teachers, and people in the local community. It can also include non-human resources, such as books, journals and other forms of media. PLNs provide individuals with learning and access to leaders and experts around the world bringing together communities, resources and information impossible to access solely from within school walls. One way to build that collection of experts is via RSS Feeds, which allows you to subscribe to their content and have it delivered to you in your RSS Aggregator (e.g., Google Reader). Every time they produce new content, it automatically gets delivered to you, allowing learner to tap their knowledge. The reader gadget in Figure 4 shows an example of PLN.
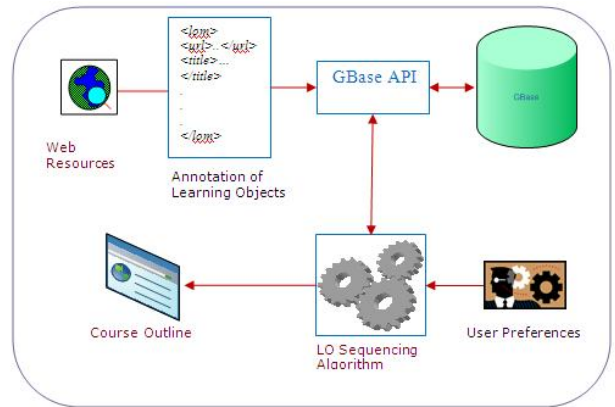

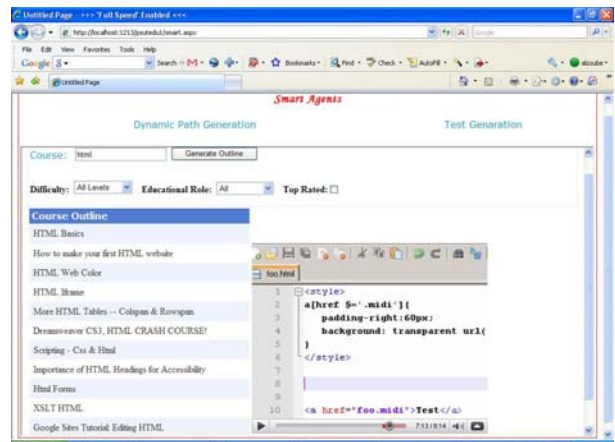Figure 4. The personalized learning path generation process.

Figure 5. A sample of generated course.

4.3. The Smart Agents

The purpose of the smart agents is to uniquely address the specific learning needs of a learner based on his prior knowledge and context. The system includes two agents; the first one is the personalized learning path generation. This agent provides an interactive mechanism for building adaptive courses dynamically. Instead of artificial intelligence-based algorithm, learners were placed at the centre of the system and asked to define their own learning style, paths and profile. The courses materials are web resources found to be suitable as learning objects, and described with suitable metadata elements. The following metadata are adopted from the IEEE LOM [15]: URI, title, topic,

difficulty, educational role, concept, and prerequisite concept. The metadata are stored in GBase which is a service where users can upload their structured data and use the GBase API to query those data. The algorithm allows the learner to choose the difficulty, type, or rate of the learning objects, and then query the GBase for learning objects of the specified topic. The retrieved list of learning objects are sorted according to their educational role while maintaining the concept and prerequisite concept relation them. Fig 4 depicts the process of generating personalized learning path, and Figure 5 shows an example of generated outline for HTML with YouTube lesson is presented.
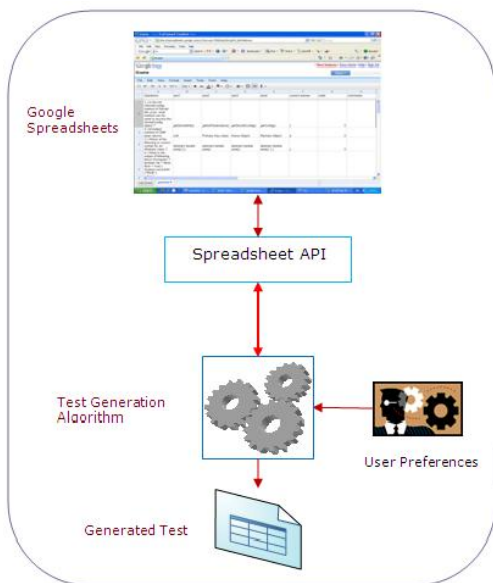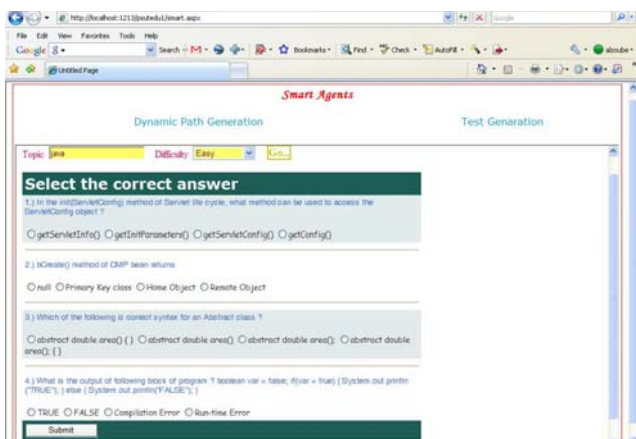

Figure 6. The test generation system

Figure 7. A sample of generated test.

The second software agent generates multiple choice tests. Google spreadsheets are used as a database for multiple choice questions, where each question record includes the following information about the question: a unique question identifier, the question text, the topic of the question, i.e. Ajax, HTML, the concept this question treats within the topic, and the difficulty level of the question. A test can be generated automatically by the application

using the spreadsheet API. The learner selects the set of concepts to be covered by the test as well as the difficulty level. Figure 6 illustrates the test generation process, and Figure 7 shows an example of a generated test.

5. Related Work

There are a number of similar or related projects that use cloud-based applications in elearning. Casquero, *et al.* [4] presented a framework based on iGoogle and gadgets over Google Apps infrastructure for the development of a network of corporative PLE. They discussed the integration of institutional and external services in order to give support, in a personal way, to the daily activity of each faculty member, and to take advantage of the framework as a test-bed for the research, implementation and testing of social services for educational purposes.

Marenzi, *et al.* [16] investigated how social software can be used in formal learning or work environments, and how to develop and integrate models and tools into an open source infrastructure for the creation, storage and exchange of learning objects, suitable knowledge resources as well as learning experiences. They presented the "*LearnWeb 2.0*" infrastructure to support lifelong learning and enhance learning experience. This infrastructure brings together information stored on institutional servers, centralized repositories, locally on learner desktops and online community-sharing systems like Flickr and YouTube.

North Carolina State University offers an online virtual computing lab [14], for requesting and reserving a virtual computer, complete with any of a number of applications such as Matlab, Maple, SAS, and many others that can be remotely accessed from over the Internet.

6. Conclusion

In this paper we verified that cloud computing technologies can be exploited to build the next generation of platform-independent tools and scalable data storage elearning systems to provide smart formal and informal learning. This set of technologies has clear potential to distribute applications across a wider set of devices and greatly reduce the overall cost of computing.

We built a virtual and personal learning environment which combines a wide range of services to create an interactive tool for education based on services available in the cloud. The proposed environment enables designing and monitoring of educational content as well as creating a platform for exploring ideas, and has a service oriented architecture that simplifies the management and increases the effective utilization of the underlying web resources. The system integrates different pedagogical

approaches to learning and teaching under the same environment. Initial feedback from users who tested the system shows this approach provides a much better user experience than the traditional learning management systems as it provides the learners a well known environment where they can easily achieve their learning goals, and flexible architecture enabling learners to mashup heterogeneous set of services that support different learning activities such as production, distribution, reflection, and discussion. In a future work, we plan to implement more services that are semantically aware of learners' context.

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Mohammed Al-Zoube received his B.Sc. and M.Sc. in Electrical Engineering from Jordan University of Science and Technology. In 2002, he received his PhD in Computer Science from University Science Malaysia, specializing in multimedia systems. Currently he is working for Princess Sumaya University for Technology at the department of Computer Graphics and Animation. . His research interest includes e-learning, cloud computing, and semantic web.