Adaptive E-Learning model for Educational Institutions Using Semantic Web

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Abstract

Research works in the field of E-Learning are represented by a broad spectrum of applications, ranged from virtual classrooms to remote courses or distance learning. The challenge of the semantic web is the provision of distributed information with well-defined meaning, understandable for different parties. As such, the Semantic Web represents a promising technology for realizing E-Learning objectives. This paper describes a framework for the implementation of an e-learning system based on the Semantic Web. The evaluation of the framework is performed through comparing the number of activities and visits to the E-learning system by both students and faculty members in the last three years.

Keywords: *E-Learning, Semantic web, Distance learning, Cloud computing*

1. Introduction

E-Learning is now considered to be one of the more significant and growing research and application areas of multimedia computing. The majority of formal e-Learning and distance education programs currently available are implemented using commercial products, such as WebCT [1], Blackboard [2] and Cisco IP/TV [3], to create, present and deliver the courses and associated materials. Although these products claim to be capable of providing interactive multimedia content services, the actual information management level is still limited by underlying low-level multimedia computing and information retrieval technologies.

E-learning has a wide range of learning strategies and technologies; from CD-ROMS, videoconferencing, TV lectures, and virtual educational classes, corporate universities and many more but our main focus here is on E-learning based on semantic web.

Semantic Web is a group of methods and technologies to allow machines to understand the meaning of information on the World Wide Web. It is about explicitly declaring the knowledge embedded in many web-based applications, integrating information in an intelligent way, providing semantic-based access to the Internet, and extracting information from texts.

Several higher educational institutions in Saudi Arabia have acquired the E-Learning platforms from different vendors. One of the leading universities in using Blackboard system is the King Saud University. However, we still face the limitations, such as, to collect, create and organize online content manually. Our students still have to bear with those huge lists of searching results. Another problem is that the university has to use two different systems; one for E-learning and another for Registration and Administrative purposes. To overcome these limitations, we present a semantic adaptive E-Learning framework towards enabling integrated learning contents, their retrieval and reuse, in this paper.

The primary aim of our framework is to provide a generic learning framework, which will serve the instructors and learners not only with flexible semantic-based learning environments, but also with manageable leaning process control. We have used Cloud databases as a knowledge base in our model. Cloud is a recent technology and many researchers have proposed the use of cloud databases for E-Learning platforms [15]. E. Aljenaa et al proposed an E-learning system based on cloud computing for Middle-East regional universities. [16].

This paper is organised as follows: Section 2 provides the conception of e-learning systems based on semantic web. The proposed framework is introduced in Section 3. Section 4 presents results and discussions. Section 5 concludes the paper and suggests the future work.

2. E-Learning Systems Based on the Semantic Web

The Semantic Web vision is based on two main ideas: adding the semantic mark-up to information resources on the Web and creation of intelligent services (agents) capable of understanding and operating with such resources at the semantic level. Intelligent agents are considered to be able to solve tasks in wide range of applications [4, 5]. Accordingly to T. Berners-Lee's vision the Semantic Web is organized as a multi-layer system with structure depicted on Figure 1.

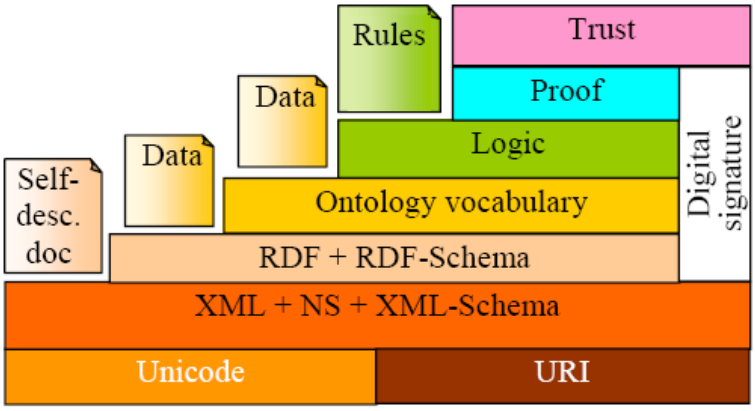

Figure 1: Layers of the Semantic Web

The lower layers of this structure (Unicode, URI, XML, NameSpaces) are well-known and widely used means within modern Web-based systems. The Resource Description Framework (RDF) is an infrastructure that enables encoding, interchange and reuse of structured metadata. RDF provides a means for adding semantics to a document. Information is stored in the form of RDF statements understandable by appropriate intelligent agents, search engines and browsers [6, 7]. The RDF statements may be (and usually) expressed in XML (although it is an optional syntax). RDF-Schema (RDFS) allows describing a hierarchy of basic classes and relations between classes and instances. RDF and RDFS provide modelling primitives that can be extended according to user's needs.

The ontology layer provides meaning of terms and domain theories shared by all participants within the information environment. Ontologies typically consist of definitions of concepts relevant for the domain, their relations, and axioms about these concepts and relationships. Several languages and systems are defined for ontology representation. The most well-known and advanced of them is DAML+OIL which have been developed as an extension to RDFS and OIL [8].

Models of reasoning with semantic data are implemented on logic layer. The real potential of the Semantic Web will be revealed when a large number of agents will be created that are able to collect information from different sources, process it and interchange results with another agents and people. The upper layers of a represented structure intend to provide the exchange of the proofs to acknowledge truth of obtained inferences.

3. Semantic Based Adaptive E-learning Framework

The semantic web (SW) extends the classical web in the sense that it allows a semantic structure of web pages, giving support to humans as well as artificial agents to understand the content inside the web applications. As a result, Semantic Web provides an environment that allows software agents to navigate through web documents and execute sophisticated tasks. Semantic Web itself offers numerous improvements in the context of Web-based educational systems contributing to the upgrade of learning quality.

According to Anderson [9], the educational semantic web is based on three fundamental affordances. The first is the capacity for effective information storage and retrieval. The second is the capacity for non-human autonomous agents to augment the learning and information retrieval of human beings. The third affordance is the capacity of the Internet to support, extend and expand communication capabilities of humans in multiple formats across the bounds of time and space. Based on these fundamental capabilities, we have designed our Semantic based E-Learning model depicted in Figure 2.

Each component concerning semantic web-based educational systems is discussed as follows:

3.1 Semantic Web

It is a collection of cloud storage, ontology, metadata, inference rules, educational resources and course descriptions, user profiles, etc. The cloud database acts as a medium for information storage and retrieval. It brings a new business model, where the services it provides are becoming computing resources [13]. Masud and Huang have described an architecture for E-Learning utilising the powers of cloud computing. [14].

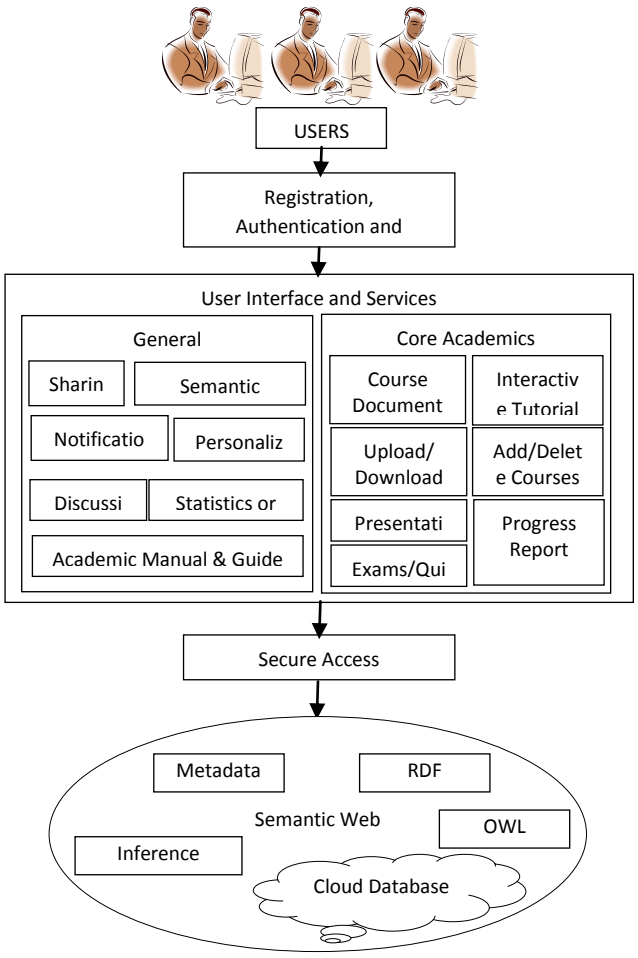

Figure 2. Semantic based E-Learning Framework

Ontology comprises a set of knowledge terms, including the vocabulary, the semantic interconnections, and some simple rules of inference and logic for some particular topic [12]. RDF is a framework to represent data about data (metadata), and a model for representing data about "things on the Web" (resources).

Metadata is data about data that helps us to achieve better search results [10]. Each component of the eLearning system can be described with the help of metadata. Also, for each user we can retain the information about his/her status. For example, we can store the user role – administrator, database manager, security monitor, regular user. The system utilizes two possible approaches that have been developed in the context of the World Wide Web, based on the XML and RDF formalisms. It is based on the usage of standard vocabularies or schemas for metadata to describe digital resources.

3.2 Secure Access Layer

The access layer is where the end-users (instructors or learners) connect to the network. This is a layer between the web and user services. It acts as medium through which all the operations on database take place. The layer identifies the queries and grant access only to authorised operations. It checks the illegitimate operations and help to secure the database. The layer is based on the principles of Secure HTTP [11]. It is like a firewall that protects the system from unauthorised users.

3.3 User Interface and Services

This is the most important layer of the system and acts as a functional layer. All the user requirements are processed through this layer. For the sake of simplicity of the system, the layer is divided into two parts: one deal with core academics and the other fulfils general requirements.

Academic facilities such as course content, online examinations, assignments, tutorials, progress reports are available anytime. Instructors and students may upload/download the assignments, projects, and home works with ease. The system provides the capability to add/remove courses at the beginning of each semester. Using the semantic capabilities of the system, the students can watch online tutorials and seek help about topics that are difficult to understand. The system facilitates the users to take online examinations, thereby reducing the efforts of both instructors and students. The results are published as soon as the student finishes the exam. The progress report becomes available at the end of each semester. The students may download and print the transcript or can use it as ready online reference.

3.4 Registration Layer

This layer provides access to genuine users. It provides an integrated interface through which students as well as instructors or administrators of academic institutions can access, upload or modify the data with particular authority. This acts as a security layer between the users and the system. It provides an interface and grant access into the system. New users can also register into the systems. The access is granted based on the user category. The administrator has full rights whereas the learners posses rights with certain restrictions.

The system permits the new user to get registered by providing the required information. Once a user is registered, the system allocates access rights to him based on his position. The user can then use the system after authenticating himself as a genuine user. The authentication process asks for a Login Id followed by a Password. After getting into the system, the user is

allowed to perform the authorized tasks depending on his access rights.

3.5 Users

These include the persons who are authorised to use the system. They may be learners, instructors, or administrators. They are the actual benefiters of the system. The access rights, however, differ from user to user. The Admin has complete access and control of the system. The Instructors are authorised to modify the contents, but do not have the right to change the structure or schema of the database. The students can access information and upload/download the materials related to their sections only.

Users will add any metadata (whether it is a personal annotation, certification, etc.) to a document referenced via the RDF learning object repository. For the end-user, this process of annotation is identical to the action of filling out fields in a Web form. After the user submits the form, the application automatically converts this additional information to a set of RDF statements, and then adds them to the existing RDF statements for this document in the repository.

In order to validate the model, it was presented to several academicians and administrators in different Arabian Gulf Universities. Their views were sought and many of the suggested changes were incorporated. Hence we can vow that the model is suitable for the learning environment in Arabian Gulf Area.

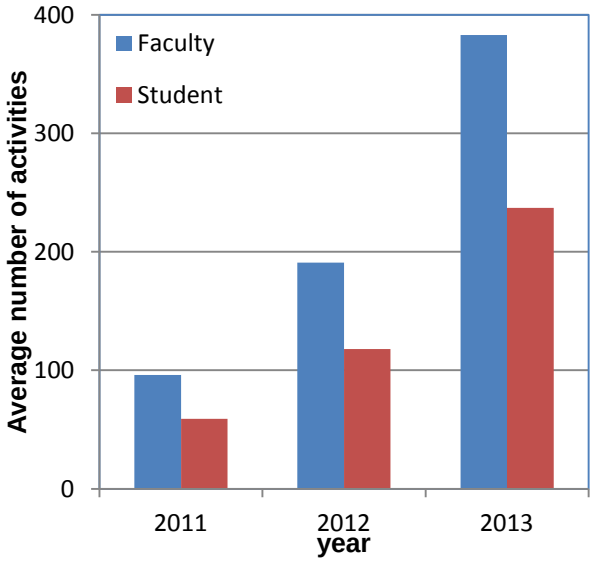

Figure 3. The average number of activities.

4 Results

This research is conducted keeping in mind the requirements of higher education institutions in Arabian Gulf Region. However, the proposed model presented here is applied for three universities in the Arabian Gulf Region. One university is public and has more than 10,000 students and the other two universities are private and each one has more than 3,000 students. In 2011, the three universities have nearly started using their blackboard systems in the learning environment. In 2013, the proposed model has been applied.

4.1 Activities

In this section, we show the effect of applying our proposed model that depends on using semantic web and one integrated system in the learning and administrative environment. Figure 3 shows the average number of activities done by both faculty members and students for the three universities from 2011 to 2013. Faculty members' activities include uploading lectures, videos, announcements, useful links, assessments, and etc. Student activities include course registration, downloading lectures, watching videos, solving exams and quizzes, uploading answers for home works, and etc.

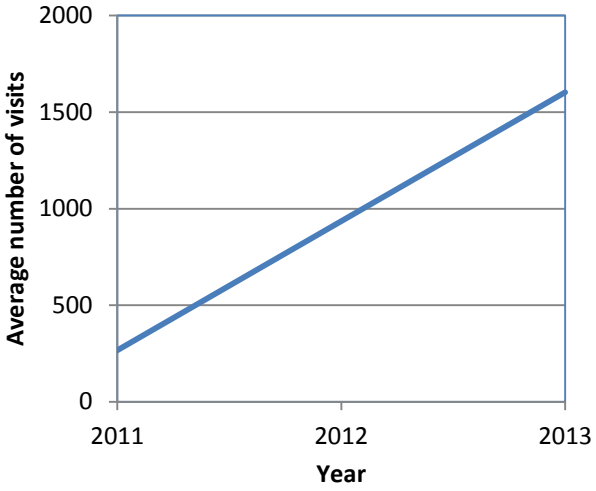

Figure 4. The average number of faculty members' visits.

In 2013, the number of activities is nearly doubled for both faculty members and students. This is because in our model, students now use only one system with the same user interface. Also, the use semantic web provides intelligent to our model. This makes our proposed model more integrated, easy to use and flexible. So, students will not get offended when using the Blackboard based on our model.

4.2 Visits

Figure 4 shows the average number of visits done faculty members and Figure 5 shows the average number of visits done by students for the three universities from 2011 to 2013. In 2013, the number of visits is nearly doubled for both faculty members and students. The great increase of the number of visits for both faculty members and students reflects the great flexibility and the great accept of the Blackboard with our model. Using Semantic model, our model provides a more realistic statistics for faculty members and provides a more attraction for students.

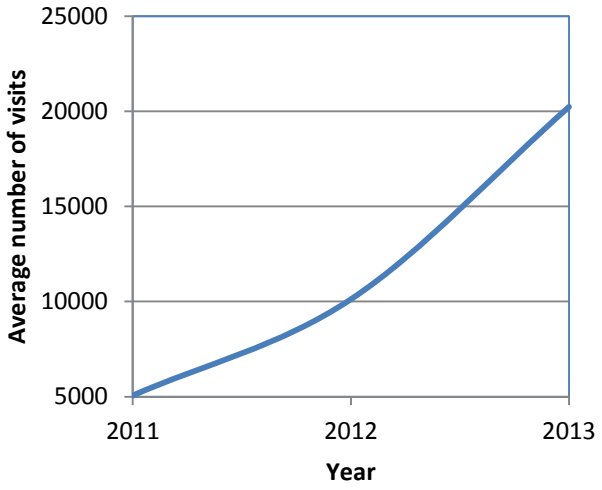

Figure 5. The average number of students' visits.

5 Conclusion and Future Work

We have described a framework for an e-learning application based on the Semantic Web technology, incorporating cooperating software agents that additionally make use of appropriate web services to provide the functionality. With our paper, hopefully we have elucidated the enormous potential of making Web content machine-understandable. Just like in the case of the present Web, the potential of a globally-linked Semantic Web network will slowly get realized as the number of active users increases. One of the killer applications for the Semantic Web might prove to be related to e-learning, considering the amount of research in this sector and the advantages those applications bring to the table compared to existing Web-based learning courses.

We are still continuing the research on this framework. Additional features will be included in it along with our progress in the research. This is a relatively young field with the promise for enormous growth.

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