A Proposed Framework to Support Adaptivity in Virtual Learning Environments

Mohammad Al-Omari, De Montfort University, United Kingdom
Jenny Carter, De Montfort University, United Kingdom
Francisco Chiclana, De Montfort University, United Kingdom

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Abstract
The revolution of the Internet and technology has dramatically changed the educational system in many countries. Learning Management Systems (LMSs) are becoming crucial and widely used in many educational institutions for the adoption of blended and distance learning. However, the "one-size-fit-all" approach is the basis of most of these systems where the differences and preferences such as knowledge level and learning styles of learners are not taken into consideration in their design. In this paper, a generic framework is proposed reflecting a novel approach in order to support adaptivity in LMSs. The framework is composed of two major modules: the Event-Condition-Action (ECA) module and the Multi-agent module. The ECA module is used as the sensing component and source for the Multi-agent module. It provides necessary and real-time data based on predefined pedagogical rules to the multi-agent module which reacts accordingly to provide adaptive experiences in LMSs.

This paper has been divided into three parts. The first part provides a background of e-learning systems and adaptivity outlining the technologies used in our proposed framework. The second part discusses our proposed framework with its components. The last part concludes our paper and states our future work.

Keywords: virtual learning environments, adaptive e-learning systems, Learning management systems, agent-based systems, ECA

Background

E-learning can be defined as the method of delivering knowledge and training using any electronic media (Hayakawa, Higashino, Takahashi, Kawamura, & Sugahara, 2012; Zimmermann, 2011). Recently, Virtual Learning Environments (VLEs) have become a paramount part of eLearning in many institutions such as universities, schools and training centres. VLEs can be seen as a generic umbrella that includes various educational platforms such as Learning Management Systems (LMSs) and Course Management Systems (CMSs). Other terms can be used to designate this type of system. VLEs such as Moodle, Blackboard and Prometheus are examples of modern VLEs (Mallon, 2010). Most current LMSs are web-based platforms that facilitate the learning process for both teachers and students by providing various tools and facilities such as Discussion Forums, Online Assignments, etc. However, the "one-size-fit-all" approach is the basis of most of these systems where the differences and preferences such as knowledge level and learning styles of learners are not taken into consideration in their design.

The idea of providing adaptive content in LMSs has emerged from Adaptive Hyper Media Systems (AHMSs) and Intelligent Tutoring Systems (ITSs) in which adaptive presentation and navigation are provided. These systems are normally used in computer-based instruction (Phobun & Vicheanpanya, 2010). Recently, LMSs are becoming increasingly popular in many educational institutions (Pitigala Liyanage, Gunawardena, & Hirakawa, 2013). Furthermore, Massive Online Open Courses (MOOCs) have been becoming popular worldwide. We believe that one of the significant keys to make the adoption of these courses successful is the use of reliable LMSs that can meet learners' needs. Supporting adaptivity in these systems is one of the challenging issues in e-learning that must be taken into consideration.

Adaptive E-learning Systems

Adaptive learning can dynamically adjust the type of instruction based on each learner's abilities and knowledge, and can personalise instruction in order to foster learner's performance. Therefore, prevalent challenges such as the limitation of resources, student motivation and diversity of students' knowledge and preferred learning styles can be addressed during the learning process. Targeting instruction to the learner's abilities and needs can diminish course drop-out rates, improve learning outcomes and achieve learning goals (Pappas, 2015). The current trends in education and training should focus on identifying tools and methods for delivering on-demand knowledge tailored to learners, taking into consideration their differences in skills and knowledge level (Musumba, Oboko, & Nyongesa, 2013). Since LMSs are widely used by many educational institutions for the adoption of distance learning or blended learning, learners' differences such as preferred learning styles and knowledge level should be taken into account when designing and implementing these systems.

Recently, with the revolution of technology, supporting adaptivity in LMSs has become the interest of many researchers in the field incorporating different

technologies. Agents can play a major role in extending the features of current LMSs and provide adaptive experiences to meet learners` needs.

Agent Technology

Agent-based systems have been applied in many systems – ranging from comparatively small systems such as personalized assistants to large complex systems such as air traffic control (Wooldridge, 2009). In the literature of the field, agent technology has also been used in the context of e-learning systems to support adaptivity and enhance the learning process. Agents are autonomous and can act intelligently in their environment (Wooldridge & Jennings, 1995). It is possible to achieve a powerful system adapted to the needs of each learner by using intelligent agents in the design of e-learning systems (Tveit, 2001). Hammami, Mathkour, and Al-Mosallam (2009) have proposed a multi-agent architecture for an adaptive e-learning system. The architecture is composed of several multi-agent levels and an intelligent blackboard as an agent in order to support adaptivity in e-learning systems. Chang and Chen (2012) have built an adaptive learning system using agents to provide learners with adaptive content based on their learning styles using Felder-Silverman Learning Style Model (FSLSM) (Felder & Silverman, 1988). In addition, a Mashup search engine has been developed to search supplementary teaching material to enhance the learning process. Agent technology can be seen as a promising approach to enhance e-learning effectiveness. Xu, Huang, Wang, and Heales (2014) have used intelligent agents in order to personalise the internal learning mechanism in VLEs. They argue that VLEs can be used for achieving e-learning effectiveness when personalisation is integrated in these systems in which learners' needs are satisfied.

Databases are the main repository of most of the current LMSs. Data about learners including their online activities and personal information is stored in these databases. However, some of this data can be automatically integrated in LMSs from the main university's Student Information System (SIS). This huge amount of data about learners can be used to understand the learners and enhance the learning process. From this point of view, the online activities (e.g. accessing the system, submitting assignments and accessing courses' content) can be seen as events stored in the database of LMSs. Therefore, the Event-Condition-Action model can be used in this kind of environment. The ECA model is widely used in Active Database Management Systems and Workflow Management Systems (Zhi-xue, Xin, Qing-chao, Hong-yue, & Qing-long, 2012).

The Event- Condition- Action (ECA) Model

The ECA model has been used in event-driven systems (Denecke, 2012). This model is a reactive model that responds in a real-time manner to any changes in its environment based on pre-defined rules and conditions. It is being used in different critical systems such as autopilot systems and anti-virus systems. It takes the form on *event* if *condition* do *actions* (Poulovassilis, Papamarkos, & Wood, 2006). It can sense the environment and react accordingly in a timely manner based on pre-defined

rules and conditions. Most of the LMSs are designed with a database where all logs and data about learners and their activities are stored and archived. From this point of view, we believe that the ECA model can play a significant role in sensing the e-learning environment using database triggers. These triggers are based on pre-defined pedagogical rules which can be updated by teachers for any new requirements without re-structuring the system. In the next section we propose our framework to support adaptivity in any LMSs reflecting a hybrid architecture using agent technology and the ECA model.

The Proposed Framework

Our proposed framework is composed of three components: the ECA module, the multi-agent module and the e-learning environment as shown in Figure 1. Our approach is designed as an independent automated system which can be integrated with any e-learning system.

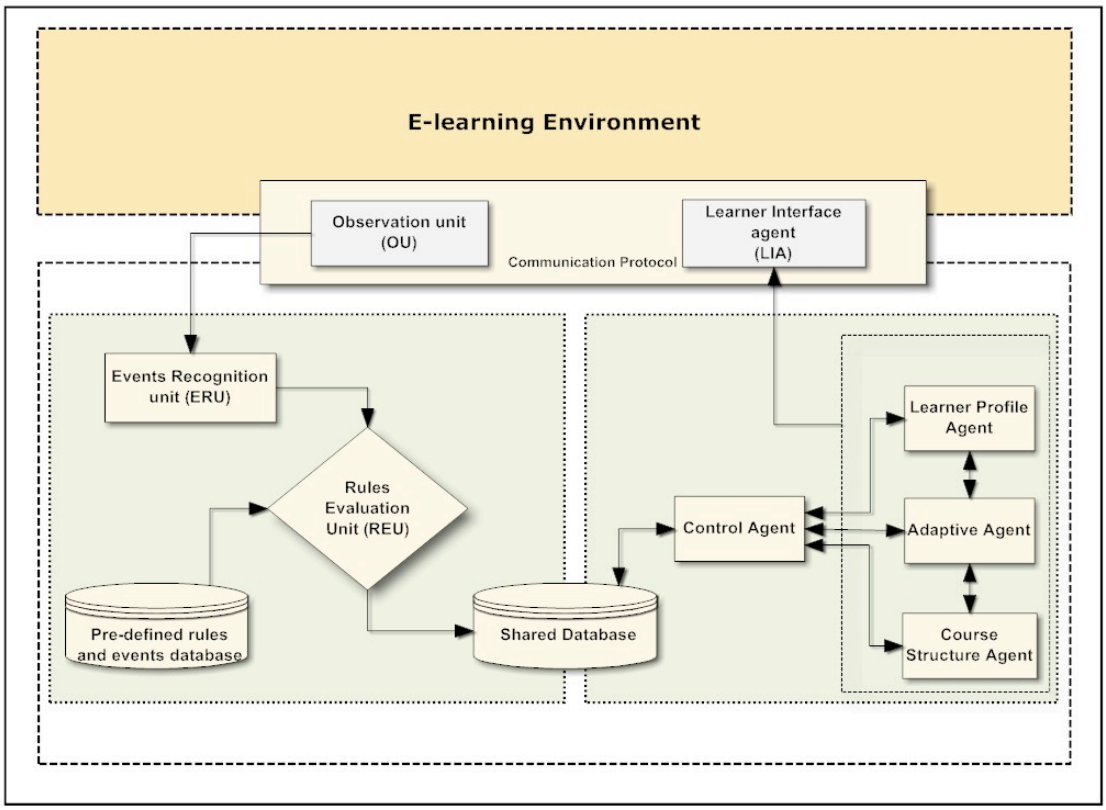

Figure 1: The proposed framework.

The proposed framework above aims to support adaptivity in E-learning systems. It is designed using a hybrid architecture reflecting a novel approach that can be used to support adaptivity in any given e-learning system as shown in Figure 1. The framework is composed of three main components:

The E-learning Environment

This component can be any LMS where learners interact, collaborate and learn. This environment is an essential part for the adoption of distance and blended learning. Moreover, it provides learners and teachers with the required tools and facilities to enhance the learning process. Moodle, Blackboard and Saba are some of the leading e-learning platforms (Pitigala Liyanage et al., 2013). However, Moodle is probably the most popular and used platform, with over 53,346 sites providing for over 70 million users across 222 countries (Moodle, 2015).

The ECA Module

The ECA module is designed and used as the sensing component in our framework. It is based on events that may occur in the e-learning environment and react accordingly. However, this process is a rule-based mechanism based on database triggers so that the events (learning activities) such as registering and accessing a course are observed by the Observation Unit (OU) which is interfaced with the e-learning environment using a communication protocol. Then, the event is received by the Events Recognition Unit (ERU) so that it is recognised and categorised before the evaluation process takes place. The Rules Evaluation Unit (REU) is responsible for determining whether or not the current event satisfies the pre-defined pedagogical rules in order to provide the multi-agent module with the necessary and required data via a shared database to provide adaptive experiences to learners.

The Multi-Agent Module

Our multi-agent module consists of several agents. Each agent is responsible for specific tasks managed by the Control Agent. Moreover, an agent can communicate with other agents in order to achieve the overall objective which is to provide learners with adaptive experiences such as adaptive content based on their learning styles. The Learner Profile Agent deals with learners' personal information such as name, age, program and preferred learning styles. It provides the Adaptive and Course Structure Agents with the required data in order to provide adaptive experiences to learners via the Learner Interface Agent. For example, each learner is provided with adaptive content based on his/her learning styles through the Learner Interface Agent. In order to design our multi-agent module, JADE is used as the platform for developing multi-agent systems (Bellifemine, Caire, & Greenwood, 2007). JADE is one of the most common platforms that researchers use for building multi-agent systems. A study by Kravari and Bassiliades (2015) shows that JADE is currently the most popular FIPA-compliant agent platform in academic and industrial community.

We believe that our proposed framework can support adaptivity in e-learning systems to overcome the limitations of these systems. This framework may open further research paths on the field. It may be used for Educational Data Mining (EDM) and Recommendation Systems (i.e. recommendation for online courses).

Conclusion

Supporting adaptivity in e-learning systems has become crucial for the adoption of distance and blended learning in educational institutions. We believe that by supporting adaptivity in these systems taking into consideration the differences between learners can enhance the learning process. Therefore, a framework has been proposed reflecting a novel approach using ECA and Agent technology to support adaptivity in any given e-learning system. We have only identified our approach using different technologies in our framework. As future work we intend to implement and evaluate our approach in Moodle as a case study to provide adaptive content based on learner's learning styles using Felder-Silverman Learning Style Model (FSLSM).

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Contact email: Mr.Mohammad Al-Omari (p13009390@myemail.dmu.ac.uk)
Dr.Jenny Carter (jennyc@dmu.ac.uk)
Prof.Francisco Chiclana (chiclana@dmu.ac.uk)