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Restrictions and abilities of SCORM adoption by Adaptive Educational Hypermedia Systems

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Abstract

Both Learning Management Systems (LMSs) and Adaptive Educational Hypermedia Systems (AEHSs) are used for online instruction. However, LMSs do not offer personalized instruction, while AEHs provide few of the LMSs functionalities and their educational content is hard to access or be reused by other systems and platforms. As a solution to these problems research proposes the use of technological standards, like SCORM, for the creation of educational material. Nevertheless, SCORM adoption incurs some restrictions to systems' design and provided adaptivity. This work attempts to contribute to this research area, investigating the restrictions and the capabilities that arise from the combined use of AEHSs technologies with the provision of LMSs features and the adoption of SCORM.

Keywords: AEHS, LMS, SCORM, adaptive educational hypermedia systems

Introduction

The growth of the Internet and e-learning has led to the appearance of Learning Management Systems (LMSs), which provide a variety of features and operations including the development, management, distribution, diffusion and presentation of educational material, as well as tools for the management of users and courses. However, many researchers (Conlan et al., 2002; Bouras et al., 2003, Jui-Lin Lu & Chen, 2006; Kazanidis & Satratzemi, 2008) have formulated questions in regards to the accessibility and reusability of the educational material, the interoperability between different systems and their durability in time. As a solution to the aforementioned problems research proposes the use of technological standards for the creation of educational material (Bouras et al., 2003; Dagger et al., 2003; Brusilovsky, 2004; Jui-Lin Lu & Chen, 2006; Casella et al., 2007; Kazanidis & Satratzemi, 2008). Some of the most well known standards for the creation of educational material are: SCORM (ADL 2009a), LOM, IMS, AICC etc. The most widespread standard, in the last years, has been SCORM (Sharable Content Object Reference Model) which is based on SCOs (Sharable Content Objects). The exploitation of this technology, not only allows the use of educational material in multiple LMSs but also facilitates the discovery and reusability of such material (Duval, 2000; Krull et al., 2006).

Some problems, however, arise due to the nature of the Internet. The courses distributed by LMSs, are available to a wide number of users, with different characteristics, cultures, learning needs and previous knowledge of the domain. Therefore, a course that is appropriate for one particular learner may not be suitable for the needs of other learners. What's more, learners have the ability to navigate freely within a course or even visit web pages not immediately connected with the course. These characteristics have led to some

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major problems which are summarized in (Murray et al., 2000; Scheiter and Gerjets, 2007), like disorientation, cognitive overload, discontinuous flow, content readiness and user distraction (Foss, 1989). A solution proposed by a large number of researchers (Brusilovsky, 1996; Stern, et al., 1997; Pilar da Silva 1998; Kavcic, 1999) is the incorporation of interactivity and adaptivity in the online learning environments.

The outcome of these research efforts was the appearance of Adaptive Educational Hypermedia Systems (AEHSs). The main objective of AEHSs is to individualize the features and operations that they provide, so as to increase their functionality (Brusilovsky, 1996). Their personalization is usually applied via the adaptive navigation and adaptive presentation of the educational content (Brusilovsky, 2001).

From the above it becomes clear, that AEHSs mainly attempt, via adaptation, to improve the educational process and its outcome, while the standardization that many LMSs follow, aims to help course developers access and re-use educational material easily, as well as provide interoperability between different systems and platforms. As a consequence many researchers (Karagiannidis, et al. 2002; Specht et al., 2002; Conlan et al., 2002; Romero et al., 2005; Modritscher et al., 2006) turned their attention to systems, which are based on these two axes. These systems incorporate adaptive characteristics, support educational material that is interoperable and can be easily re-used; in addition, they adopt certain technological standards like SCORM. According to Brusilovsky (2004) these systems may eventually even replace traditional LMSs.

The present work attempts to contribute to this research area, investigating the restrictions and the capabilities that come from the combined use of AEHSs technologies with the provision of LMSs features and the adoption of SCORM.

Technology Background

Adaptive Educational Hypermedia Systems

The main characteristic of AEHSs is the individualization of the educational process according to learner needs. The student oriented instruction, allows students to follow an optimal learning path, adapted to their individual characteristics, utilizing their strengths and at the same time helping them achieve a better learning outcome.

AEHSs usually adopt a structure which varies according to the needs of each system. There are three main parts that AEHSs usually consist of: i) the Domain Model (DM), which represents the system's knowledge of the domain, ii) the User Model (UM), which records the learner's personal characteristics, like age, language, learning style etc., as well as his/her domain knowledge, and iii) the Adaptation Module (AM), which adapts the presentation of content and user navigation, according to the records of UM.

Personalized instruction through an AEHS, however, requires accurate design of both the AEHS itself and its courses. The problem which arises is that there is no common development framework of such systems and therefore a lot of time must be spent in their development. Besides this, most times, the development of suitably formed educational content is required, which makes it difficult for it to be re-used by other identical systems. As a consequence, precious time is spent on the development of educational material, which means that nowhere near enough attention is paid to the application of suitable educational strategies (Sidiropoulos & Bousiou, 2005).

Learning Management Systems

LMSs and their courses are one of the most popular ways of knowledge distribution via the Internet. Yet, there is only one form of teaching for all types of learners, without meeting the individual's potential needs. The use of previously presented AEHSs technologies deals with these kinds of problems. However, developers of such courses are confronted with a variety of problems: i) lack of a predefined development standard of LMSs and its corresponding educational material, a consequence of which is that it is difficult to develop and apply educational material that was designed for use by one platform to another; ii) many times the upgrading of LMS in a new version requires changes in the structure of educational material; and iii) both re-use and recall of educational material require additional work from the course designers. Due to the abovementioned problems, as happens with AEHSs, many resources are expended on the programming implementation of the courses rather than on content quality and educational strategies.

The solution to these problems comes from the adoption of certain international standards and specifications in combination with the use of learning objects (LO) of the educational material. Learning objects are a set of assets (text, pictures, sound, video etc.), that are grouped in autonomous entities with self-existent learning value (Samara, 2007). Since LOs are autonomous, their re-use in different electronic courses is possible. Consistently more educational material, consisting of LOs, is being developed on the World Wide Web (Duval, 2001). This tendency is also confirmed from their use by the most well known LMSs (Samara, 2007). In order for the use of LOs from different systems and courses to be successful, appropriate standards have to be adopted.

SCORM specifications and restrictions

Standards and specifications were developed in order to facilitate the description, packaging, sequencing and distribution of educational content, learning activities and learner information (Campbell, 2002). The description and development of suitably structured educational material comes mainly via the metadata. These standards and specifications provide reusability, accessibility, interoperability and durability to possible software updates.

The most popular technical standard at the moment is SCORM. SCORM is a set of specifications for the development, organization and distribution of educational content. Its goals are to enable compliant systems to import, share, re-use and export electronic educational material. SCORM prescribes the entire development process of the educational material, from the units' segregation to the definition of which metadata is essential or optional for each LO. SCORM is comprised of three main parts, for there is the equivalent "technical book" (ADL, 2009a). These are: the Content Aggregation Model (CAM), the SCORM Run Time Environment (RTE), and Sequencing and Navigation (SN).

SCORM, in accordance with other standards, places concrete specifications and restrictions both for the educational content and for the compatible LMSs. In this work we focus on the restrictions that are related to the production of educational content, while investigating ways for the development of dynamic and adaptive educational material which will conform to SCORM and its specifications. SCORM compliant educational content is structured from independent LOs. Each LO is composed of either assets or SCOs (Sharable Content Objects). Assets may be elementary units of knowledge like text, sounds, images etc. and there is no conformity rule with the standard. However, assets cannot communicate with the system and therefore, such type of content is static.

In contrast, SCOs have the ability to communicate with the system. Each SCO is composed of various assets and additionally, it includes an essential JavaScript code for communication with the system. Substantially, a SCO may be composed of one or more HTML web pages, while it follows concrete rules so as to be compatible with all the SCORM compliant LMSs. The JavaScript code which is included in the SCOs, is in accordance with the SCORM Application Program Interface (API) and Data Model. This code has to execute concrete actions. In particular, it has to i) locate the provided API of the LMS, ii) initialize and terminate every communication session with the LMS, iii) record and store concrete information about the learners, and iv) provide error management. The storage of information in the system's database takes place through the SCORM API and Data Model. Consequently information is dispatched for storage with the use of specific commands in concrete form.

SCORM API, provides among others the following functions for SCO and system intercommunication (ADL, 2009b):

- Initialize(). Initializes the communication session between the SCO and the system.
- Terminate(). Terminates the communication session between the SCO and the system.
- GetValue(). Gets appropriate data from the system.
- SetValue(). Sends data to the system.
- Commit(). Promotes the permanent storage of data that has been submitted after the last call of Inizialize() or Commit() functions.

The abovementioned requirements, substantially prohibit the course author from developing electronic courses in a dynamic programming language, such as, PHP, ASP, JSP etc. using his/her own communication and adaptation techniques, as happens in most of the AEHSs. In contrast, every dynamic presentation of the course, needs to be based on the communication between the SCO and the system's database. This communication comes with the JavaScript code, which exploits the SCORM API.

Since each SCO, must be autonomous and ready for use in any other compatible course, the use of external links in the educational material is not permitted. This restriction does not allow a connection of concrete words from the educational content with exterior content or even with a system index; practices that are applied by some AEHSs.

There are also some restrictions at the course construction level. Each course should be packaged according to the specifications of the SCORM. Apart from educational material, these specifications require the existence of a metadata XML file, which includes concrete information about the course itself and its SCOs. All the essential information about the course, such as, the place and use of educational material, course structure, SCOs weight, minimal learner's progress in order for a SCO to be considered as known, possible adaptive navigation etc. should be stored in this file, according to the SCORM CAM rules.

In contrast, SCORM does allow the production of personalized courses via adaptive navigation and adaptive content presentation of the educational content by the course author.

Related work

The above requirements, have not allow most of the AEHSs to conform to SCORM specifications. However, according to Brusilovsky (2004), an upcoming generation of web based educational systems attempts to provide system interoperability as well as the reusability of educational content by supporting standards like SCORM.

OPAL (Conlan et al., 2002), is a environment which provides personalized learning and is based on learning objects which are described with SCORM 1.2. metadata. OPAL is trying to personalize the educational process, delivering the educational content in adaptive sequence. In addition, OPAL adapts the presentation of educational material according to user preferences. However, it only uses the SCORM metadata for the description of learning objects and does not support the import of SCORM courses.

VIBORA (Morales, 2003) supports SCORM and provides some basic functionalities of LMSs. More specifically, it offers the possibility to record and deliver learning objects from SCORM compliant courses. However, its adaptivity is limited to the dynamic sequencing of learning objects.

AdeLE (Modritscher et al., 2006) is an eye-tracking adaptive system, which with very small modifications, can be connected to an LMS. AdeLE supports the import of SCORM courses. However, the adaptation in AdeLE presupposes the existence of special equipment in order to record the user's eye movements. Also, it cannot provide adaptation according to user learning goals and it does not support feedback during the educational process, concerning user progress.

WINDS (Specht et al., 2002) provides adaptive link annotation and adaptive presentation of educational content according to user learning style. It also incorporates an authoring tool, which helps the teacher to create adaptive courses that are based on SCOs. In addition, it supports both the import and export of SCORM courses even if the latter has not been applied to the practice.

The third version of AHA! (Bra et al., 2006; Stash, 2007), supports the import of SCORM courses (Romero et al., 2005) and allows teachers to write courses which are adaptive to user learning style (Stash, 2007). The imported courses, however do not include all the features that AHA! offers and additional work as well as modifications are required. In addition, it is still not possible to export its courses in a SCORM compatible form. As a consequence AHA! courses cannot be reused by other SCORM compliant systems.

Most of the aforementioned systems either do not completely adopt the SCORM standard and its specifications, or provide limited adaptive functionalities. In order to study the feasibility of the development of a system that will completely adopt the SCORM standard while simultaneously providing adaptive courses, we developed an AEHS, which we named ProPer (from the initial letters of the Greek words Adaptive Environment).

ProPer

ProPer combines characteristics from both AEHSs and LMSs and provides adaptive navigation, as well as adaptive presentation of the educational content by exploiting SCORM API, which it completely adopts. ProPer provides adaptive technologies both for user navigation and for the presentation of the content. These technologies can be separated into two main categories: those provided by the system and those provided by the appropriate design of the educational material.

Adaptive annotation and direct guidance of the learner are the technologies of the first category. In addition, ProPer allows the learner to declare his/her previous knowledge as well as his/her learning goals, afterwards adapting user navigation accordingly.

The technologies that belong to the second category are link hiding and the adaptive presentation of educational content according to particular user's characteristics, such as his/her learning style, knowledge in pre-required concepts, technological infrastructure etc.

In order to provide adaptive navigation, ProPer constructs a model for the learner based on his/her actions, and estimates his/her knowledge of the domain. We propose a mechanism of user progress evaluation (Kazanidis & Satratzemi, 2010), according to the learner's goals and grades in each course unit. We therefore, propose: i) the exploitation of information that can be collected via the SCORM API, like the user score in every course unit, as well as the weight of each SCO in the score of the whole course; and ii) the use of appropriate rules for the exploitation of this information, which will lead both to the adaptation of the course table of contents, as well as to the localization of the most appropriate unit for study. ProPer is described in more details in (Kazanidis & Satratzemi, 2009a).

In order to achieve wider adaptation, we also studied the development of appropriate educational content which is adapted according to user needs. Therefore, we created adaptive courses that provide adaptive presentation of their content according to user characteristics, and at the same time, we proposed a framework for the development of SCORM compliant courses that can be adapted to user learning style (Kazanidis & Satratzemi, 2009b).

Following, we will focus on the exploitation of SCORM API so as to overcome its initial restrictions and achieve the construction of adaptive courses. Since every SCO should be autonomous and suitable for use by all SCORM compliant courses and systems, the import of an extra code that would collaborate with the system so as to adapt the content, is not allowed. In order to overcome this restriction, we propose the exploitation of SCORM functionality and more specifically: the use of SCORM Objectives of a course for user modeling, ii) the adaptation of educational content through JavaScript code, which will initially read the user model and later provide appropriate adaptation, and iii) the exploitation of SCORM sequencing rules in order to adapt user navigation.

SCORM CAM allows the statement of concrete Objective, in every course, through an XML code of the course's manifest file. Later, depending on the user's actions in the course, a SCO may asses user progress on each Objective via the JavaScript code and more specifically, by using the method SetValue() of the SCORM API. Therefore, by recording the user score in particular Objectives, a user model is created which will allow the adaptation of educational content according to the data stored in the course Objectives.

Content adaptation is applied through the JavaScript code using the function GetValue() of the SCORM API. Initially, user score on the appropriate Objective will be acquired via the GetValue() function, and afterwards the JavaScript code will modulate the presentation of the educational material accordingly.

The SCORM sequencing rules make the adaptation of user navigation in a course possible. Sequence rules may determine the SCOs that the user is allowed to study, as well as their presentation sequence. These rules are formulated following the syntax:

if < *condition* > *then* < *action* >.

In the case that the condition is true, then the appropriate action is executed. Conditions usually check user progress in a course activity. For example, if a learner does not achieve the objectives that are related to the current activity, then the system proposes the study of additional course activities (Bouras et al. 2003). The action parameter in each sequence rule defines the action that the system has to apply, if the condition is true. Sequence rules are divided according to time, into three different steps i) pre-condition, which is applied when the user visits a course activity, ii) post-condition, which is applied when a course activity is terminated, and iii) exit action, which is applied after exiting an activity. As a consequence, specific course activities may or may not be available to the user for study, according to the extend of course Objective coverage, in order to improve the user learning path.

The existence of an adaptation code in the educational content itself, enables its adaptation into any SCORM compliant LMS. However, the development of such courses requires programming knowledge from the course's author(s). For this reason, we have developed an authoring tool, named ProPer SAT (Kazanidis & Satratzemi, 2009c) which allows the creation of SCORM compliant adaptive courses, without requiring the author to have any programming knowledge.

Conclusions

In the previous sections we presented the way a system that combines characteristics from both AEHSs and LMSs, can simultaneously adopt SCORM and its specifications, as is the case with ProPer. ProPer's main advantage is that it incorporates both adaptive technologies and LMS features, while it complies with the SCORM standard and its specifications, in contrast to the most of the AEHSs which either are not completely compliant with SCORM and its specifications or incorporate limited adaptive capabilities. This is also confirmed by ProPer's evaluation results, which show that students achieved better learning outcome in less studying time, while authors found ProPer easy and useful and stated that they would also use it in the feature. In addition, some specific actions were proposed, which enable SCORM compliant systems to provide adaptive courses. This makes the easy re-use, discovery and maintenance of educational content possible, while simultaneously achieving the personalisation of the educational process according to particular user needs.

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