LMSPlan: An Architecture to Integrate Adapted Learning Objects Sequences within a LMS

Abstract. E-learning process is customizable thanks to the wide development of systems of learning management and their standardization, together with the advances on artificial intelligence techniques that complement them. This article presents LMSPlan, a novel architecture that integrates Learning Management Systems (LMS), e-learning standards and intelligent planning & scheduling technologies (AIP&S) in order to customize a learning objects sequence and display them effectively to students in any LMS that supports standards.

Keywords: Adapted Learning Objects Sequences, Student Modeling, Continual Planning.

1 Introduction

The use of intelligent technologies for planning and scheduling applied to the adaptation of learning paths is not new, since 1986 Peachy and Mcalla [9] innovated with a rudimentary approach of this proposal applied to Intelligent Tutoring Systems (ITSs).

These systems evolved to accommodate the huge amount of information that brought with it the use of the internet for educational purposes and, therefore, the emergence of standards for definition, management and exchange of educational material for the web, better known as Learning Objects (LOs).

At the same time, several planners used in this kind of systems have evolved over the years too, and according to Ullrich [12] we can see that planners as SHOP2 [8] and SIADEX [4], based on hierarchical task network, are the best suited to represent the tree structure of the courses and/or books: title, chapters, subchapters, objectives, and finally activities at the lowest level of the tree hierarchy.

However, for organizations responsible for providing online courses to the masses of students around the world, it is clear that ITSs are not the first choice to manage all their courses, because the most of them are limited to a certain area of knowledge, and on the other hand, many of them require the installation of special software on the computer.

These and many other reasons are persuading administrators of online courses to use the ITSs as an external educational tool to complement the benefits of the traditional courses platform, and not as an integrated tool within the platform. This platform is usually a Learning Management System (LMS) such as dotLRN [6], Caroline [2] or Moodle [5].

On the other hand, developers of the LMSs have chosen to integrate within the courses structure, several content management standards in order to adapt to new needs of knowledge exchange. Among the most important standards are SCORM [11] and IMS-CP, from the IMS-GLC standards family [7].

Given the above considerations, it's clear that if we want a real and extended use of intelligent technologies originally proposed by ITSs' creators, they should be adapted and generalized to be used by any LMS in the market. This could be done taking advantage of the facilities that allow integration with e-learning standards, as demonstrated in the example shown in [10].

In this article we present an innovative architecture that integrates LMSs, e-learning standards and intelligent planning & scheduling technologies. We use a common interpretation of the e-learning standards proposed in [3] for the automatic generation of domains and problems in HPDL planning language, we have established a communication protocol between the LMS and the planning server, and a set of rules to determine if it requires a continual planning or re-planning process to adapt the sequence of learning objects. Finally, we conducted an experiment to determine the feasibility of implementing our architecture in MOODLE, one of the most used LMSs worldwide, besides to measure the student's satisfaction using this kind of technology tools.

2 General Architecture

LMSPlan is a communication architecture via web services that allows to any LMS to contact with a planning server in order to adapt the learning sequences of the topics in an e-course to every student profile related with the course. The LMS and learning objects must meet the next criteria:

1. LO's must be related and labeled under the IMS-MD or LOM [1] standard, following the instructions described in [3].
2. The LMS must support the SCORM or IMS-CP standards, and it owe use them to store and display the learning objects sequences.

The architecture shown in Fig. 1 describes the above criteria, in addition to the planning client that must be integrated into the LMS, and the planning web server used to interpret and adapt the information given by the client. These modules are described in the next subsections.

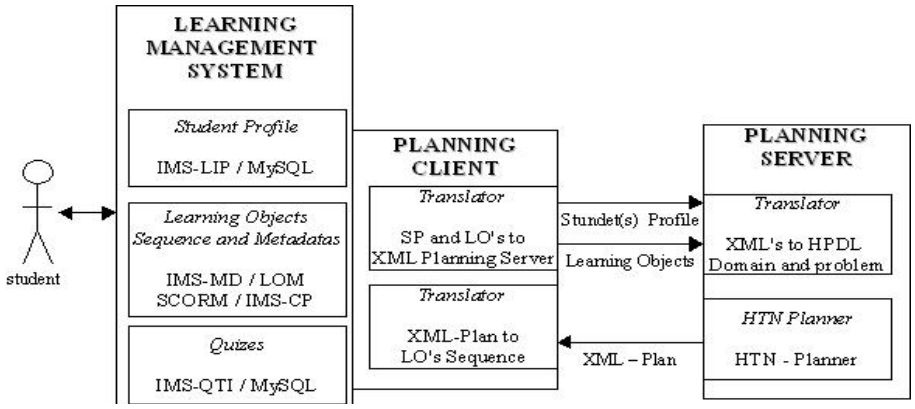

Fig. 1. LMSPlan Architecture

2.1 Planning Client

The LMSPlan planning client is the intermediary between the LMS and the planning server. It is responsible for obtaining all the information it needs from:

- The SCORM package content that is requested to adapt to the students of the e-course. That is the LOs and metadatas that describe and relate them.
- The student profile. Preferably in the IMS-LIP standard.
- The score obtained by each student in the quiz applied before the item you want to adapt. This information should be, preferably, within the IMS-QTI XML manifest which describes the quiz.

In most of the used LMSs, the two last standards above mentioned, are not yet integrated; therefore the client has the option to obtain information from the LMS' databases.

Once the information is obtained, the students' profiles and the quiz score for each one are combined in an XML file called `students_profile` that must be dispatched to the learning server through an xml-rpc call. The XML manifest containing all the data from the LO's will be dispatched using this sort of calls too.

The planning client interface shown in Fig. 2 allows to the professor or system administrator specify the e-course where is located the SCORM that wants to customize, the SCORM itself, and the previous quiz if exist, besides the objective of the subject. The objective is needed because the SCORM can contain several objectives as part of it.

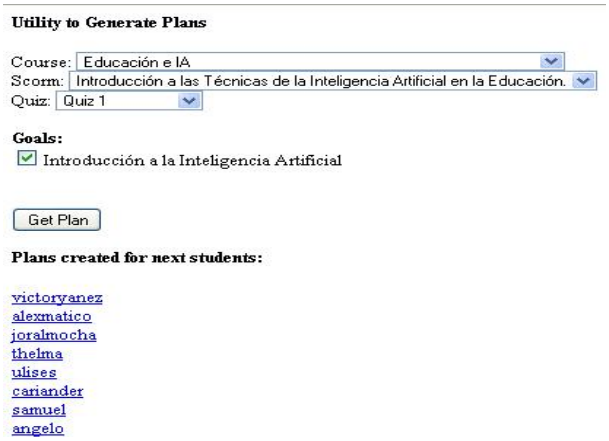

Fig. 2. Planner Client

Once each parameter is select, the user can press the "getPlan" button and leave the rest to the planning server that will return a hyperlinked list with the course's students which allows checking the adapted SCORM contents in plain text for each of them. These contents would be displayed to each student inside the LMS platform.

2.2 Planning Server

When you press the getPlan button, the planning server receives the XML files containing the students' profiles and the LOs information. Then, according to the information given by these files, the server decides if a planning, continual planning or re-planning processes will be held. This decision process is described in the next paragraphs.

First of all, if the planning history of the received SCORM does not exist, and also the previous quizzes' scores of the students' profiles neither exist, then the server performs the translation process from the LOs to the HPDL planning domain and from the students' profiles to the HPDL planning problem as described in [3] as a simple *planning* process.

Otherwise, if the SCORM has not been planned previously, but the students' profiles file contains the scores of the previous quiz. Then, the server recognizes that the user is requesting a continual planning process, where the subject contents customization is based on the previous subject knowledge. Therefore, the planning domain and problem will be generated as in the previous point, but the information about the student's profiles must be modified before the translation according to the score obtained in the previous quiz, and given rules as e.g.:

- If the score of the previous quiz is greater than 90/100, then the student' performance will be increased to the maximum.

- If the score of the previous quiz is less than 50/100, then the student' performance will be reduced to the minimum and a high availability will be reassigned, so he/she could take optional activities for reinforcement.
- It is expected that in a short future the above rules could be adapted, through a web interface, to the preferences of each professor, and according to different e-courses. This will allow a mixed initiative process much more sophisticated than the current.

The last case occurs when the two previous cases are not met and the SCORM has a planning history, in this case the re-planning process must take place. It means that students' profiles have changed or a new version of the SCORM has been received. As this process requires a real-time adaptation, just the file where a change is detected (students' profiles or LOs), will be translated into a planning domain or problem, allowing the subject to be re-planned in a few seconds.

Finally, the planning server returns to the planning client the customized plan for each of the students in a predefined XML file format. This file will be processed by the planning client and integrated into the database tables that contain the SCORM information for each student.

3 Experiments

In this section we have described the design of the experiment conducted to demonstrate the feasibility of implementing the proposed architecture, and the qualitative results we have obtained through a satisfaction survey applied to the students which have used the adapted sequence of LOs.

Quantitative evaluation and comparison of the learning sequences obtained from the process of Continual Planning or Re-planning will not be covered in this paper due to the lack of space.

3.1 Experiments Design

The experiment was conducted on a sample of 20 Mexican students and teachers aged between 18 and 43 years old and with a studies level minimum of Bachelor and maximum of Doctoral degree. These students were enrolled in an e-learning seminar with duration of four weeks, with four different topics, and four quizzes.

Training materials for each subject were converted to the format of LOs and were labeled under the IMS-MD standard according to [3], and then we created a SCORM package supported by the Moodle LMS hosted in the sepia server (http://sepia.ugr.es/moodle) from University of Granada (UGR). The communication with Moodle is made through the planning client integrated on it, and goes to a planning server named SIADEX (http://siadex.ugr.es/planner_server), another server of UGR.

Seminar participants filled the fields of their user profile within the platform. The "adaptation fields" were English level, learning style based on the Honey-Alonso

questionnaire, time availability to attend the seminar and the performance level associated with previous academic experience. In order to know their ages, expectations and motivation level, an initial survey was applied to them.

Once this preliminary step was completed, we proceeded to begin the process of adapting the first topic and then apply the first quiz; and so on culminating with the applying of the fourth quiz. It is possible to observe the outcome of the adaptation process that is visible to any student within Moodle, just by accessing to the sepia server using a provisional user which can be asked for the authors.

Sometimes, during the experiment, it was necessary to use the web service of re-planning because some students changed their profiles through increasing their English level or changing their learning style. This process was also necessary when the teacher decided to change the note of one or more students, when the next topic had already started.

	Amount	*Percent*		*Amount*	*Percent*
Learning Style			*Availability*		
Active	7	35,0%	Many	13	65,0%
Reflexive	8	40,0%	Little	7	35,0%
Theoretical	0	0,0%			
Pragmatic	5	25,0%			
English Level			*Performance*		
Excellent		0,0%	High	11	55,0%
Acceptable	13	65,0%	Medium	8	40,0%
Low	7	35,0%	Low	1	5,0%
Very Low		0,0%			

Table 1. Students‘ Profiles Summary

It is important to highlight that, given the limited experience of students with these kind of course, were necessary weekly video conferences to support the adapted SCORM material.

At the end of the experiment we applied an electronic survey to measure the degree of acceptance of students with the online course and in particular the adaptation given by the system.

In the next section we will discuss the values of the adaptation fields and contrast the results obtained from the initial survey and final to determine the student degree satisfaction compared with their initial expectations.

3.2 Results

In Table 1 we can see how the student profile is very diverse. Notably, being a course of engineering, the number of students with theoretical learning style turned out to be zero and the rest of the styles were well-balanced, as well as the rest of the results for the other three variables taken into account for this experiment.

In the initial satisfaction survey 97% of students have good or high motivation to use e-learning platform, plus 55% which hoped to learn better, 44% expected to learn in a more fun way and 26% organize their own study time, among others.

The results of the final satisfaction survey, shown in Table 2, indicate that 85% of the group agreed that the seminar topics were interesting or very interesting, more than 53% have agreed with the timing that have been given according to their temporal needs and, finally, it's worth noting that 75% of students would be willing to use the system in other subjects and they feel that have learned enough or a lot using our proposal.

4 Conclusions

In our country the LMS have begun to be used to support the students learning but not with a high impact due to the complexity of adapting the contents to each student' profile. The proposed model tries to solve this by using an architecture called LMSPlan that integrates the LMS capabilities and a planning server to provide a continuous customization of e-course contents that are shown to the student through e-learning standards. This architecture takes in to account the uncertainty associated to the results of interim quizzes and continuous changes the student profile.

Question	**Do you think the contents of the topics were interesting?**		**Do you think the time to do exercises and understand all the subjects has adapted to your needs?**				**How much do you think yo have learned?**	
Value	*Amount*	*Percent*	*Little Time*		*Much Time*		*Amount*	*Percent*
			Amount	*Percent*	*Amount*	*Percent*		
Much	13	65%	5	71%	7	53%	4	20%
Quite	5	25%	1	14%	5	38%	9	45%
Average	2	10%	1	14%	1	7%	6	30%
Little							1	5%
Nothing								

Table 2. Final Survey Summary

When testing the model into a real e-course, there was a wide variation in learning styles, English level, previous performance and temporal availability of the students. A traditional course does not take in to account these issues due to the large effort that implies the adaptation process for the professor and because the previous performance of the students is usually static. It should also be noted that a 75% of the students are willing to use this e-course model again.

We have also concluded that more training is needed in order to use LMSs in which autonomous participation of the student is needed, and intensify the use of this kind of courses in order to improve the student performance on them.

5 Future Work

In the future it aims to improve the planning client interface, so as to have an automatic interaction with the planning server.

It would be either interesting to carry out a mixed initiative process where the professor could change the rules to customize the course quickly, considering the information about the students performance that the system could provide. This information could be obtained using data mining techniques over the LMS databases and the adapted standards.

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