Integration Model of E-Learning based on Pedagogical Software Agents and Collaborative Learning Environments

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Abstract: With the growth and popularity of Internet, Web based education systems are becoming more and more attractive; however, most of them are nothing more than a network of pages with static content. To improve these applications, more adaptability and interactivity should be provided, enabling the educational content to adapt to the users' characteristics and further facilitate the use of collaborative tools that enhance their knowledge. Therefore, the aim of this paper is to present an environment of virtual teaching/learning through an integration model based on Multi-Agent System (MAS), Intelligent Tutoring Systems (ITS), and Computer Supported Collaborative Learning (CSCL), offering adaptability through the planning of educational content as well as interaction with the formation of study groups that are guided by protocols specified in different strategies of collaborative work. It should be noted that this system will be assessed through the implementation of a prototype which is being developed in the CIA project (by its acronym in Spanish Cursos Virtuales Inteligentes Adaptativos).

Keywords: E-learning, Intelligent Tutoring Systems, Computer Supported Collaborative Learning, Multi-Agent Systems.

1. Introduction

Intelligent Tutoring Systems (ITS) allow students to facilitate their learning process, automatically planning a series of activities adapted to their characteristics. Thus, we can say that ITS are different from the traditional methods because while studying the apprentice not only listens and takes note passively, but carry out some significant learning activities in an autonomous and personalized way.

The collaborative learning environments are instructional methods that aim to strengthen the student's knowledge, through the collaborative effort, providing an environment that fuels and enriches the process, allowing students to interact to solve a problem. Our hypothesis is that a system that integrates the benefits of ITS with the capabilities of Computer Supported Collaborative Learning (CSCL), may provide an active learning in a clear and attractive way for the students.

By the other hand Multi-Agent System (MAS) have been one of the most widely used paradigms for the development of Intelligent Tutoring Systems, due to the ability of these systems to work in a distributed way, enabling the coordination of a collection of autonomous or semi-autonomous 'agents' that carry out different tasks that provide teaching/learning processes in a clear and quick way. Therefore the objective of this paper is to present a virtual learning environment through the integration of MAS, ITS, and CSCL looking for the improvement of the virtual teaching/learning processes.

The rest of the paper is organized as follows: Section 2 presents a brief description of the theoretical framework and the state of the art of the problems addressed. Section 3 describes how the ITS and CSCL modules were integrated, clearly detailing the changes that took place on each module to achieve a useful and successful integration and presents the MAS model developed. Section 4 presents some results that were obtained from the prototype that was implemented in the CIA project (by its acronym in Spanish Cursos Virtuales Inteligentes Adaptativos) and finally the findings and future work are submitted.

2. Theoretical Framework and Review of the State of the Art

First there will be a brief description of the main elements of the fields and tools that were addressed and then the review of the state of the art will be submitted.

2.1 Intelligent Tutoring Systems - ITS

ITSs are computational systems that are designed to provide a smart support to the teaching learning process through the interaction with the student [9]. The ITS generates a plan based on the instructional needs of the students in a specific domain and are designed for the students to carry out a series of activities to help them acquire new knowledge. These plans are constantly re-planned according to the advances of the apprentice. To carry out such planning, the ITS makes use of 4 models that are described below:

- Pedagogical Model. It is responsible for deciding what pedagogical actions are carried out, how they are performed and when are they carried out taking into account the students characteristics.

- Domain's Model. It is the component that provides the knowledge that is intended to be taught.
- Student's Model. It is responsible for managing the information of each student.
- Interface: It is responsible for managing the interactions between the system and the users allowing the communication with the ITS modules and among the groups [9].

2.2 Computer Supported Collaborative Learning Environments - CSCL

The CSCL are defined as instructional methods that look for promoting learning through a collaborative effort in a particular area of learning, where students interact with others to solve a problem [3].

Ellis [5] identifies different applications, decomposing the collaborative systems across a temporary space matrix. Some are presented bellow.

- Face to Face Interaction (same place and same time). A shared screen for explanations, conversation environments and brainstorming.
- Centralized Asynchronous Interaction (same place and different time). An example of this application is the discussion forum provided on a computer where people contribute with their comments.
- Distributed Synchronous Interaction (different place and same time). Examples of these applications are the synchronous distributed editors, the working environments, the chat and videoconferencing.
- Distributed Asynchronous Interaction (different place and different time). An example of these applications is the email.

2.3 Multi-Agent System- MAS applied to learning environments

A MAS [12] is an organized society composed by software agents that interact with each other, either to assist in resolving a series of problems or in achieving a series of individual or collective goals. These agents can be homogeneous or heterogeneous and may have common goals or not, but always involve some degree of communication between them [7].

The principles of the MAS have shown an appropriate potential in developing education systems, where the elements can be decomposed into collections of pedagogical independent agents exchanging information and cooperating with each other in achieving the learning goals.

2.3 Related Works

Some works about the development of teaching/learning systems using MAS are:

- MACES (Multi-Agent Architecture for a Collaborative Educational System). It is a collaborative educational system for Distance Learning (DL) developed at the Federal University of Rio Grande do Sul in Brazil. Its architecture is composed of human agents (Users and teachers) and five kinds of software agents: diagnostic agent, mediator, collaborative, social and semiotic [4].
- AMPLIA (by its acronym in Portuguese Ambiente Multi-Agente ProbabiLístico Inteligente de Aprendizagem). It is an intelligent learning environment, designed as an additional resource for the training of medical students and it aims mainly to support the development of diagnostic thinking and modeling of diagnostic assumptions in the medical area [11]. In this tool users are represented by autonomous agents that are part of a social gathering based on objectives, which communicate, cooperate and negotiate.
- SMAW (MAS for the adaptation of web content). This system integrates technologies such as MAS and hypermedia adaptive systems to adapt Web content considering the characteristics of the access device of the users, incorporating a student model that takes into account the learning styles when delivering the appropriate material to each user [10].

3. Integration Model

The integration model proposed in this paper is based on the three approaches described earlier: ITS, CSCL, and MAS, which corresponds to three modules into the virtual learning environment CIA. The MAS is the base of the model, the ITS is the main module in the teaching/learning process and the CSCL acts as a meeting point that is provided for achieving or strengthening students knowledge in a collaborative manner. In the rest of the section, a description of each of these components is presented.

3.1 ITS Model

As expressed earlier, the ITS is the backbone in the proposed virtual teaching-learning environment, which aims to introduce courses with multiple forms of intelligent adaptation. The general pattern previously submitted to the ITS clearly shows the interaction that both student and teacher have with the domain's model, pedagogical model and student's model. Figure 1 shows in detail each of the elements taken into account for each model, in order to achieve the adaptability of the courses and their integration with the CSCL.

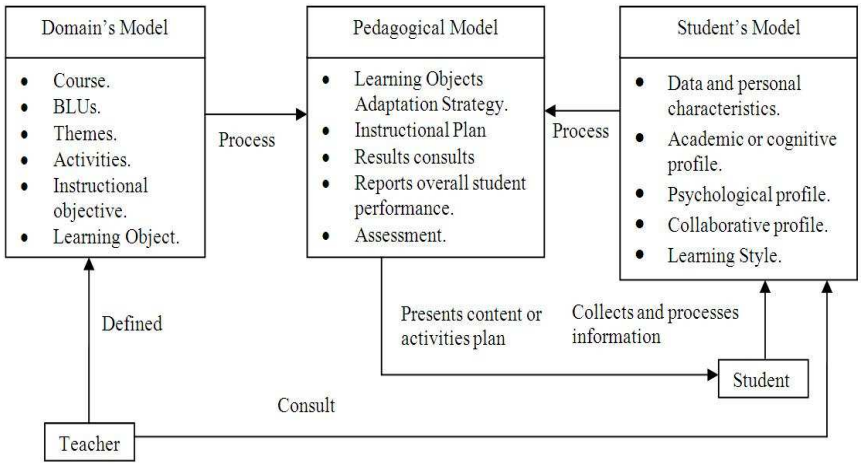

Figure 1 Knowledge Model of the ITS developed within CIA.

Some elements of the student's model, that may be used for the contents adaptation within the ITS and for the group selection in the CSCL are: the learning style, the collaborative profile, and the psychological profile [8].

In the Student's model the learning style is related to the manner in which students may more easily learn a concept. There are some people who learn faster watching examples of a particular issue, while others must first read the theory [2]. The learning style is determined in CIA by the test developed by Richard Felder and Linda Silverman [6]. In this test each student is classified according to four dimensions, and for each of these dimensions the student may be classified into one of two categories or in both. These dimensions and their categories are: Sensory-Intuitive, Visual-Verbal, Active-Reflexive and Sequential-Global. The collaborative profile, along with the psychological profile can identify student's abilities in different contexts of individual and group learning.

In the domain model the knowledge is divided into Courses, which in turn are composed of Basic Learning Units (BLUs) that are composed of Themes and these themes will have one or more Instructional Objectives associated which can be achieved by the development of one or more Activities which have associated one or more Learning Objects.

Finally as explained above, the pedagogical model is responsible for deciding which pedagogical actions have to be performed, which requires some adaptation strategies of contents and of the information of the students in order to generate and store for each trainee an instructional plan that allows guiding them in the learning process on an individual basis.

3.2 CSCL Model

The idea of using a CSCL module is the development of activities of group work, which will be planned by the pedagogical model of the ITS, in order to reinforce the knowledge gained by the students on an individual basis. Following this approach, it is necessary to extend the scope of the student model to be used in the CSCL as well. This new version is named Student´s Collaborative Model (SCM), which is composed of the Student Model and the Group Model.

Tthe teamwork is carried out according to a group work strategy which consists of a series of steps that guide the development of the collaborative process [3]. These steps are the group activities to be developed and vary depending on the chosen strategy. Such selection is carried out according to certain characteristics of the students who make up the group (collaborative profile and psychological profile), like the number of students available, and the type of group work (it could be a workshop, a consultation, a report, or a problem). It is also advised that within the study groups there should be a leader, who is in charged with guiding the development of group work and guide the team, this person is called a facilitator and may be the teacher of the course.

3.3 MAS Model

The MAS is the backbone of the functionality and integration of both the ITS and the CSCL, in which the actors (human agents) involved in a teaching/learning process interact. Such actors and their respective tasks are located in the proposed model into the following Software agents:

- Professor Agent: Its main function is to build and modify the domain module.
- Student Agent: Its main objective into the system is to get the knowledge in a particular area of knowledge offered in this environment.
- Facilitator Agent (Student's collaborative model): Is responsible for guiding the students in the teamwork within the CSCL, carrying out a strategy of collaborative work. It is assumed that this agent has a higher degree of knowledge on the subject of interest than the other students involved (it may be the teacher).
- Working Group Supervisor Agent (Student's collaborative model): Is responsible for the formation of the working groups and the updating of the collaborative profile of each student.

Besides these agents, who have a human counterpart, there are specific tasks in the proposed model that are also received not only in the ITS but also in the CSCL that can be assigned to software agents such as:

- Planner Agent (pedagogical model): Is responsible for planning the learning activities.

- Assessment Agent (pedagogical model): Is responsible for planning the assessments [1].
- Recovery Agent (domain model): Is responsible for conducting the search and storage of relevant educational contents.

The architecture of the proposed MAS model is shown in Figure 2. The learning environment presented in this paper is currently being developed under the name of CIA, Adaptive Intelligent Courses. It's design follows distributed architecture in several ways, first the courses submitted may be accessed from the Web, since it is raised under a client-server architecture, and secondly the server that provides all service of ITS and CSCL is distributed internally with the model of Multi-Agent System. The system is distributed across a LAN: A Tomcat Web server will be hosted in a main server and the main container will be identified, in it the internal agents provided by JADE are executed, such as: Agent Management System (AMS), Directory Facilitator (DF), and Remote Monitoring Agent (RMA), as well as some agents of the ITS, such as: Planner, Assessment, Facilitator, and Supervisor, since these agents have constant activity.

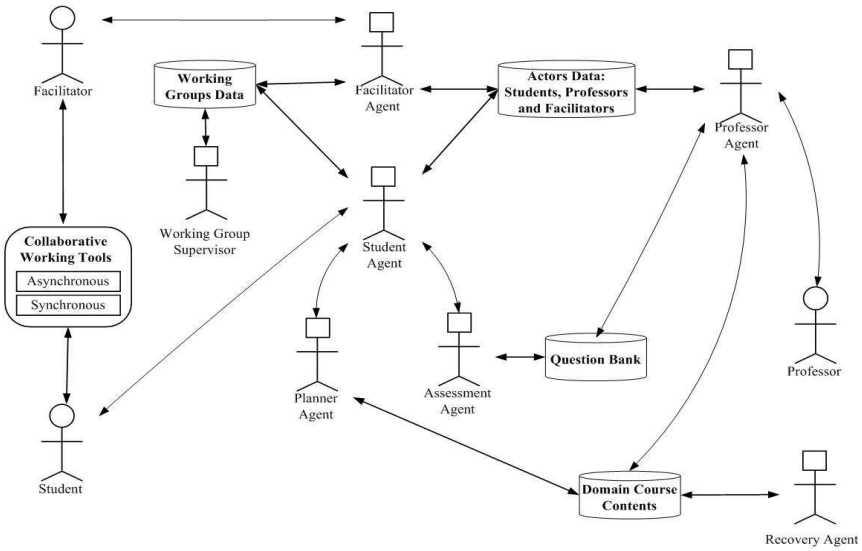

Figure 2 Multi-Agent Model Architecture of CIA.

4. Results

In order to validate the proposed model a prototype of a CLIPS course (C Language Inference Production System) in the area of Artificial Intelligence was built in the Computer Science Department from the National University of

Colombia, adjusting the respective assessments, dynamically re-planning the activities according to the goals achieved or failed by a student, and facilitating collaborative work through the use of working group strategies and tools. The results of such implementation are presented bellow in two parts. In the first one an example of the individual work is presented, meanwhile in the second one the focus is the collaborative work.

4.1 Individual Work Results

Figure 3 shows, through a sequence diagram that is generated by the agent Sniffer of JADE, the petitions carried out by the interface agent (represented as other), the Planner agent, and the assessment agent, in a specific case. The requests that can be seen in this communication sequence diagram are as follows:

- A student, through the interface agent, sends a request for planning (REQUEST: 63) when selecting a theme of the course.
- The planner agent receives the request sent by the interface agent and immediately asks the assessment agent to plan the evaluation (REQUEST 64) and sends a response to the interface agent about its application for planning (CONFIRM 5).

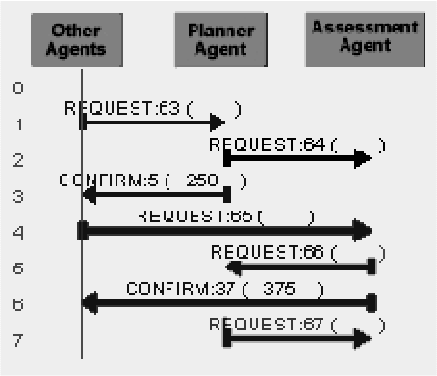

Figure 3 Message Sequence Diagram obtained by the JADE Sniffer Agent

- When the student finishes studying all the activities an assessment is presented to him (prepared by the assessment agent). Once the student finish the test the sends, through the interface agent, a request for qualification to the assessment agent (REQUEST 65).
- When the assessment agent grades the test verifies whether there are not approved IOs, if so, this agent sends a request to the planner agent (REQUEST 66) to re-plan new activities and through the interface agent sends the outcome of the assessment (CONFIRM 37).
- Finally, the planner asks the assessment agent to re-plan the contents and assessment for the new activities.

4.1 Collaborative Work Results

The collaborative works are created by each teacher who runs a course through an administrative module for collaborative work, where they must enter the following information: name, type of work, type of facilitator, starting date, the state of development and the collaborative strategy that such work should follow. Currently, only the Jiwsaw and the Peer to Peer Questioning are implemented.

While the students carry out the work on individual basis, the agent called Group Supervisor regularly reviews the starting date of the working group that are scheduled, and immediately one of these dates is complied he builds one or more groups of students according to the strategy, changes the status of group work (from planned to ongoing) and creates the working group schedule with all activities to be undertaken by the group taking into account the collaborative strategy, the protocol of the strategy and the tools that are used in this protocol.

When the student enters the system, in a small box he will have the activities that are active (according to the starting date, finishing date and depending on the type of person in charged) and is given a link with which he can access the tool with which he can carry out the activity: forum, chat, mail, repository, etc.

5. Conclusions and Future Work

This paper proposes a model of e-learning based on the integration of Intelligent Tutoring Systems, Multi-Agent Systems and Collaborative Learning Environments, making the necessary modifications to the models to withstand such integration. The proposed environment presents adaptability in the following issues: the instructional planning, the presentation of contents, the planning of assessments, the conformation of working groups, and the choice of strategies for collaborative work. Even if a detailed explanation of each processes are not presented on this paper, the general functioning is described.

Such environment is supported by a Multi-Agent approach, which was helpful to modularize and specialize the functionally of the different issues of the environment. It is noteworthy that a distributed architecture has been raised looking for greater versatility, parallelism, and better system performance.

As future work we aimed at developing a resources manager module of the ITS (especially for the handling and management of knowledge of the domain model), to create courses in a quick and guided manner. This module should include all the elements individually required by each of the three approaches ITS, CSCL, and MAS, and the relationships between each element. Finally, we can improve the system CIA including standards to enhance the planning and the integration with other platforms, because only the LOM standard is currently covered.

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