Mastem: A Mathematics Tutoring Multi-Agent System

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Abstract. The results of IDEB 2009 indicate the elementary students are failing mathematics exams. It is well known Intelligent Tutoring Systems could of be assistance in such cases because they are always available and resourceful. However, tutor systems need to be autonomous, flexible and adaptable. We claim that agent orientation has the natural paradigm for the development of such systems. The objective of this work is to propose the design and implementation of an educational software, called Mastem, to aid the teaching of mathematics targeted to students of 5th and 6th grades. This tutor system assists the students, adapts itself to the student's difficulties by identifying errors and presents tips/examples. We have successfully used the Tropos methodology and JADE frameworks to develop this software.

Keywords: Multi-Agent System, Framework i*, Tropos, JADE

1   Introduction

The agent paradigm is a technology that has been used in several areas. One of its applications is to improve significantly the process of developing of learning environments of educational software, especially those like Intelligent Tutoring Systems (ITS) [1]. This occurs in function of autonomy, flexibility, collaboration and adaptation provided by this paradigm [1].

In this context, it was found that the high failure rate of elementary students causes, among other things, reducing the number of students enrolled in these series. Furthermore, the results of IDEB 2009 [2] shows that performance in mathematics increased slightly compared to the performance in Portuguese. The poor performance in mathematics of students in upper grades of elementary school, combined with high repetition rate of these same series promotes the need for a specific intervention.

In this work, we performed the design and implementation of educational software like intelligent tutoring system (ITS), called Mastem (Multi-Agent System to Teaching

and Evaluation of Mathematic), to aid of the teaching of mathematics intended for students of elementary schools of Brazil, especially students of 5th and 6th grade.

The Mastem has the ability to adapt itself according with user difficulties, providing tips and detailed examples. We used Tropos framework [3] to guide the development of the Mastem. This framework adopts the i* organizational modeling framework, which offers the notions of actor, goal and (actor) dependency [3]. We developed the Mastem software in Java language and used the JADE library [4].

2 Objectives of the research

The objective of this work is to evaluate the use of Tropos and JADE to define, model, and implement intelligent tutor system to help the teaching of mathematics.

3 Scientific contributions

3.1 System Description

The Mastem addresses the following topics: multiple and natural number divisors, prime numbers and composite numbers, factoring, and fractions. These topics are the main difficulties found in students of elementary schools of Brazil [2]. The system works with an ordered sequence of 120 questions in three difficulty levels (easy, medium, and hard) and answers divided in four options each one. The user evolution depends on answering correctly the questions within a time interval previously established. If the user does not be successful in answering the questions of a specific topic, the agent Tutor will teach him with tips and examples related on the question. Tutor agent monitors the user performance and displays the ranking of the three top users with the highest scores, the Ranking agent updates the display after each answered question, stimulating the efforts to overcome the user.

When the user answers correctly the questions, it increases his score progressing to the next level, being awarded with medals displayed in a table. The medal table (shown in Figure 2) is another motivational factor for the user, since it challenges and encourages the learning of content worked in the software.

3.2 The use of tropos to develop an educational software

The Tropos framework [3] is a methodology for developing multi-agent systems. Its name is derived from the Greek "tropé", which means "easily modifiable" or "easily adaptable". Thus, this framework allows the development of systems according to the actual needs of an organization, seeking to integrate the system and the changing environment in the best way.

The Tropos framework defines five phases in the development of multi-agent systems [1]: i) early requirements, ii) late requirements, iii) architectural design, iv) detailed design and v) implementation.

The modeling of early requirements of the Mastem was done by generating the models of Strategic Dependency (SD) and Strategic Rationale (SR) defined by framework i* [1]. In this phase, we identified the actors Student and Teacher and the Tutor Agent. In addition, we need the resources Time, Questions and Punctuation, the softgoals Entertainment and Usability and the following objectives: Mathematics be learned, Student's performance be monitored and Questions be answered).

The phase of late requirements consisted of the addition of the System actor, the Ranking and Difficulty agents and new modeling elements. The Strategic Dependency model in the phase late requirements was built using OpenOME [9] and it is shown in Figure 1.
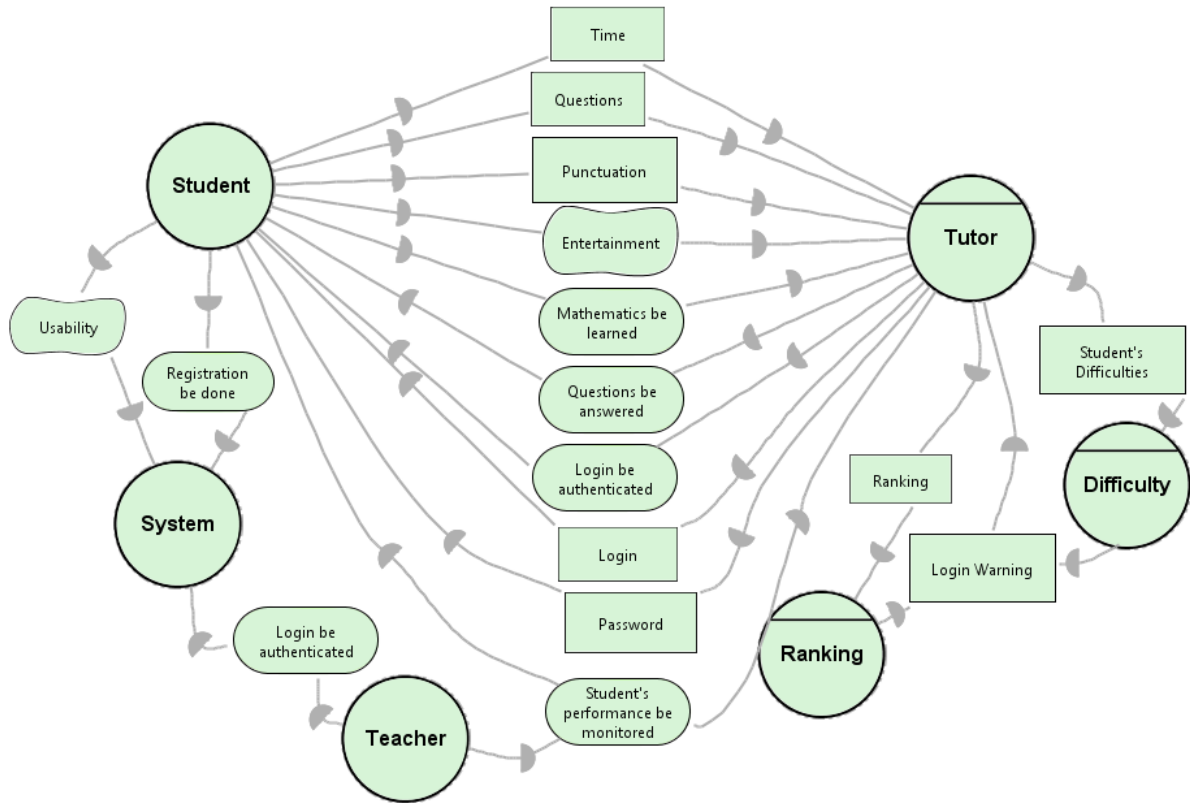
Figure 1. SD model of the Mastem in the late requirements phase.

A brief description of the dependence between actors and agents is given as follows: Teacher Actor - It can insert questions in the software and also check the performance of the students. Student Actor - It aims to learn mathematics, answering questions and

have his performance monitored by the agent Tutor, and this makes use of available resources by agent Difficulty. System Actor - It is responsible to register and to provide usability on the Mastem. Difficulty Agent - It manages the difficulties list that the student has, and deliver this list for the Tutor when the Difficulty agent receives the warning of login. Ranking Agent - It should provide the ranking with the three students with the highest scores for the Tutor agent to show this information to the Student actor. Similarly, the agent performs this task when the Tutor notifies him about the student login.

In architectural design phase, we constructed the Non-Functional Requirements (NFR) diagram [3] through the softgoals of the Mastem. Then, we consulted the table of attributes correlation and styles [6] to determine if they contribute positively or negatively on achieving the goals.

We chose the Strategic Union style because it is the most suitable for the architecture of Mastem because it involves agreements between two or more partners in order to obtain benefits from larger scale. Thus, agents will work collaboratively to achieve their goals.

In the detailed design phase, we performed a micro-level specification of agents [3]. The Mastem specification was designed by AUML language [8] and we created the class diagram, sequence and communication in the Astah Community tool [7]. All diagrams and more details can be found in [10].

The implementation phase consisted of developing the relational model and the Mastem's database using the PostgresSql. Then, the system was coded in Java through the IDE Netbeans and the JADE framework [4] to create the agents behaviors.

The main screen of the student, shown in Figure 2, consists of a button bar that contains other resources that he can access, information about his score and medals and the ranking with three users with the highest scores. In addition, this screen contains the field where the question appears, the option of response and the time in which the student must answer the question.

4   Conclusions

This paper presented the development of educational software Mastem of intelligent tutor system type, adaptable to the user difficulties, from the design phase through implementation. The Mastem was conceived with the objective of contributing to the learning process of the topics addressed in it since the system focus on the users' difficulties and when he identifies at least three errors of the same subject, he presents tips or examples related to the issue that is being worked on.

The characteristics of autonomy, deliberativeness, reactivity, organization, ability to socialize, interaction of the agents as well as their ability to be multi-threaded contributed to the modularization of the system. The use of this technology allowed each agent to have specific characteristics that collaborated with achieving of the objectives of Mastem.

The property of the JADE framework to be multi-thread was fundamental to Mastem since agents are permanently active and involved in an infinite loop to observe your

environment, update its internal state, select and perform an action. Moreover, it was observed that the use of this framework on Mastem resulted in a drop in performance since it depends on the communication of the agents.
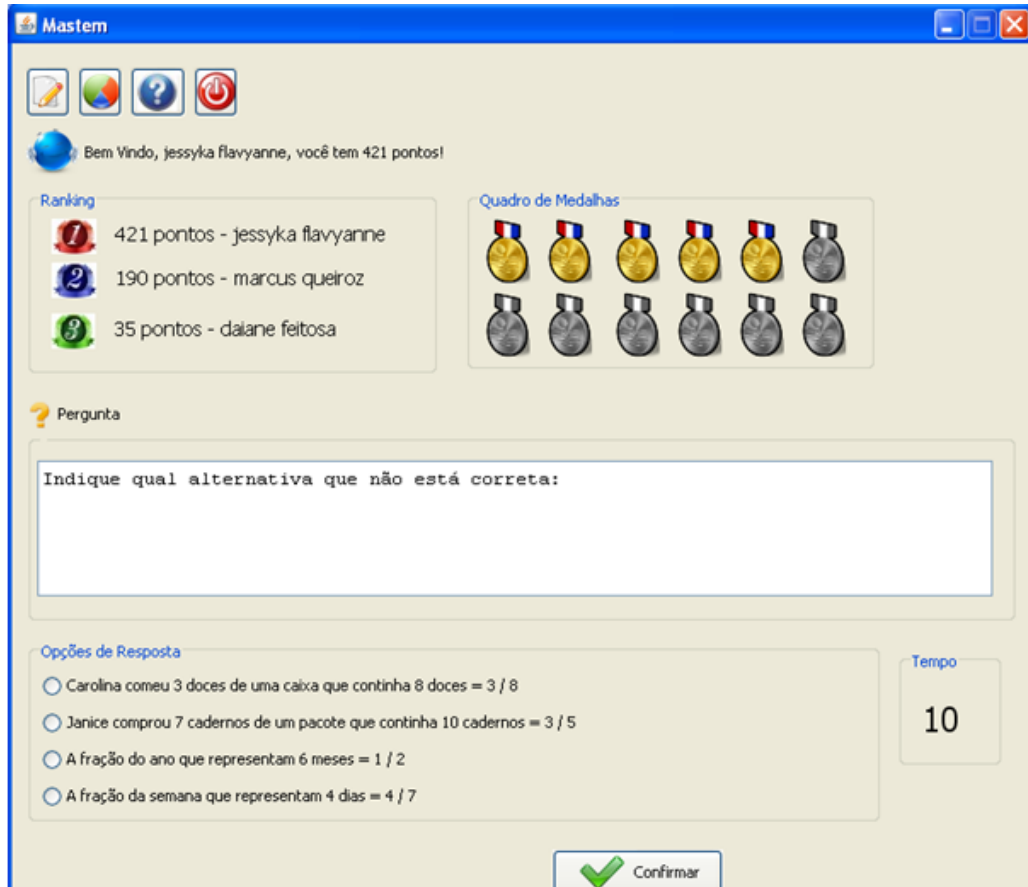
Figure 2. Main Screen of Student User.

The Tropos methodology proved to be suitable for the development of Mastem since it is a complete methodology that covers from the stage of the requirements collection to system implementation. The i* framework and language AUML allowed the full specification of Mastem through the models of strategic dependency and strategic rationale as well as class diagrams, sequence and communication respectively.

Some difficulties were obtained during the implementation of Mastem regarding the JADE framework. Among them, we can mention the complexity of creating agents automatically in software and the creation of an installer.

5   Ongoing and future work

As future work, we intend to create an installer for the Mastem and make it available under the GNU terms. Moreover, for the ranking be composed of students from differrent schools it is necessary to create and maintain a server that would be responsible for managing the accounts of all Mastem users. Finally, we intend to conduct a formal validation with mathematics teachers and consequently the use of Mastem by students during class.

6   References

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