Stefano A. Cerri Guy Gouardères
Fábio Paraguaçu (Eds.)

Intelligent Tutoring Systems

6th International Conference, ITS 2002
Biarritz, France and San Sebastian, Spain, June 2-7, 2002
Proceedings

Springer

Series Editors

Gerhard Goos, Karlsruhe University, Germany
Juris Hartmanis, Cornell University, NY, USA
Jan van Leeuwen, Utrecht University, The Netherlands

Volume Editors

Stefano A. Cerri
LIRMM, University of Montpellier II and CNRS
Montpellier, France
E-mail: cerri@lirmm.fr

Guy Gouardères
LIUPPA, IUT de Bayonne - University of Pau
Bayonne, France
E-mail: Guy.Gouarderes@iutbay.univ-pau.fr

Fábio Paraguaçu
Universidade Federal de Alagoas, Department of Information Technologies
Maceió, Brazil
on leave at
LIRMM, University of Montpellier II and CNRS
E-mail: paragua@lirmm.fr

Cataloging-in-Publication Data applied for

Die Deutsche Bibliothek- CIP-Einheitsaufnahme

Intelligent tutoring systems : 6th international conference ; proceedings / ITS 2002, Biarritz, France and San Sebastian, Spain, June 2 - 7, 2002. Stefano A. Cerri ... (ed.). - Berlin ; Heidelberg ; New York ; Barcelona ; Hong Kong ; London ; Milan ; Paris ; Tokyo : Springer, 2002
(Lecture notes in computer science ; Vol. 2363)
ISBN 3-540-43750-9

CR Subject Classification (1998): K.3, I.2.6, H.5, J.1

ISSN 0302-9743
ISBN 3-540-43750-9 Springer-Verlag Berlin Heidelberg New York

Springer-Verlag Berlin Heidelberg New York
a member of BertelsmannSpringer Science+Business Media GmbH

http://www.springer.de

Printed in Germany

Typesetting: Camera-ready by author, data conversion by PTP-Berlin, Stefan Sossna e.K.
Printed on acid-free paper SPIN: 10870295 06/3142 5 4 3 2 1 0

Developing Distributed Intelligent Learning Environment with JADE – Java Agents for Distance Education Framework

Ricardo Azambuja Silveira[1] and Rosa Maria Vicari[2]

[1]Universidade Federal do Rio Grande do Sul – UFRGS
Universidade Luterana do Brasil - ULBRA
rsilv@inf.ufrgs.br

[2]Universidade Federal do Rio Grande do Sul – UFRGS
rosa@inf.ufrgs.br

Abstract. Over the last years, many organizations started to use Distance Teaching tools as instruments in employees' qualification programs, creating what we may call *E-learning* or *Virtual Training* in Human Resources Development Programs. However, usually these organizations tend to use technological resources already available, and do not shape their technological platform into a pedagogical project. Recent advances in the field of Intelligent Teaching Systems have proposed the use of Artificial Intelligence through architectures based on agents' societies. Teaching systems based on Multi-Agent architectures make possible to support the development of more interactive and adaptable systems. The objective of the paper is to discuss the feasibility of implementing Distributed Intelligent Learning Environment – DILE based on the Multi-Agents Architecture approach, aiming at the achievement of human resources qualification through Virtual Training. Besides, we present a proposal of an architecture named JADE - Java Agent Framework for Distance Learning Environments.

1 Introduction

Computer Science, together with Psychology and Education, has been trying to refine teaching computational tools towards personalized self-learning. Everyday, new approaches to the use of Computer and Education are bringing new perspectives to this area. The evolution of Computer and Education became computational teaching environments an excellent choice for Distance Learning, by bringing new vigor to this field of science. Computer Networks and Multimedia fields have provided tools for the development of Tutoring Systems based on client-server architectures. The popularity of Internet along with the extensive development and use of standard protocols and services make Internet very attractive for distance learning. There has been a big boom of tools and mechanisms available for implementation and support of Distance Learning.

Many business organizations have been using Distance Learning tools as an instrument to implement Human Resources development or qualification programs,

S.A. Cerri, G. Gouardères, and F. Paraguaçu (Eds.): ITS 2002, LNCS 2363, pp. 105–118, 2002.

by creating what we may name *Virtual Training*. However, these organizations usually use the legacy technological resources, and do not shape the technological platform with a pedagogical concern. The traditional Computer Assisted Instruction Systems approach (CAI) lacks to provide an adaptable learning process according to each individual student. The simple use of technological resources without an adequate pedagogical and organizational project results in inadequate virtual training programs, within learning environments excessively static and with quite directive teaching techniques. These issues claim for adequate implementation methodologies of virtual training programs and for suitable learning environment projects with adequate pedagogical proposal and proper use of technology.

According to Rosenberg [15], the use of modern technologies and delivering of good learning programs are essential but insufficient to guarantee the efficacy of these programs The increase of human capital of an organization must be based on an E-learning strategy focused on factors that include building a learning culture marshaling true leadership support in consonance with the business model.

Projects of E-learning must take into consideration that there are different classes of students: the *non-cooperative*, those who act in a passive way or even try to frustrate the program's objective; the *cooperative*, who follow nrientatinns, hut do not necessarily know where to go; and the *pro-active* students. who know very well their objective, and search for aid to relief the task burden. The teaching methodology employed in *each* case is different and there must have a clear concern by the technological environment on the profile of the student that will use the system.

In order to reach this goal, cognitive student's modeling is required, and it must make a clear specification of the students' profiles. An intelligent teaching environment must build and update the student model according to what the student already knows, and this may vary from student to student. This difference must be considered when in the search for efficiency in the development nf intelligent teaching environments. Student's performance in the domain, transparency of technical terminology. the student's objectives and expectations and his/her previous experience must he also taken into account. That is why the Intelligent Learning Environments, such as JADE, are a class of teaching instruments much more advanced from the pedagogical and organizational point of view, more adequate to the aims of Virtual Training in organizations.

The state of the art in Intelligent Tutoring Systems and Intelligent Learning Environments fields points to the use of Agent Society-Based Architectures. The fundamentals of the Multi-Agent systems have demonstrated to be very appropriate to design tutoring systems, since the teaching-learning problem could be handled in a cooperative apprnach [5] [7] [8] [10] [13]. Using Multi-Agents Systems approach to design Intelligent Tutoring Systems can result in mnre versatile, faster and at lower costs systems. The introduction of AI techniques and, specifically. the use of Multi-Agents architecture in these environments aim to provide student-modeling mechanisms [8]. Wc believe that these concepts can he used in modeling and implementation of Intelligent Distance Learning platforms aimed at qualification programs in organizations.

The objective of the paper is to discuss the feasibility of implementing Distributed Intelligent Learning Environment – DILE based nn the Multi-Agents Architecture approach, aiming at the achievement of human resources qualification through Virtual Training. Besides, we present a proposal of an architecture named JADE - Java Agent Framework for Distance Learning Environments. This project was born in 1997

[16][17][18] as a thesis project. Different from the homonymous JADE (Java Agent DLivelopment Framework) [2], a FIPA [6] compliant software framework implemented in Java language which simplifies the implementation of multi-agent systems. the Java Agent Framework for Distance Learning Environments implements an agent framework with specific educational purposes.

2 Theoretical Issues

There is a new look upon Education developed in the last 20 years that has been highly influenced by Cognitive Science. The educational system has focused more and more on learning instead of on teaching. The development nf learning theories has changed the nature of student's learning and perception. Knowledge is today considered something socially built throughout students' actions, communication and reflections. The classic approach of education on knowledge transmission has been changing into a model of practical experimentation and interaction that promotes changes in concepts and student's strategy, until he/she reaches proficiency. In this context, teachers perform the role of supporter instead of information provider.

As we pointed in previous papers [16] [17] [18], the idea of Distance Education, however not new, has showed a great capacity of integrating new technologies successfully. Lately there has been appearing a great deal of mechanisms and tools available for Distance Education support and implcmentntion.

Classic definitions of distance teaching imply that the ideal situation for learning is the. traditional one, with teacher and student Face-to-face. From this viewpoint, Distance Education would be an "inferior" way of education, always trying tn fill the lacks of the traditional model. This conception may be true in many cases, but a growing body of research, exploring other options, has been taking their place, in the light of new educational paradigms, changes in the social dynamics, and technological advance of means of communication and computational systems.

It is important to highlight that Distance Education cannot be seen as a replacement for traditional and presential education. They are two modalities of the same process. Distance Education dues nnt compete with the conventional means, once this is not its objective. If Distance Education presents, as a basic characteristic, the physical and temporal separation between teaching and learning processes. this does not mean only a specific quality of this modality. but essentially a challenge to overcome, promoting the advance in the use of cooperative processes of teaching in a combined way

Keegan [9] summarizes the central elements that characterize the concepts of Distance Education: Physical separation between student and teacher. different from Presential Teaching; Influence of the educational institution: planning, systematization, and project, different from private learning; Use of technical means of communication to put teacher and student in contact and to send educational contents; Availability of a twn-way communication, where the student benefits from the possibility of two-way dialogue inatiatives; Possibility of occasional meetings.

We rake a simpler and more encompassing definition, which explores new possibilities [19]: "Distance Education is a system that must provide educational opportunities anytime, anywhere for anyone".

According to Spodick [19], five basic points are essential in a successful Distance Education program: contact between teacher and student. active learning through

student's answers, fast feedback to the teacher about the student's understanding level, fast feedback to the student about his/her own performance, the student has the opportunity to review and learn through his/her own mistakes.

2.1 Pedagogical Agents

One of the major problems of traditional computer based learning systems is how to provide adaptive teaching, suitable to each student A Distance Education system must support as much as possible the problems caused by the physical distance among reacher. student, and classmates. This claims for more efficient mechanisms of adaptability and assistance in problem-solving processes. The system **must** perform the teacher's role as much as possible, building a robust student model for each user that would enable: Adapting the syllabus to each user; Helping him/her to navigate over the course activities; Giving support in the task accomplishment, and in exercises and problems to be solved. Providing help resources whenever is *needed*

As the **student's** performance is rarely consistent, and it is impossible to preview the entire set of student's behavior, the ITS adaptability is limited and the classic ITS models are not robust enough to provide the minimum requirements necessary for an interactive learning environment. According to Mathoff [10], *these requirements* are: *Interactivity, Adaptable Instruction, Robustness, Direct Monitoring of the Learning Process, Empirical Evaluation* and *Parsimony.*

Most recent advances in the field of Intelligent Learning Environments have proposed the use of agent's society based architectures The principles of Multi-Agent systems have showed a very adequate potential in the development of teaching systems, due to the fact that the nature of teaching-learning problems is more easily solved in a cooperative way For that end, JADE , as well as other teaching environments [5], [7], [8], [12], [13], [20], uses this kind of architecture, implementing *Pedagogical Agents* as a specialized class of agents with the necessary abilities to deal with teaching strategies

In this context an agent is described [3] as a software entity that works in a continuous and autonomous way in a particular environment, generally inhabited by other agents and able to interfere in that environment, in a flexible and intelligent way, not requiring human intervention *or* guiding. Ideally, an agent that works continuously for long periods of time must be able to learn through experience and, if it inhabits in an environment with other agents it must he able to communicate and cooperate with them, sharing a common world

3 The JADE Project

The *Java* Agent *framework for Distance learning Environments* – JADE project [18] proposes an infrastructure of project, development and implementation of Distributed Intelligent Learning Environments – DILE, based on the approach of Multi-Agents architecture towards Distance Education, for multiple domains. In this project we implemented different versions of Eletrotutor prototype Eletrotutor is a teaching environment for Electrodynamics teaching, and in each version we have been refining JADE architecture

3.1 Architecture

JADE architecture encompasses a very short Multi-Agent family composed of just four types of agents: an agent responsible for the system's general control, one responsible for agents' communication, one in charge of student's environment, and a set of agents responsible for tasks related to teaching tactics (Pedagogical Agents). where each agent may have its tusks specified according ro its goal.

The agent's architecture is designed as robust and standardized as possible and aims to enable reusing codes for different kinds of agents. The intelligence of the environment is strongly based on interaction among agents by message interchanging. The tasks performed in teaching are decomposed and performed individually or in groups of agents, and a set of messages is designed to be sent according to the knowledge base of each agent.

Communication between agents is performed through a KQML-based message set, implemented with communication resources nf JAVA language objects named RMI (Remote Method Invocation). used in the project [1].

The system contains a special agent responsible for each teaching strategy (*Pedagogical Agents*), that is. for the domain knowledge retrieval over each point Lo be presented to the student, for the task of proposing exercises and evaluating proposals, examples and extra activities.

The Student's Model agent takes all actions of student's data accessing. When a Pedagogical agent is required to update the student's history, this agent sends to the Student Model agent the data to be updated, as well as any other change in the student's cognitive state.

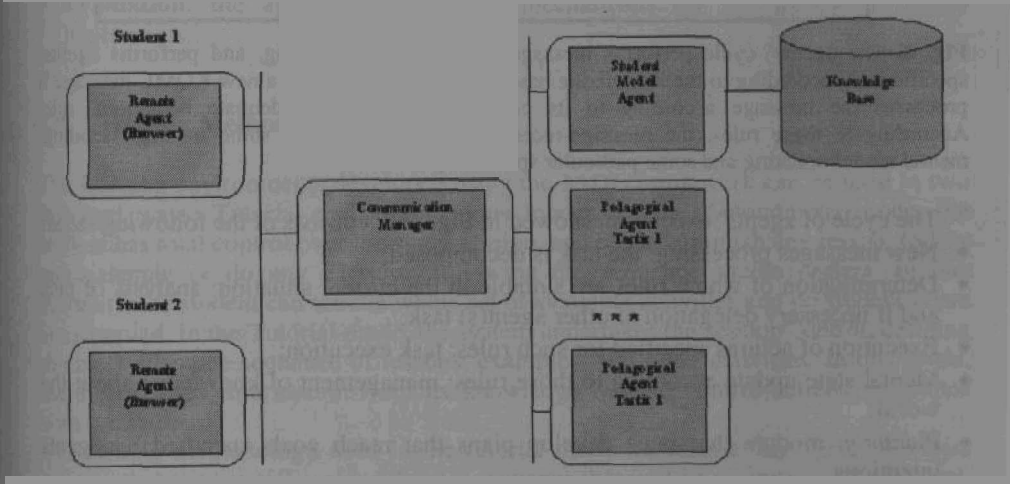

Fig. I. System Architecture: The Architecture of JADE system is composed *of* a set of apcnts: (*Pedagogic Agent*) in charge of performing learning activities as examples, exercises, an others. One special agent (*Communication Agent*) performs communication management among the agents There is an agent (*Student Model Agent*) responsible for student modeling and agents' coordination. The Browser component (*Remote Agent*) performs the student interface and the communication between the student and the system

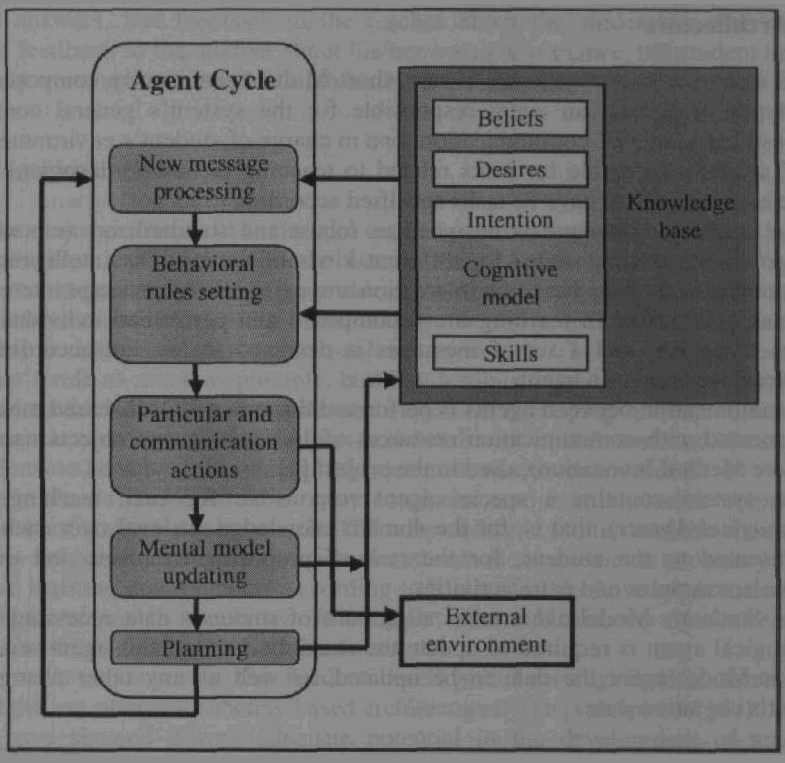

Fig. 2. The agents' cycle performs messages sending and receiving, and performs agents' specific task, according to the knowledge base. As the agent receives a new KQML message it processes the message according to its content, applying the adequate behavioral rule. According to these rules, the message-receiving event can trigger some message sending, mental model updating and some particular specific agent action

The cycle of agents' execution, showed in Figure 2, consists of the following steps:

- New messages processing: the task is decomposed;
- Determination of which rules are suitable in the current situation: analysis of task and if necessary delegation of other agent(s) task;
- Execution of actions specified for such rules: task execution;
- Mental state update according to those rules: management of knowledge about the world;
- Planning: module that must develop plans that reach goals specified by agents intentions.

JADE's Knowledge base implements BDI architecture [11] by using Java data structure and a relational data bank to represent beliefs, desires and intentions. The Student Model agent performs all actions related to knowledge base retrieval and updating. When a pedagogical agent needs to update the student" historic, for example, it will send data to the Student Model Agent. The major rules of the Student Model Agent are: To load the current student's state; to generate the overall student's historic; to generate the report of every student's steps; to generate the assessments

results; to select the teaching strategies; to check the last access date and to verify tactics available for a certain lesson.

The **Pedagogical Agents** are generated from a tactics previously defined by the course specialist. Their tasks *are* defined according to the agent's needs. However. as the tutor is based on the content presentation(HTML pages presentation), some tasks are previously defined for all pedagogical agents:

- **Show current content:** when the pedagogical agent receives this request. it communicates with the Student Model manager agent to retrieve from the knowledge base the content that is being presented to the student and sends it to the student's browser.
- **Advance:** with that quest, the pedagogical agent communicates with the Student Model Manager to retrieve from the knowledge base which content will be presented ti, the student.
- **Return:** the pedagogical agent retrieves. from the knowledge base and through the Student Model Manager. which is the content previous to the one the student sees at that moment.
- **Options:** if requested, the pedagogical agent can propose some tools or resources to the student, according to the teaching tactics s/he is performing
- **Update historic:** at every task implemented, the pedagogical agent must register at the Student Model the actions that were performed, as for example, date and hour the student left the current content, date and time of a new content input. etc.
- **Communication:** the agent implements a function that locates where the Communication Manager is in order to re-send information.
- **Evaluation:** the agent has evaluation mechanisms for the tactics the agent implements.

33 Teaching Methodology

The learning environments developed using the JADE framework can be used in two different ways: Tutorial and Autonomous modes. In the Autonomous mode. the student has total control over the study session. and can accomplish any lesson, follow any example or do any exercise, following the sequence she/he prefers. In this modality, the student can see the whole set of available activities and no student's data are recorded. In the Tutorial mode, the system undertakes the session control, defining the most adequate sequence of lessons, examples, and other activities. In this mode, the system uses information from its knowledge base to control actions developed with the student.

Teaching methodology used in the tutorial mode assumes a *Teaching Strategies* concept that is a set of *Teaching Tactics* sequence that will be proposed to the student. Evaluation is carried out while the student does the activities proposed, and the assessment of the student is continuously registered in the system's database. JADE knowledge base comprises the following aspects:

- **Student's Cognitive State**: the student model is based on the overlay method [8]: The system registers what the student has learned and compares against the course domain to propose the next topics. Through the guiding of every student's steps, the tutor could adapt the Teaching Strategy to *the* student and present some resources defined by specialists in order to reinforce his/her learning.

- Teaching Stralegies: in the Teaching Strategies model, the specialist puts different strategies available by associating several tactics in different ways. According to the student's action within a teaching-learning tnctics, the tutor can change the strategy of the next action, in order to better fit the student's abilities.
- Assessment: for each lesson presented to the student. the specialist must determine an evaluation method and define rules that will generate strategies to determine actions. according to the student's evaluation result in each lesson.

When the specialist designs the course. he/she can determine which resources or tools will be displayed to the student in each teaching strategy. The student will have at his/her disposal three kinds of resources:

I. Changing tactics: the specialist can create alternative tactics. When the tutor realizes the, student is calling a new tactic. it activates another tactic related to this action and changes the way lesson's characteristics presentation.
2. Local tools: these tools are displayed on the screen and consist of: Help (explains to the student the interface's and tutor's function), Hints (hints on how to solve an exercise, learn a certain content, ctc) and Calculator (used in exercises solving).
3. Online tools: the model proposed will put available several tools online in order to provide students with more resources to solve doubts, lcam more about a topic, etc. These tools are chat. forum and search. The system is flexible and accepts the inclusion nf other tools.

The course content can be developed using any kind of HTML authoring tools. Documents and multimedia resources created can be hosted at any web server. An Administrative Tool allows the specialist to build a course by designing lessons, strategies, tnctics. and content associating all those resources fa m HTML pages. When designing the course, the Administrative Tool inserts in the database all the information the system needs to retrieve those pages and other documents developed by the authors.

3.3 Features

Snme special features were: implemented [14] aiming to expand JADE functions and to implement mechanisms that improve adaptability and dynamism to the system by creating a flexible structure that allows specialists to organize their web course content. as well as the strategies, tactics and help toots they want to provide when designing learning environments projects. Several Learning Support Tools are also available and can bc included as additional features of the learning environments implemented with JADE. These tools were implemented as WEB oriented features to improve interaction among students and teachers as well as to provide on line help tools that avnid the student has to leave the teaching environment when using another tool. Nevertheless. with the number of resources available today on the Internet. it is normal that the student looks for other tools to complement his/her learning. The following tools are currently available:

- On Line Calculator: this tool is intended to help the student in problem solving tasks. The development of this tool used JavaScript in a FTIML page, and it has functions of a scientific calculator that can be used by the student as a web page.

Chat: this tool intends to allow students to chat within the tutor. Chat is automatically initiated with the student's login. In case the student leaves the tutor. the chat will automatically prevent this student to use it.

- **Forum**: This tool allows the students to discuss the course through topics. The student has always the possibility of sending a new message or reply an existent message just by clicking on the message and typing the text.
- **Search Tool:** This tool allows the student to research over any topic. This resource triggers the search in three search sites. After getting the answers, it collects the first three links of each site and builds a single page. The configuration of these sites was chosen at random (AltaVista, Yahoo and Google) but the implementation is flexible and any search site can be used.

Figure 3 shows a snapshot af the Eletrotutor prototype with the Learning Support Tools menu on the left side of the screen and the On Line Calculator window.

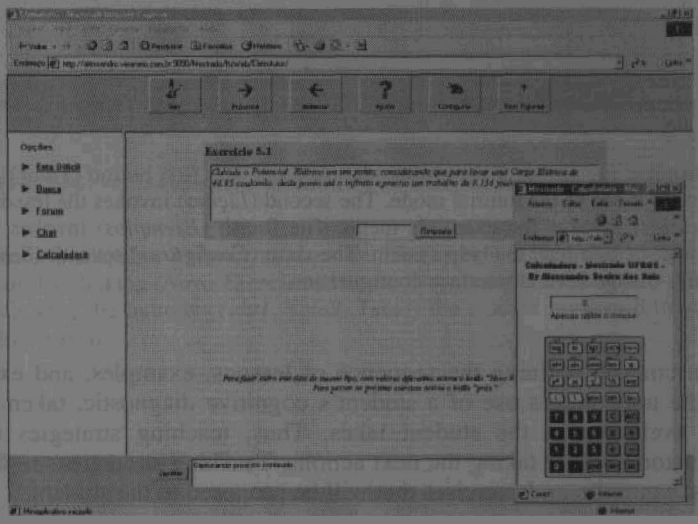

Fig. 3. Snapshot 1: This picture shows the features menu on the left side of the screen and the on line Calculator in the right side as an example. The features menu contain links to the It is too hard help feature (*Está Difícil*), Search tool feature (*Busca*), Forum tool (*Forum*), Chat (*Chat*) and Calculator (*Calculadora*).

34 The ELETROTUTOR Prototype

The Eletrotutor prototype was implemented as a test bed to evaluate JADE platform. It is an Electrodynamics client-server intelligent learning environment designed according to JADE architecture (available *in* http://www.inf.ufrgs.br/~rsilv). Figures 4 and 5 show two snapshots of The Eletrotutor prototype.

As mentioned above, the environment may be used in two different ways: Tutorial, and Autonomous modes. In the Autonomous mode, the student has total control over the study session, and mny perform any lesson, check any example or make any exercise in the sequence he/she chooses. In the Tutorial mode, the system undertakes

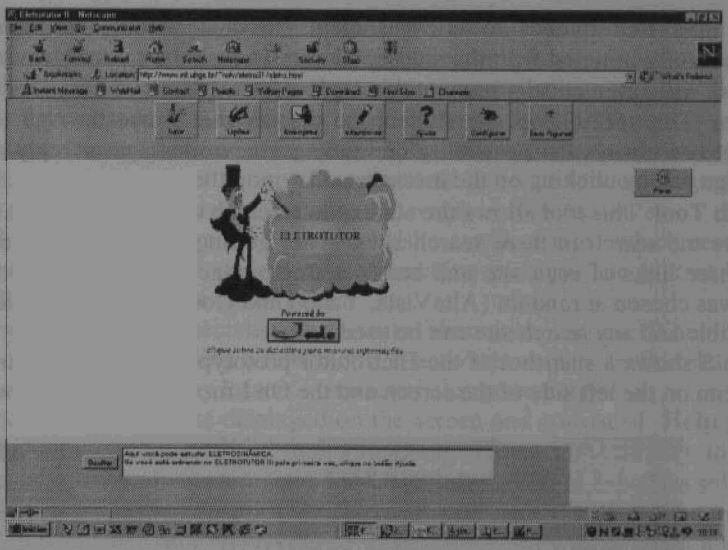

Fig. 4. Eletrotutor's snapshot 2 shows the main screen. The first button (*Tutor*) changes from the autonomous mode to the tutorial mode. The second (*Lições*) invokes the lessons menu. The third (*Exercícios*) invokes the exercises menu. The fourth (*Exemplos*) invokes the examples menu. The fifth (*Ajuda*) call the help system. The sixth (*Configurar*) seventh (*Sem* figures) and etghth (*parar*) change several interface configuration

the session control, defining the sequence of lessons. examples, and exercises. For that end, the tutor makes use of a student's cognitive diagnostic, taken through the record of every action the student takes. Thus, teaching strategies observe the student's historic before taking the next actions. Teaching strategies are the sequence of contents, examples and exercises that will be proposed to the student.

4 The System Evaluation

In order to have some partial evaluation of the teaching tactics used in this environment, we perform an experimental investigation comparing the performance of two groups of students in high school classes [16] [17]. The first group attended a special course using the Eletrotutor in non-tutorial mode. The second group attended a classic expositive claw. The same test measured the knowledge acquired after the session class. Figure 6 shows the obtained results. The findings show that both groups have similar performance.

This evaluation shows that the experimental group has a performance similar to the control group. This shows the potential of the tools and teaching tactics implemented. Further work will evaluate the tutorial mode to verify how much the pedagogical agents can improve learning.

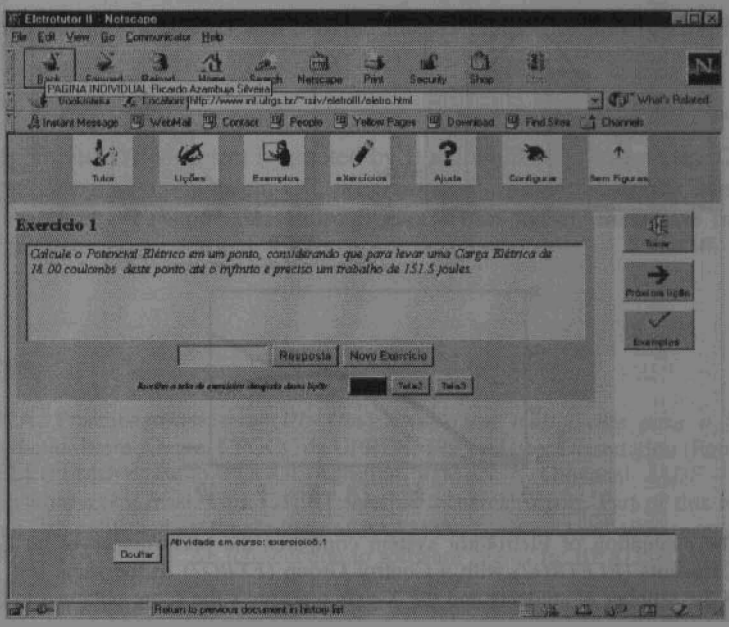

Fig. 5. Eletrotutor's snapshot 3 shows an exercise. The system presents as many exercises as the student want by clicking (*Novo Exercício*) button. This changes the instance of this kind of exercise. By clicking the buttons (*Tela1*, *Tela2*, *Tela3*) the student invokes different kinds of exercises for this lesson

5 Conclusions

Distance Education systems based on the Internet does not have any time or space constraint. Students can interact with the system anytime. anywhere. The available tools enable the communication between students and teachers very easily and allnw quick feedback. Students and teachers can share information. Excellent teaching strategies may be taken through the available resources over the web. all over the world. Nowadays, it is possible tn have access and display broad and advanced knowledge, not available until then. Students can decide what, how nnd when to learn, fnvorinp teaching methodologies focused on the student and with an explorative and constructivist basis.

Huwever, there are not only advantages in the www-based teaching. Some important aspects should be considered: Most of Distance Education systems based on the web are not intelligent or adaptable. Students usually get lost when they need to navigate choosing paths among the labyrinths of links displayed in HTML pages.

Web pages by themselves are not a teaching system. It is very hard for the student done to get material that is of his/her interest. amid the great deal of material available.

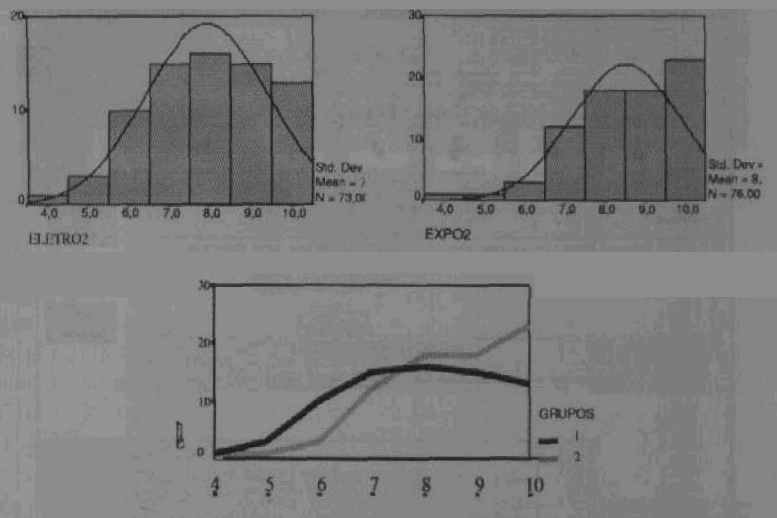

Fig. 6. The evaluation of Eletrotutor system compares the performance of an Experimental Group of students (*ELETRO2*) with a **Control** Group (*EXPO2*) in the same test. The Y-axis represents the number of students and the X-axis represents the scare obtained in the test. The **first group (dark *line*) had a little hit** lower performance than the second group (*gray line*). **But** Parametric Statistic test shows that **this** difference is not significant. This experiment used Eletrotutor in the non-tutorial mode.

Research **have turned** towards **three, great directions:** the use of **adaptive www pages** that **use some method** to verify the **pages content** and **adapt them to the student's actions; the use of www systems** based on ITS, **which use the traditional** architecture **of** Intelligent Tutors **and use** a **www interface**, including sometimes **collaborative learning mechanisms: and architectures** that use **intelligent agents. as in** the **case** of the **architecture** proposed in the **present work.**

However, **all these issues have in** common a strong dependence **on** a **sharp and robust student** modeling. Through **the student model** it *is* **possible** to provide **customized teaching tactics, which reflect the knowledge** level of **each student. his/her learning abilities** and objectives. The **Student Model registers the student's mistakes** in a way that the **system can provide teaching strategies adequate** for content **review. Thus, the** more **precise this** model is **the. better** and higher is **the system adaptability.**

In **this work we intend to bring some important contributions. refining the efficacy** of learning environments. aggregating **cnncepts of** different areas to establish a **methodology for** the **implementation** of **Distance Education projects, and stressing the use of cooperative problem solving** paradigm using **Multi-agent** architecture.

Further work will integrate **the JADE implementation of** pedagogical **agents** with commercial or **well-known** academic learning **environments** or **frameworks** [4]. **This** integration **takes** advantage of the pedagogical **and administrative resources of** these environments and **improves their** adaptability **using cognitive modeling and solving problem** strategies of **JADE** framework. **In** addition **we intend** to consider **the use** of some FIPA-compliant **communication** framework. **This** will improve the message

interchanging among the agents and provide more adaptability and flexibility to the system.

Acknowledgements. This project is granted by Brazilian research agencies: CAPES - PAPED program. CNPq – Protem-CC program and FAPERGS – ARD program. Thanks to Francine Bica, and Alessandro Boeira. Their master thesis are important part of this project.

References

1. BICA, Francine. *Eletrotutor III: Uma abordagem multiagente para o Ensino a distância.* Porto Alegre: CPGCC da UFRGS, 1999. Master Dissertation (Portuguese).
2. BELLIFEMINE, Fabio, POGGI, Agostino, RIMASSA, Giovanni. JADE – A *FIPA-compliant agent framework* CSELT internal *technical* report. Part of this report has been also published in: Proceedings of PAAM'99, London. April 1999. pagg.97-108.
3. BRADSHAW, J. M. An introduction to software agents In: BRADSHAW, J. M. Ed. *Software Agents.* Massachusetts: MIT Press. 1997.
4. Centre for Curriculum, Transfer & Technology. *Online educational delivery applications.* Disponível em: < http://www.c2t2.ca/landonline/>. Acesso em: 08 nov.2001.
5. CHEIKES, B. A GIA: Agent Based Architecture For Intelligent Tutoring Systems. In: THE CIKM WORKSHOP ON MTELLIGENT INFORMATION AGENTS. 1995. *Proceedings* . [S.l.: s.n].1995
6. FIPA: The foundation for Intelligent Physical Agents. *Specifications.* Available by HTTP in http.l/www.fipa.orgMarch 2002.
7. GIRAFFA L.M.. VICCARI R. M ; *SELF.* J. *Multi-Agent based pedagogical games.* In: ITS, 4.. 1998. *Proceedings* .. [S l : s.n], 1998.
8. JOHNSON, W. Lewis; SHAW, Erin. Using agents to overcome deficiencies in web-based courseware. In: WORLD CONFERENCE ON ARTIFICIAL INTELLIGENCE IN EDUCATION, AI-ED. 8., 1997. *Proceedings...* [S.l : s.n], 1997. Disponível em: <http: //www.isi.edu/isd/johnson.html.>. Acesso em: 05 mar.2000.
9. KEEGAN. D. *Foundations of distance education.* 2nd ed. London: Routledge, 1991 apud NUNES. Ivônio Barros. *Noções de educação à distância.* Disponível por WWW em http: //www.Ibase.org.br/~ined/ivonio1.html [out. 1997).
10. MATHOFF, J.;VAN HOE. R. APEALL: A Multi-agent approach to interactive learning environments. In: EUROPEAN WORKSHOP ON MODELING AUTONOMOUS AGENTS MAAMAW, 6.. 1994. *Proceedings...* Berlin: Springer-Verlag. 1996.
11. MÓRA, Michael C. et al. BDI Models and Systems: Reducing the Gap.In: WORKSHOP ON AGENT THEORIES. ARCHITECTURES. AND LANGUAGES. 5., 1998. *Proceedings...* Berlin: Springer-Verlag, 1998.
12. NAKABAYASHI, Kiyoshi et al. Architecture of na intelligent tutoring system on the WWW. In: WORLD CONFERENCE OF THE AIED SOCIETY. 8.. 1997, Kobe. *Proceedings* .. [S.l : s.n], 1997.
13. NORMAN. Timothy J.; JENNMGS. Nicholas R. Constructing a virtual training laboratory using intelligent agents. *International Journal of Continuos Engin-eering and Life-long Learning,* [S.l.], 2000.
14. REIS, Alessandro Boeira dos. *Um modelo do aluno adaptativo para sistemas no Web.* Porto Alegre: CPGCC da UFRGS, 2000. Master Dissertation (Portuguese).

15. ROSEMBERG. Marc J. *E-Learning: strategies* for *delivering knowledge* in *the digital age.* New York. McGrawHill, 2001
16. SILVEIRA, R. A.; VICCARI. R. M. Projeto Eletrotutor: Desenvolvimento e Avaliação de Ambientes Inteligentes de Ensino-Aprendizagem. In: CONFERENCIA LATINO-AMERICANA DE INFORMATICA, 23.. 1997. *Proceedings...* Valparaíso: CLEI. 1997.
17. SILVEIRA, Ricardo et al. Desenvolvimento e avaliação de duas abordagens de ambientes de ensino inteligentes. In: SIMPÓSIO BRASILEIRO DE INFORMÁTICA NA EDUCAÇÃO, 8.. 1997. *Anais...* São José dos Campos: [s.n.], 1997.
18. SILVEIRA, Ricardo Azambuja. Modelagem Orientada a Agentes Aplicada a Ambientes Inteligentes Distribuídos de Ensino – JADE - *Java Agent framework for Distance learning Environments* Porto Alegre: PPGC da UFRGS, 2000. Doctoral Thesis (Portuguese).
19. SPODICK, Edward F. *The evolution of distance learning.* Hong Kong: University of Science & Technology Library. 1995. Available in: <http: //sqzm14.ust.hk/distance.>. Acesso em: 08 ago. 1995.
20. WEBER. Gerhard; SPECHT, Marcus. User modeling and adaptative navigation support in WWW – based tutoring systems. In: USER MODELING INTERNATIONAL CONFERENCE. 6.. 1397. *Proceedings...* Viena: Springer-Verlag, 1997.