- El título del artículo.
  The Conception of Agents as Part of a Social Model of Distance Learning

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- Un resumen de a lo sumo 200 palabras.

Abstract. This paper is part of a research project called "A Computational Model of Distance Learning based on the Socio-Interactionist Approach". This project is related to situated learning, i.e., in the conception of cognition as a social practice based on the use of language, symbols and signs. The objective is the construction of a Distance Learning environment, implemented as a multi-agent system composed of artificial and human agents, and inspired by Vygotsky's socio-interactionist theory. This paper aims at the conception of two of the agents from such architecture: the Semiotic and the Collaboration Agents. The Semiotic Agent is responsible for searching adequate instructional material in the database to be presented to the student. The Collaboration Agent is responsible for assisting the interaction among students in a collaborative communication tool and it will consider the cognitive, social and affective capabilities of the students, which becomes a more qualitative mechanism for learning.

- Un conjunto de a lo sumo cinco palabras claves.

Keywords: Intelligent Tutoring Systems, Distance Education, Socio-Interactionist Pedagogical Theories.

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  Sistemas Inteligentes Aplicados a la Enseñanza
  Sistemas Multiagente e IA Distribuida

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  Paper Track

The Conception of Agents as Part of a Social Model of Distance Learning

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1 Introduction

The present work aims to present the conception of two agents (the Semiotic and Collaboration ones) that are modeled as part of the multi-agent architecture of the project "A Computational Model of Distance Learning Based on the Socio-Interactionist Approach".

The system proposed initially [1] [2] was formed by four classes of artificial agents – the ZDP agent, the Mediating Agent, the Social Agent and the Semiotic Agent – and the human agents (learners and tutors). The current system performed evolutions so that, now, it is composed by human agents (students and tutors) and by five classes of artificial agents: the *Diagnostic Agent* has the function of describing the cognitive diagnosis, modeling the group and suggesting pedagogical tactics; the *Mediating Agent* is an animated pedagogical agent responsible for the interface of the environment with the student and for applying the support tactics suggested by the Diagnostic Agent. Its role is auxiliary in the process of the student's internalization due to the contact with the social environment of distance learning; the *Collaboration Agent* is responsible for mediating/monitoring the interaction among students' groups in synchronous tools of communication among the students (for example, chat); the *Social Agent* that should establish the integration of the society forming students' groups for study and creating a Collaboration Agent for each formed group; and the *Semiotic Agent* responsible for the use of signs, concepts and language send to the Mediating Agent or Collaboration Agent and, consequently, presented to the student. Further details of the system may be found in [1], [2] and [9]. The tutoring system may function as an individual tutor, where the Mediating Agent presents pedagogical contents to the student in accordance to his/her profile and cognitive style, or as a facilitating system of collaboration, where the Collaboration Agent monitor and mediate the interaction among the students with collaborative tools. The architecture of the system can be viewed in the Fig. 1.

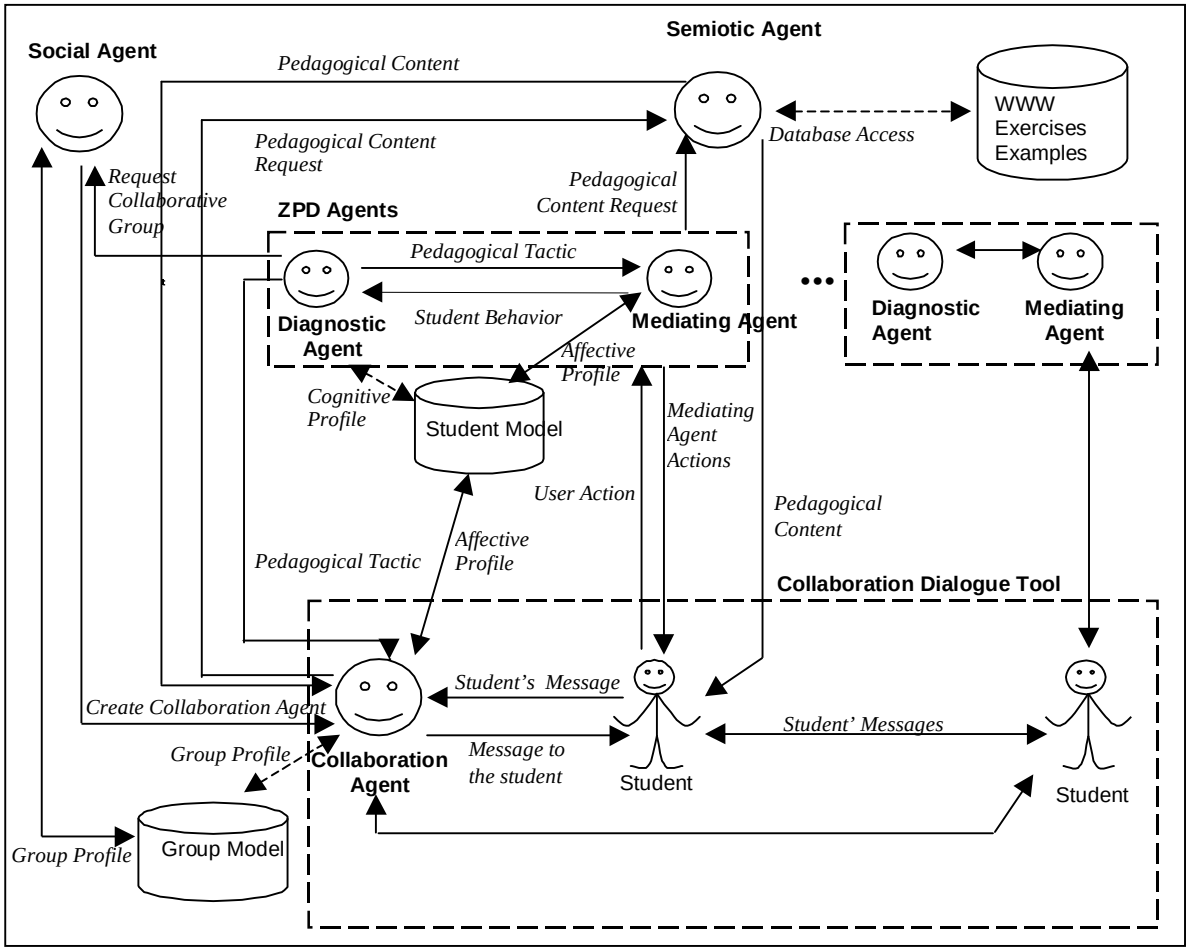

Fig. 1. A society of Social Agents for a Learning Environment

The social model implemented by the proposed system is strongly inspired by Vygotsky [18] [19]. One of the important concepts of the socio-interactionist theory of Vygotsky is that the relationship man-environment is a relationship mediated by symbolic systems, through instruments and signs. According to Vygotsky [18] [19], the signs are artificial incentives with the purpose of mnemonic aid; they work as middle ground for adaptation, driven by the individual's own control. The sign is guided internally. The function of an instrument is to serve as tool between the worker (in the case of this research, the student) and the object of his work, seeking help in some activity; these are guided externally.

To fulfill this function, the system is composed by an agent (the Semiotic Agent) that has the role to present the instruments and signs to the student as external stimulations. These signs and instruments (such as pictures, sounds, texts and others) compose the instructional material in the database, as we can see in the Fig. 1, represented by www, exercises and examples.

The presentation of this instructional material is based on Semiotic Engineering. According to the Semiotic Engineering [4], [15], [17], for the communication designer-user to be possible, it is necessary to consider that software applications (that comprehend interfaces) are signs, formed by signs, and that generate and interpret signs. The Semiotic Agent has the role of interface's designer. It decides which signs will be used to present a determined subject to the student. In the Fig. 1, this pedagogical content will be presented to the student as a HTML page (HyperText Markup Language) that is sent, indirectly, to the Mediating Agent - a personal and animated tutor responsible for presenting the instructional material to the student. The Mediating Agent will also capture the student affective state for react in a appropriated way to develop a spirit state more positive to learning in the student.

In the Fig. 1, we can see that all information on user actions will be gathered by the Mediating Agent and sent to the Diagnostic Agent. The Diagnostic Agent updates the information in the student model and verifies, according to received data, if it is necessary to use a new educational tactic. In this case, it sends this information to the Mediating Agent. If this tactic is, for example, the presentation of an instructional content, the Mediating Agent makes a request to the Semiotic Agent.

The Diagnostic agent uses the concept of Zone of Proximal Development [19] to parameterise the cognitive diagnosis of the learner. The Diagnostic agent has the role of modelling those skills of the group

that are either in the “core” (learned) or in the ZPD - Zone of Proximal Development (need of support). The purpose is to support decisions on how to adapt the tutoring or choose the right level of coaching for the group.

When the Diagnostic Agent finds a deficiency in the student’s learning and considers it would be interesting to perform an activity in group, it will make a request to the Social Agent. The Social Agent, in the Fig. 1, will create a Collaboration Agent and form a study group of students.

The Collaboration Agent, as we can see in the Fig. 1, is responsible for assisting the interaction among students in a virtual class within a collaborative communication tool, motivating them, correcting wrong concepts and providing new knowledge. This guiding agent will consider not only cognitive capabilities of students, but also social and affective characteristics, which becomes a more qualitative mechanism for collaboration among students and learning.

To implement the idea of social model of distance learning, this work presents a strong approach of communication among the agents which interact using KQML (Knowledge Query and Manipulation Language) performatives [5]. The architecture and further details about the system can be found in [2].

In the next section we describe the architecture and functionalities of the Semiotic Agent. In the section 3, we describe the Collaboration Agent. Finally, in section 4, we present some conclusions and some proposals of future work.

2 Semiotic Agent

The Semiotic Agent [11] looks for signs and instruments in the database, when requested by the Mediating Agent, to aid the student’s cognitive activity, building dynamically the page to be introduced to the student and showing more specific contents as the student is going deeper in the detail of the subject. In this aim, the agent uses several signs, expressed in the most several ways, for example: the drawing, the writing (presenting the domain in form of paragraphs, examples, citations, tables, keywords, exercises), systems of numbers, illustrations and multimedia resources, propitiating, thus, the presentation of the instructional material conforms the teaching tactics specified by the Diagnostic Agent.

The Semiotic Agent is an agent that is inserted in a society of agents possessing the following properties [7] [20]:

- *autonomy*, because it gets to act in the society for its own means and controlling its own actions;
- *social ability* interacting with other agents, as the Mediating Agent and Collaboration Agent;
- *reagent*, because it reacts to the incentives of solicitation of content of the Mediating Agent and Collaboration Agent;
- *continuity*, because it gets to stay continually in the society;
- *communicability*, because it exchanges messages with other agents (Mediating Agent and Collaboration Agent);
- *rationality*, although it is a weak "rationality", based on rules of decision, because it possesses the capacity to take decisions, in relation to which signs, or sequence of signs, it is better to present to the student’s cognitive activity;
- *flexibility*, because it allows another agents’ intervention (Mediating Agent and Collaboration Agent).

To implement the idea of social model of distance learning, this work presents a strong approach of communication among the agents. The communication among the agents became a factor of great importance for the operation of the system. Detailed examples of messages exchanged among the agents can be seen in Jung [11].

2.1 Internal Architecture of Semiotic Agent

It can be observed that the Semiotic Agent, starting from the solicitation of incoming pedagogical content of the Collaboration Agent or Mediating Agent, verifies which are the tactics, preferences and the student’s level, seeking in the database which are the ideal signs to be used for the pedagogical content, generating dynamically a HTML page (as answer for the Mediating Agent) to be presented to the student. It can still send a message for the Collaboration Agent, in KQML, saying if the pattern found by the Collaboration Agent during the changes of messages among the students, it is part of certain content to be treated in the teaching-learning process [11] .

The Fig. 2 shows the internal architecture of the Semiotic Agent.

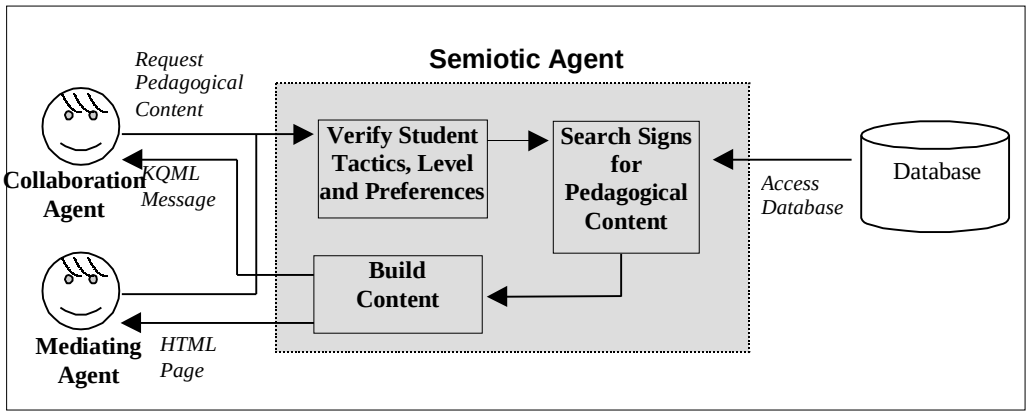

Fig. 2. Internal Architecture of Semiotic Agent [11]

2.2 Semiotic Agent and Semiotic Engineering

The Semiotic Agent has the role of interface's designer. Its function is to decide which signs should be send for the Mediating Agent, given a certain situation, it means, depending on the teaching tactics specified by the Diagnostic Agent.

It is important to have a model to specify which signs will be used and how to present them to the user. In this research, we adopted the Message Specification Language of the Designer (MSLD) proposed by [12] and [13], whose objective is to support the formulation of the messages on the usability model.

Below, we show an example, using MSLD, of an instructional content introduced to the student. We can see that the rule of behaviour *Pedagogical_Content* (it will be explicated later at section 2.3), represented by action *Show_Content*, is composed by one junciont's repetition of information of C*hapter*, *Section*, *Paragraphs*, *Html*, *Figure*, *Table*, *List*, *Example*, *Citation*, *Link*, *Keywords*, *Exercise*, followed by information's repetition of *Reference*, followed by *Previous* or *Next* options. Further details can be found in [10] and [11].

```
Command-Message Show_Content for Application-Function Pedagogical_Content
Join { Sequence { Repeat { Join { View Information-of Chapter
                                  View Information-of Section
                                  View Information-of Paragraphs
                                  View Information-of Html
                                  View Information-of Figure
                                  View Information-of Table
                                  View Information-of List
                                  View Information-of Example
                                  View Information-of Citation
                                  View Information-of Link
                                  View Information-of Keywords
                                  Activate Show Command_Message Exercise}}
                    Repeat { View Information-of Reference } }
          Select { Activate Previous Application-Function Pedagogical_Content
                   Activate Next Application-Function Pedagogical_Content } }
```

2.3 Semiotic Agent Implementation

The Semiotic Agent was implemented in Java, more specifically with the technology of servlets. An environment was built, in Java, that allows to manage the whole instructional material (signs) stored in a database, where, later on, a XML file (eXtensible Markup Language) is generated with the content of each subject (see Fig. 3).

The Semiotic Agent, starting from the XML file, generates the instructional content (signs), according to the rules of behavior *User_Login*, *Pedagogical_Content* and *Requisition_Pedagogical_Content* defined by Jung [10]. Besides, it applies presentation styles (style sheets), through XSL (eXtensible Style Sheets), for formating the exit, showing like this, in HTML, the same signs in a different way, depending on the level and the student's preference in subject.

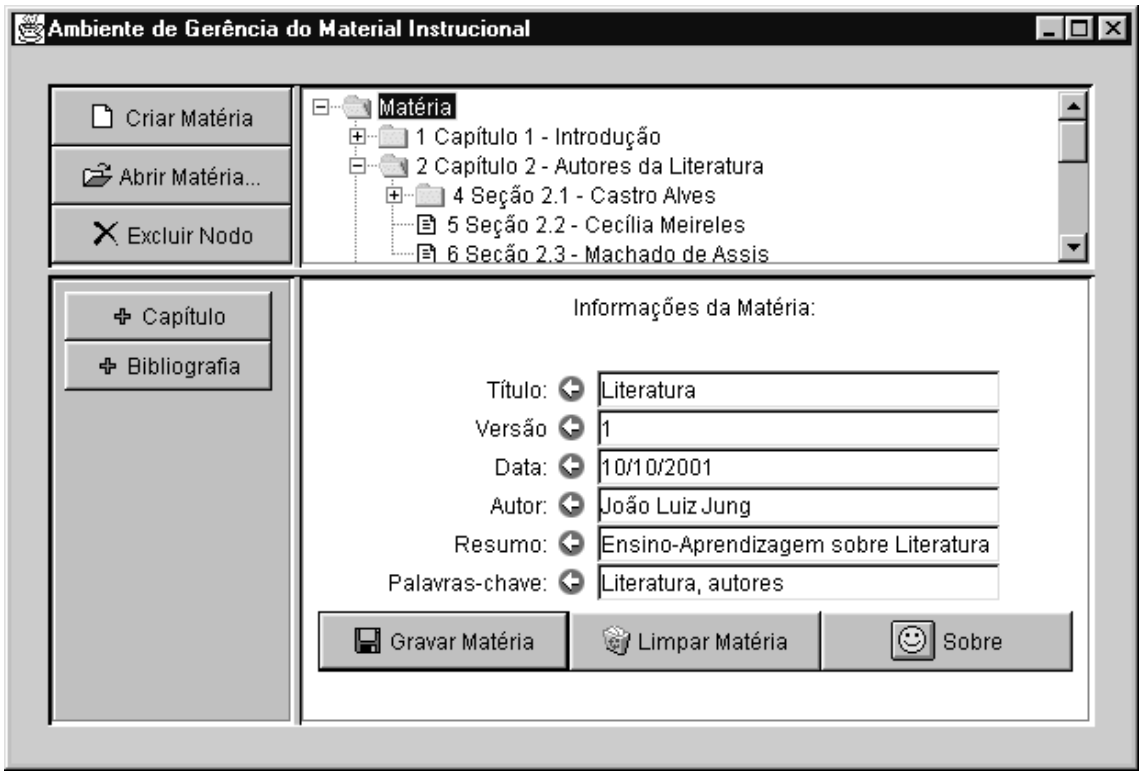

Fig. 3. Interface of the Management Environment of the Instructional Material

All the actions of the Semiotic Agent are executed as a result of incentives generated through messages comings of the Mediating or Collaboration Agents. The rules of behaviour determine the course of the action that an agent should take in the whole point of the beginning to the end of the agent's execution.

The rules of behaviour used in the implementation of the Semiotic Agent work in the following way [11]:

– **User_Login**: this rule happens when the Mediating Agent sends a message to the Semiotic Agent, informing that a student was connected to the system.

```
If user is registered Then
   it shows last pedagogical content accessed for the user
   it triggers the rule Pedagogical_Content
Else
   it registers the student
   it shows the first pedagogical content
   it triggers the rule Pedagogical_Content
End If
```

– **Pedagogical_Content**: the Semiotic Agent sends a message for the Mediating Agent as answer to the rule *Requisition_Pedagogical_Content* or *User_Login.*

```
If (operation = next) Or (operation = previous) Then
   it seeks in the database last content accessed for the user
   it accesses XML file
   it seeks ideal sign according to specified pedagogical tactics and user
level
    If found ideal sign Then
        Show_Content exemplified in the section 2.2
        it applies XSL formatting exit according to level and user preference
        it sends message KQML for Mediating Agent with content in HTML
    Else
        it sends message KQML for Mediating Agent with empty content
    End If
Else If (operation = end) Then
   it keeps in the database the last action done by the student
End If
```

– **Requisition_Pedagogical_Content**: this rule is triggered by the Mediating Agent for the Semiotic Agent or of the Collaboration Agent to the Semiotic Agent. In the first case, according to the tactics

defined by the Diagnostic Agent and the student's preference, the Mediating Agent will send a message to the Semiotic Agent requesting that the same generates a pedagogical content to be introduced to the student (it rules *Pedagogical_Content*). In the second case, the Collaboration Agent will request to the Semiotic Agent to verify certain pattern, found during interaction in the tool of collaboration, is part of the pedagogical content that is discussed in the moment.

The illustration to proceed, presents the KQML performative sent by the Semiotic Agent for the Mediating Agent. For a complete explanation of the Distance Education Environment, with simulations of some messages KQML exchanged among the agents in the system, see [11].

TABLE 1. KQML Message User Login

Parameter	Value
:performative	Tell
:sender	Mediating Agent
:receiver	Semiotic Agent
:ontology	user login
:in-reply-to	Mediating Agent
:reply-with	pedagogical content
:content	user
	password
	subject

The standardization of the signs (for example: chapter, section, paragraph, example, citation, lists) generates a cognitive pattern with the objective of facilitating the usability of the system and assistant the mnemonic process of the student's learning.

3 Collaboration Agent

3.1 Definition of Collaboration Agent

Talk and discourse have long been seen as critical components in the learning process [14]. According to Vygotsky [19], the learning is frequently achieved through interactions supported by talk and that talk and language are frequently associated with the development of higher order learning.

Our system privileges the social interaction encouraging the students to interact in collaborative tools. In this way, the system has two agents with the ability to encourage the interaction among students: Social and Collaboration Agents. The Social Agent searches for peers that are capable of assisting a student in his/her learning process and creates a Collaboration Agent for mediating the interaction among the students. The Collaboration Agent will monitor and mediate the interaction between students in collaborative communication tools (for example, chat, discussion list and bulletin boards). It attends the students during the interactions, stimulating them when they look unmotivated, presenting new ideas and correcting wrong ones. In the Fig. 4, we show the internal architecture of the Collaboration Agent.

We can see in the Fig. 4, that during the interaction with the students in the collaborative tool, the Collaboration Agent interacts with the Diagnostic Agent to obtain new tactics to be used. In such a way, it must send the actions of the user, in this case, sent messages, so that the Diagnostic Agent decides which tactics must be carried out.

The Collaboration Agent interacts with the Semiotic Agent to get the pedagogical content (Fig. 4). For example, the Collaboration Agent can check, in accordance with statistical analyses of the students' message, which students presented incorrect ideas. As the interactions progress, the Diagnostic Agent can decide if a more difficult subject can be presented. In that case, the Collaboration Agent requests that the Semiotic Agent sends certain contents at a more difficult level.

The Collaboration Agent updates the affective model of the student (Fig. 4). It is responsible for obtaining the affective state of the student and updating the student model, in order to reply to the student with an appropriate emotional behaviour.

In collaborative learning, the group is an active entity; therefore, the system must contain information that refers to it as a whole. This information generates a group model, which is constructed and stored by the Collaboration Agent, as showed in the Fig. 4.

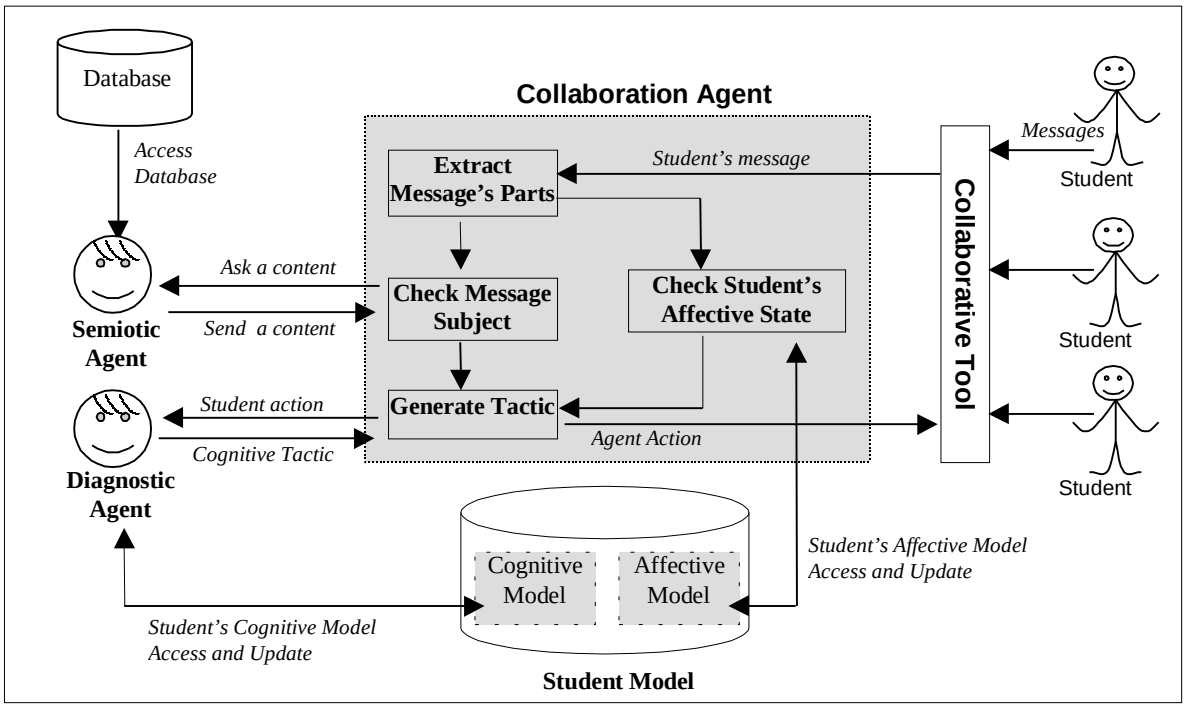

Fig. 4. The Internal Architecture of the Collaboration Agent

3.2 Collaboration Agent Implementation

Due to its social function – to communicate with students, to promote and monitor the interaction among students – it would be interesting for the Collaboration Agent to have an interface that would allow it to exploit students' social nature. In fact, one of our main concerns is to better exploit the social potential of the students to improve their learning, since studies demonstrate that people interacting with animated characters learn to interact with other humans [8]. Therefore, we chose to represent it as an animated character who has a personality and which interacts with the student through messages in natural language.

Thus, as in human social interactions, the Collaboration Agent must be able to show and perceive emotional responses. Learning is a comprehensive process which does not simply consists in the transmission and assimilation of contents. A tutor (in this case, the Collaboration Agent) must promote the student's emotional and affective development, enhancing his/her self-confidence and a positive mood, ideal to learning. The way in which emotional disturbances affect mental life has been discussed in the literature [6]. He recalls the well-known idea that depressed, bad-humoured and anxious students find greater difficulty in learning.

In order to interact with the student in an adequate way, the agent has to correctly interpret his/her emotions. In this way, we are studying with the aid of psychologists which affective states of the students the agent would consider and capture. Therefore, it is necessary for Collaboration Agent to have not only a student cognitive model, but also an affective one. We are going to use the student model proposed by [3], which considers the affective states such as effort, self-confidence and independence.

Still, it is necessary to have in mind the responsibility about the use of affective agent architecture for interaction with the user, especially in the education. Often we observe that agents have attitudes that are not suitable to students' mood (e.g., if an agent gets sad when the student could not carry out an exercise). This kind of attitude may generate a disturbed reaction in the student, making him/her more anxious and less self-confident. It is necessary to identify which behaviours are appropriate to promote a mood in the student that provides better learning conditions.

The Collaboration Agent will carry out the analysis of the student's dialogue based on statistical methods, such as pattern matching, message categorisation and information retrieval [16]. The messages will be generated in natural language, using dialogue models and frames.

4 Conclusions and Future Works

The use of agents in Intelligent Tutoring Systems (ITS) allows a better representation of the domain, with a larger possibility of application of pedagogical tactics that can aid in the learning process.

In this research, it tried to use the Semiotic Engineering through the formalism of MSLD for generation of signs, icons and symbols, representing the instructional material to be introduced to the student. The function of generation of the appropriate signs is responsibility of the Semiotic Agent, respecting like this, the important paper that it represents the mnemonic process of the student's learning through the signs, inspired by Vygotsky.

Besides, we tried to start the construction of a social model of distance learning, in that one of the involved agents has the role of designer and the role of meta-communicate the system's usability and functionality, generating the necessary signs for the teaching-learning process. The Semiotic Agent was implemented as part of the conception of collaborative learning in multi-agent system [9] obeying the negotiation, communication and learning properties.

When the systems function as a facilitating system of collaboration, the Collaboration Agent takes action. It monitors and mediates the interaction among the students in a collaborative dialogue tool, like a chat. In this case, it will collect and analyse the emotional data for react in an emotional way to promote a positive mood in the student, more ideal to learning. It must also present new ideas and correct wrong ones. In this aim, it will do a pre-analysis of the students sentences and request to Semiotic Agent to verify if the sentences sent by the student are part of the discussed subject in the virtual collaborative class. It is possible due the model adopted to save the information in the database and by the form that they are manipulated by the Semiotic Agent.

The society of agents provides an environment that facilitates, through the social-interaction of the artificial and human agents (tutors and students) by talk and language, a process of teaching-learning inspired in the ideas defended by Vygotsky.

With the progress of implementation of the other agents, we can verify and to analyse the usability of the system, as well as to evaluate the results obtained with the use of the system.

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