Intelligent Agent-Based Approach for Distance Learning

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Abstract- *This work proposes a multi-agent approach for the development of personal software agents supported by networks. Personal assistants that help users with several tasks like finding information, learning, scheduling calendars or consulting to decision-making are general-purpose systems that can be viewed as a collection of intelligent agents. A distributed framework with three different types of agents will be defined in this paper. Each type of agent uses different intelligent techniques to solve specific problems. The combination of these agents provides an environment that supports and mediates the cooperative work and learning in a network. The use of the proposed framework for supporting distance learning will be shown as an application. In addition, this paper will discuss another possible scenario: an application for working capital administration.*

Keywords: Intelligent Agents, Personal Assistants, Collaborative Learning, Case-Based Teaching, Expert Systems, Distance Leaning, Working Capital.

Introduction

The use of intelligent agents as personal assistants will increase with the improvement of the agent technology. Software agents can be viewed as computational autonomous entities capable of sensing and acting in an environment to accomplish a set of goals. Multi-agent systems are composed by agents that share a common environment; therefore, they must act collectively to identify and resolve conflicts, while at the same time they must take advantage of the actions of other agents.

This work proposes a multi-agent approach for the development of personal software agents supported by networks. An environment that supports and mediates the cooperative work and learning in a network will be defined. The use of personal assistants for supporting distance learning and working capital administration will be shown as possible applications.

The next section presents a quick overview about Software Agents and the types of agents that have influenced the framework to be presented in this work. Section 3 details the proposed model for collaborative learning in the context of hybrid systems and multi-agent systems. Section 4 examines two possible scenarios where the defined model would be used. Finally, section 5 concludes the paper by discussing future work directions.

Software Agents

Software agents could be defined in a variety of ways. Usually, these definitions are based on the functions of the agent under consideration. The definition of software agents have a broad scope in terms of specificity. When an author try to enclose the concept about agents, he/she usually loose the general scope in which any other agents could be inserted. Franklin and Graesser [6] believe each definition depends on the set of examples of agents that the definer had in mind.

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According to Wooldridge and Jennings [17], agents are systems whose behavior is determined as a result of a reasoning process based on representation of its attitudes, such as beliefs, commitments and desires. Russell and Norvig [15] adopted that intelligence is concerned mainly with rational action. Acting rationally means acting so as to achieve one's goals, given one's beliefs. In this sense, an agent is just something that perceives and acts. Ideally, an intelligent agent takes the best possible action in a situation, but they conclude that acting rationally does not always imply that correct inference would to be drawn. Sometimes, there is no correct action to undertake, however, something still needs be done.

Agents can also be defined operationally in terms of the domains in which they provide their services [8], including searching for information, filtering data, providing context-sensitive help, on-line tutoring, performing actions on behalf of a user and others. In this context, a possible approach to define agents could be done by arranging them through the use of some kind of classification. Nwana [12] defined a typology of agents based on three minimal characteristics: autonomy, cooperation and learning. Combining these characteristics, four types of agents can be derived: collaborative agents, collaborative leaning agents, interface agents and truly smart agents. This classification must not be interpreted as definitive. Nwana pointed out that the fact that cooperative agents have more emphasis on cooperation and autonomy than on learning do not implies that they can never learn.

Special Purpose Agents

As we have state before, there are many classifications for software agents. However, this paper will briefly discuss four different groups of agents: collaborative agents, learning agents, information retrieval agents and advising agents. These groups had been used as a basis for the multi-agent framework that is proposed in the next section.

In collaborative agent systems, each agent contributes its own embedded intelligent technique to solve of a complex problem. Collaborative agents emphasize autonomy and cooperation with other agents in order to perform tasks for their owners. In this environment it became clear the necessity of negotiation in order to establish some mutual agreements and commitments. Although learning is not the major emphasis of collaborative agents operation, they may perform limited parametric or rote learning.

Learning agents emphasize autonomy and learning in order to automate tasks for their owners. This type of agent runs in background watching the user actions, finding repetitive patterns and automating these patterns with the approval from the user. This paradigm uses the metaphor of a personal assistant. A learning agent is capable of customizing its performance to an individual's preferences by learning form a user's past behavior [11].

Information Retrieval Agents must be capable of searching for information in an intelligent mode. The expectations from this type of agent are about the capability of operating in autonomous mode, finding data quickly regardless of location. An example is a search agent that can conduct complex searches by interpreting the search criteria defined by a user. In that case, learning agents functionality can be added to provide the capability to learn the user's preferences.

Advising agents could be understood as smart personal assistants. This kind of agent combines some features of helper agents and learning agents. Helper agents perform tasks autonomously, without human interaction. Usually, they cope with diagnosing and fixing problems [11]. As discussed in the paragraph above, learning agents use some intelligent mechanisms, as connectionism, in order to learn and assist their users. An advising agent must be capable of identifying situations where the user may need assistance and provide some additional information to help him or her. Another interesting feature is the ability of acting autonomously on the user's behalf. Thus, people will be engaged in a cooperative process in which both human and agents initiate communication, monitor events and perform tasks to meet a user's goals [13].

An Agent-Based Framework Approach to Collaborative Learning

According to Crook [4], there is a necessity of modeling environments and software for collaborative learning environments supported by networks. Collaborative Learning Environments are electronic environments that support and mediate the cooperative work and learning in a network [1].

Figure 1 presents the proposed multi-agent framework for a collaborative learning environment. Three types of agents are defined: interface agents, information agents and advising agents. The interface agent is responsible for the interaction with the user. The information agent is related to database and knowledge access. The advising agent provides personal assistance to the users. The agents cooperate through a computer network, which can be the Internet, an Intranet or even a small local network.

The complexity of the proposed framework and the different types of services that the agents can provide clearly indicate the necessity to use more than one single intelligent technique. Intelligent Hybrid Systems make use of particular computational properties of different intelligent techniques and combine them to solve a problem. These systems represent not only the combination of these techniques but also the integration of them with conventional computing systems [7].

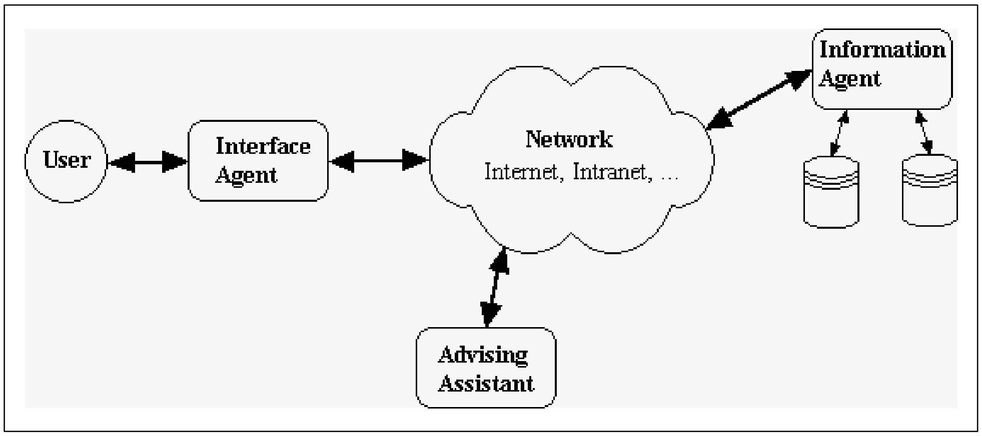

Figure 1: Multi-Agent Framework

Initially, two intelligent paradigms are being combined to build the proposed agents: Expert Systems and Case-Based Reasoning (CBR). A rule-based expert system is appropriate for domains where the knowledge can be represented in the form of heuristics or rules of thumb. This technique has been mostly reported for classification and diagnostics problems. The CBR approach uses the reasoning based on similar past problem-solving experience [9,10]. This feature helps the user to exploit the useful details to apply them to a similar case. CBR provides many advantages to problem solving in a knowledge environment. It allows one to propose solutions quickly, thus avoiding the long process of decomposition and recomposition involved in a synthesis process. It is useful in situations where the domain knowledge is not completely available or difficult to obtain. The past cases may help to provide warnings of potential problems that have occurred in the past and to avoid repeating the mistakes.

The agents used in this proposed framework and how the intelligent techniques are involved in their construction will be described in the following sections.

Interface Agent

The interface agent interacts with the user and cooperates with another agents by exchanging information about capabilities, commitments and learning goals of the users (Figure 2). This agent can be viewed as a representation of the user's learning. Furthermore, the interface agent must be provided with capabilities for the representation of its user. In fact, the interface agent will be able to assume the role of its user when he or she is absent.

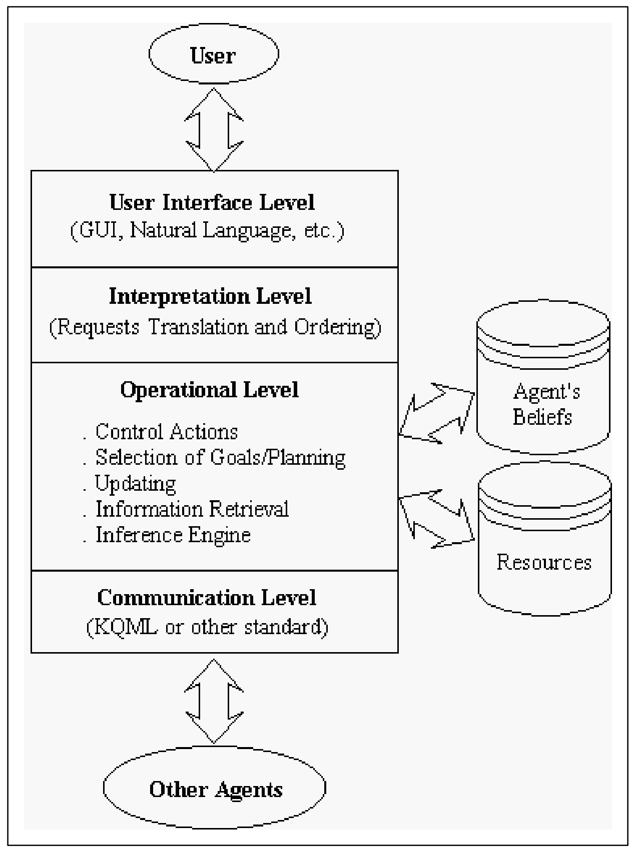

Figure 2: Interface Agent

The agents in the proposed framework are being modeled by using a layered structure. Each layer has well-defined functions. This analogy with computer network architectures allows the independence of implementation for each layer. The communication between the layers will take place through a well-defined interface. This approach also provides modularity. For example, the Interface Level can be initially implemented as popup menus and messages. Thus, a natural language interface can be added later with minimal impact on the agent structure.

The user's learning process consists of creating a set of beliefs about the information available by the system. These beliefs will be implemented as two different knowledge bases. The first knowledge base will use a rule-based approach to learn and represent the information about the preferences of the user. The second knowledge base will use a case-based approach to build the knowledge about the domain, i.e., the knowledge to be learned.

The Resources database represents additional information. It can be an agent address and its networking mapping, the language used for the knowledge representation or the current ontology.

Information Agent

The information agent holds the representation of knowledge and maintains an interface to the data access. The Interface and Interpretation Levels are not present, since the user does not have direct access (Figure 3). The agents perform all the communication process. Both the interface agent and advising agent may access the information agent.

The information will be stored using two different approaches: a relational database and a knowledge base. The relational database will store straight information, such as texts, examples and multimedia. The knowledge base will combine rules and cases in order to represent the domain knowledge and to guide the access to the relational database.

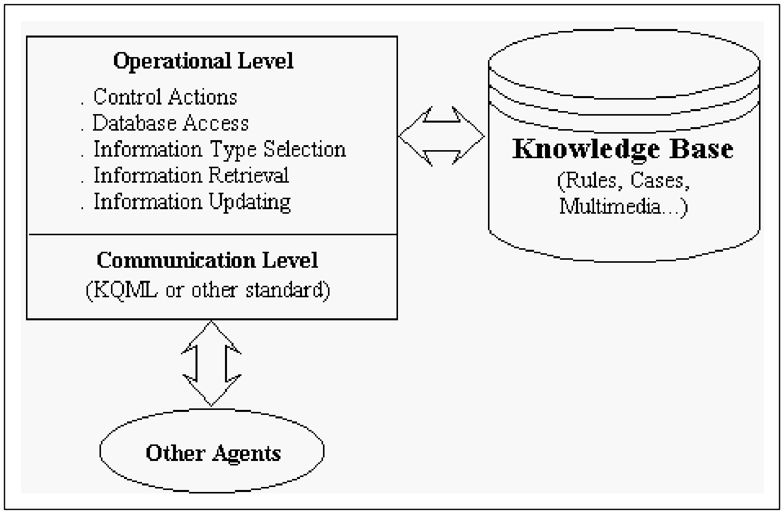

Figure 3: Information Agent

Advising Agent

The advising agent is a special kind of agent that works as a smart personal assistant. This agent assists the users by monitoring them and presenting the appropriate application of the domain knowledge. The user through the interface agent can also access the advising agent. Other feature related to this agent is the evaluation of the user's actions and constructions of his or her beliefs.

The structure of the advising agent is almost the same that had been used to implement the information agent (Figure 3). Once again, there is no need for the Interface and Interpretation levels. However, the main difference is at the Operational Level. While the information agent has database and knowledge access features, the advising agent has features to monitor users and recognize situations where there is need to present an explanation. Also, the agent can provide some additional information such as examples or counter-examples to the user.

The advising agent uses the case-based teaching approach [3,16]. One of the most valuable types of learning conversations that can occur is when a user with a problem describes his situation to an expert, and the expert is reminded of and reciprocates with an applicable story. In such a situation, the user can adapt the story, labeling it and applying it to his current problem. A good example of case-based application for teaching is the SPIEL (story producer for interactive learning) program [3].

Scenarios

This section introduces possible applications of the framework described. In order to give an example of the flexibility of the proposed model, we present two different scenarios. The first scenario presents a distance learning support environment and the second one presents a multi-agent system specification for supporting working capital administration. These two environments are being developed by the AI Research group of the Graduate Program in Production Engineering at the Federal University of Santa Catarina.

Distance Learning

Distance learning is not a new subject, but it currently has come in vogue again. The emergence of new educational and training technologies added to meet the needs of learners in a fast-paced world makes distance learning a necessity [14]. However, one of the major problems with learning these days is the increasing tendency to confuse information with learning. Bork [2] believes that this is particularly a problem with the use of World Wide Web in learning. Textbooks and lectures are primarily sources of information, rather than learning media. Thus, it is important to find solutions that allow real distance learning.

Currently, the Production Engineering Research Group at Federal University of Santa Catarina (Brazil) has special interest in adding new tools to distance learning. An interesting natural application for the proposed framework is the definition of a collaborative learning environment to support distance learning. In this context, interface agents interact with the learners (users), information agents represent the knowledge about the course subject, and advising agents can be interpreted as monitors or support teachers.

Learners see the whole environment as an intelligent browser (interface agent). This browser can work as a traditional computer-training tool helping the learner during the information navigation and learning process. However, the environment provides mechanisms to allow the interaction among learners. It is also possible to make direct queries to domain monitors or receive asynchronous information from them. The advising agents assume the role of these monitors.

The case-based teaching structure of the advising agents (section 3.3) could be used to provide learners with applicable cases at the time that they are required. Furthermore, the advising agents can help learner to explore and figure out useful generalizations from cases. Learners could also be faced with situations in which they will fail. In this case, the learner learns a new case by experiencing an expected failure (teaching by counterexamples).

The process of construction of the learner's beliefs makes possible the individualization of the learner. Individualization considers that each student is different [2] with different background and knowledge. At the same time, collaboration among the learners to solve or to understand some situation provides an interesting mechanism to improve the knowledge acquisition process. In this context, the proposed framework can be used as an interesting tool to support distance learning programs.

Working Capital Administration

Working Capital (WC) administration comprehends all current assets-related decisions; therefore, WC administration decisions’ horizon is the short term. Working Capital investments represent an average of 50% of the firm’s capital, reaching up to 75% in the retail sector. The related decisions involve exogenous and endogenous variables. An example of exogenous variables that a WC administrator have to consider are liquidity, sales forecasting, inventory turnover and purchase volume. The exogenous variables corresponds to information about the market and governmental decisions that could affect the balance level between WC requirements and financing.

The main objectives of the multi-agent based system for WC administration is to provide intelligent support to WC decisions. The proposed framework was initially designed to accomplish an education environment. However, this section shows how the particular types of agents previously defined could be used in a financial environment, amongst many others.

The interface agent could be responsible of the communication between the user and the system. The advising agent would act as a consultant, indicating to the interface agent the results of the financial evaluation performance. The information agent operates as an intelligent communicator, checking out whether or not the information stored in the knowledge needs to be updated.

The advising agent would act autonomously in order to verify the financial performance of the firm and give advice in case of finding any incongruent relationship between the firm’s financial policy and the control parameters.

Conclusions

This work proposed a multi-agent framework to support collaborative learning and cooperative work in a network. Three different classes of intelligent agents were defined: interface agents, information agents and advising agents. Each one of these classes combines different intelligent techniques in order to achieve its goals. This combination explores the specific characteristics of each technique expanding the agent's capabilities and providing flexibility for the reasoning model.

The proposed layered approach to construct the agents established the Communication Level as an interface with other agents. Although the communication process between various agents was not specified in this paper, there is a necessity to adopt an agent communication language (ACL). Currently, the use of KQML (Knowledge Query and Manipulation Language) [5] is being considered because of its relevant characteristics for communication among agents.

Distance Learning was presented as one possible scenario in which the proposed framework can be used. Currently, there is a necessity for intelligent tools that can deal with real learning instead of only information dissemination. The use of personal assistants and case-based reasoning in distance learning programs can offer an interesting approach to meet education goals. In this context, a prototype is under modeling and development. A second prototype, the WC administrator, is being developed as part of a research project which has the aim of giving financial consulting to small firms.

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