Paper 7:

Towards a Multi-Agent Framework to Assist Networked Learning

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Summary

- Through the continuously evolving information technologies, Networked Learning (NL) has set the scene towards an effective and low cost Open and Distance Learning (ODL) scheme. It is argued that Artificial Intelligence (AI) provides a technology which is already available and also has the potential to support NL both at the organisational and educational level. This paper proposes a framework based on multiple AI agents which can be used to automatically or semi-automatically assist various stages of NL. This assistance is indented for both learners and course providers who need to carry out specific tasks before, during and after the delivery of a course. The architecture of such a multi-agent system is presented and the processes which are automatically supported are briefly discussed.

Introduction

1.1 Internet-Based Distance Learning

- Through the continuously evolving information technologies, Networked Learning (NL) has set the scene towards an effective and low cost Open and Distance Learning (ODL) scheme. Many course providers worldwide offer courses on various topics through the use of the Internet and the World Wide Web. The current technology allows: course material to be electronically distributed, communication between students and instructors as well as between students themselves to be established [1,2], on-line digital libraries to be accessed [3], etc. Since all of the facilities have the potential to efficiently amalgamate text with sound and image in a hyper-structure form, Internet seems to be evolving as the future's most effective medium for supporting lifelong learning. It must be noted that, Network supported distance learning is far from being a process without problems. Non-active participation, early drop out from the courses and information overload are among the ones reported most often.

  Apart from the pedagogical model used, the success of an NL course depends on the efficient functionality of a number of layers, such as: administration, students, course providers, course instructors, and course mentors. A number of procedures and processes are involved, such as: organisation of courses, advertising and admissions, delivery, interaction between students and instructors, technical support for the students, assessment, evaluation, etc. On the other hand, although the number of courses provided nowadays could be considered fairly limited, within the next years, more course providers and more courses of a wide variety of themes will be available in the global networked market. The increase is expected to be analogous to the everyday increase of the information in the www, inevitably resulting in a chaotic situation, causing severe problems. For example, it will be almost impossible for a potential student to choose effectively among several course providers and vice versa. The combination of people involved in the procedures mentioned together with the problems reported impose the need of using software structures and tools which will automatically or semi-automatically assist the process of NL [4,5,6].

1.2 Artificial Intelligence and Multi-Agent Systems

Artificial Intelligence (AI) is the area of Computer Science concerned with the development of intelligent computer systems [7]. One of the aims of AI is to define, design and implement intelligent software agents, i.e. programs that will perceive data, use their domain knowledge to reason about a specific problem in a human-like way and apply the results of their reasoning. Research in AI over the last decade have proved that agents [8] are capable to deal with many complex domains and provide efficient solutions to various problems [9]. The tasks which could be carried out by an agent may differ in complexity and nature, but all of them converge to providing intelligent assistance to users by adapting to every individual user's behaviour.

An agent's abstract structure and operation is shown in Figure 1. The knowledge base contains the knowledge that an agent possess on a specific domain. This knowledge is used by the built-in inference mechanism to provide rational solutions to specific problems that arise in the world domain. An agent is often specialised. For example, given a goal by the user, an agent performs planning, in order to produce a sequence of actions to be taken in order to achieve this goal. Other agents may be appropriate for communicating with the users in natural language, others for discovering new knowledge, others for machine learning etc. It is often necessary to allow the coexistence of many agents which will cooperated in order to solve their goals. The main issue that arises in such a multi-agent system is the efficient communication and exchange of information. Lately, many applications have been developed in both single and multi-agent environments. Work has been aimed mostly at sensory networks, such as air traffic control or robotic systems, at office automation, such as news filtering or meeting scheduling, at user interfaces, such as Internet services or desktop facilities, etc.

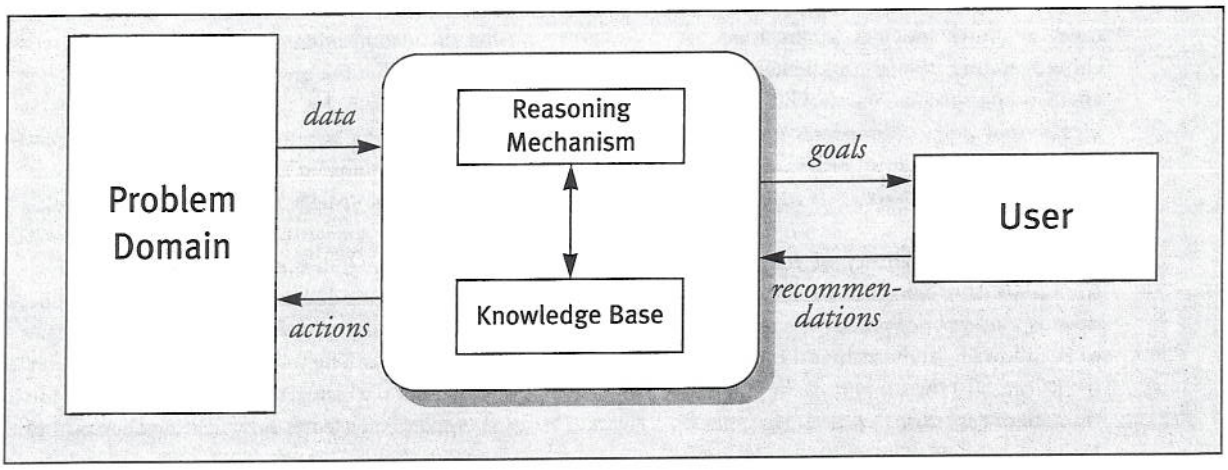

Figure 1: Abstract structure and operation of an intelligent software agent.

1.3 Artificial Intelligent Agents for Networked Learning

This paper proposes a framework based on AI agents which could be used to assist various stages of NL, concerned with supporting tasks which are carried out before, during and after the delivery of a course. As the information on the Internet grows, such tasks will become extremely complex for humans to handle, unless a form of automated assistance is provided. All the tasks need domain specific knowledge which can be acquired by establishing specifications (standards) on every party or component involved in the learning process. It could then be possible for the agents to use such specifications, e.g. user or course profiles, in order to provide intelligent automated assistance to both the provider and the learner.

In the next sections, we present a basic process scenario for conducting distance learning. We then suggest specifications about courses, virtual classroom activities and learners. This is followed by the presentation for the proposed agents and how these could be used to assist NL. Finally, the impact of this framework to a future implementation is discussed and directions are given for further work.

2. Procedures Involved in an Internet-Based Learning Course

- The following comprises a typical scenario describing the processes connected to the life cycle of an Open and Distance Learning course. All these processes are considered with regards to the special conditions applied to Network supported distance learning, and the potential of their automatic or semi-automatic support:

  - **Publishing** - advertising courses on the web: After designing and implementing courses, a course provider is publishing them on the Web, seeking for potential students.

  - **Seeking information about courses:** When a student decides to take an NL course on a specific domain subject, he/she starts seeking information about relevant courses offered through the Internet/WWW, most typically either by 'surfing around' or by using some kind of search engine.

  - **Matching request with availability:** It is most probable that a student after seeking information about courses will end up with a number of courses that seem appropriate for his/her needs. At the same

time, a course provider might have to choose among several candidates interested in the specific course. This in turn means that some admissions procedure should be followed in order to match request with availability.

- **Monitoring the delivery of the course:** After a student enrolls to an NL course, there is a number of procedures that have to be followed; (a) the technical support of the learner, (b) the support of the interaction between tutor and learner and between learners themselves, (c) the need of the learner to keep up with the course obligations and (d) the need of the course provider to keep track of learners progress.

- **Evaluating the course:** Before, during and after the delivery of the NL course, a number of evaluation and assessment procedures have to be undertaken. These procedures aim both at evaluating the progress of the learner and the suitability of the course itself.

- **Refining the course:** Based on information collected through the previous processes, the NL course should be refined for future sessions.

3. Specifications and Knowledge Required

- AI research has so far developed the appropriate technology which makes us confident that most of the above procedures can be fully automated. Through the use of intelligent agents, the burden of carrying out administrative tasks can be eliminated. Since the current technology has the potential to direct more providers in the Internet educational market, the inevitable plethora of information needs to be managed as effectively as possible. It is therefore believed that the cost of developing supporting customised tools will pay off in the near future.

After the identification of the problem's characteristics described in the previous section, the next step towards an intelligent system for NL is the analysis of the knowledge required. This includes identification of the ontologies, i.e. a list of all objects and concepts in the specific domain. The categories, objects, events, processes, measures, time and space changes involved in the proposed multi-agent system should be defined in order to establish specifications-standards in describing the ontologies in the NL process. The following is an informal conceptualisation which acts as a design structure for the domain knowledge on which the operation of the agents will be based.

3.1 Student Profiles

Potential learners have their own profiles. These include personal data about the learner as well as obtained qualifications, background knowledge, qualification aimed at, etc. It is also essential that a student should complete their profile by stating preferences-constraints on period and duration of study, level of difficulty of a preferred course, fees etc.

3.2 Course Profiles

On the other hand, course providers should clearly indicate what a NL course is about. Apart from a traditional abstract textual description, a course profile requires explicit information concerned with the target group, such as admission qualifications, maximum number of admissions, level of difficulty, prerequisite knowledge needed from potential learners, etc. In addition to those, a clear view of the delivery of the course should be provided, including period of study, qualifications to be obtained, credits and links to other courses, role of the course as a module in an integrated programme, mode of delivery, assessment scheme, etc. Relevant work has been taken into account, such as the Upsalla grid for specifying courses as reported in [2], the European Credit Transfer System (ECTS), and other educational standards which are currently under development by various academic societies (IEEE P1484, ANSI etc.) [10].

3.3 Virtual Classroom Activities

The activities of the virtual classroom are focused on the interaction of students with the teachers as well as the communication between students. These factors are widely considered as the primary factors for enhancing the quality of the learning environment created by the course provider. Existing tools offer the potential of maintaining an interaction through e-mail, frequently asked questions, learners discussion groups etc. Information is also distributed on a bulletin-board basis without the students being able to distinguish on criteria such as priority, importance, relevance, etc. This is the effect of having 'one-to-one', 'one-to-all' or 'all-to-all' interaction. A more standard approach facilitates the filtering of information, tailored to the specific needs of any individual student, thus achieving more effective group collaboration and interaction.

3.4 Problems of Students

Students may have various types of problems, varying from technical problems with their supporting tools, learning problems due to distributed course material, administration problems con-

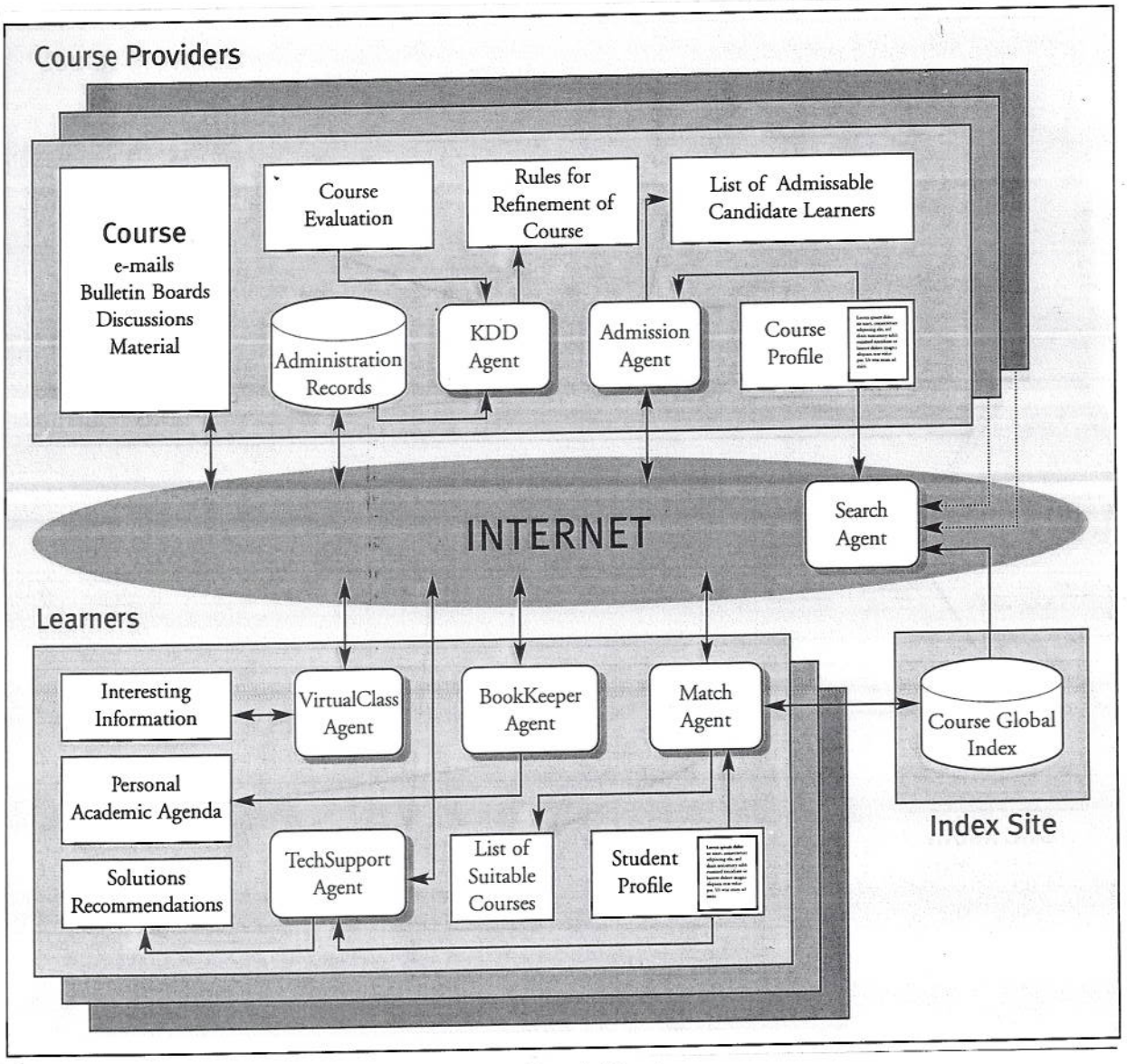

Figure 2: The architecture of a multi-agent system supporting Networked Learning

cerned with the formalities of the course delivery etc. It is essential to categorise these types of problems in order to provide, if possible, on-line expert assistance, thus focusing on the specific characteristics of the potential problem and allowing interaction at the appropriate level with the appropriate people, i.e. instructor, mentor, registrar etc.

4. A Framework of Agents to Assist Networked Learning

- The knowledge described above allow us to proceed with the design of the framework of the multi-agent system proposed. Figure 2 shows the abstract architecture of the system, the interaction between agents, the input data and the output of reasoning. The system includes several types of agents which contribute in their own way to the overall process. Based on this contribution, the following paragraphs briefly describe the functionality of the multi-agent system. A list of the agents involved together with a brief description for each agent is given in Table 1.

4.1 Selection of Courses

Specialised search agents are working in the Internet, in order to gather information about courses offered in the web. The course specifications written by the providers act as classification criteria for the courses. The appropriate information is stored on an global index site which provides the potential students with the ability to effectively search the availability of courses. Since not all candidate courses may be suitable for the student, a customised search should be performed. This is feasible by the operation of the match agent, which given the profile of the student and a list of all available courses, produces through cooperation with an admission agent, a list of the most suitable courses for the student.

4.2 Admissions of Students

Although a potential student considers a course as suitable, his/her belief might not match with the provider's admission criteria. The admissions agent undertakes the task to suggest to the admissions officer possible candidates for the course, thus helping the providers to choose their students. Given the applicant's profile and the restrictions imposed from the provider in the analytical course profile, the admissions agent contains the appropriate rules which, through interaction with the potential applicant, can recommend a student for admission to the course.

4.3 Technical Support

The technical support agent produces recommendations-assistance for the learner on how to use the appropriate infrastructure based on the relevant student and course profiles. For instance, the agent can suggest to the learner to follow a specific technical course module in order to be acquainted with the technology used for the delivery of the course.

4.4 Administration Book-Keeping

The distant learners often find difficult to keep up with their academic record, diary and agenda which contain personal course delivery details, i.e. things already done and things to be done over a time period. The book-keeper agent provides a personal assistant that keeps track of the student's actions, and recommends a new schedule. The agent may also play the role of a reminder for the student's obligations.

4.5 Virtual Classroom Activities

Once registered for a course, a student may impose certain criteria on the information that he/she will be getting from the bulletin board, e-mails or discussion groups. Some of these criteria are also apparent from the student profile. A virtual classroom agent acts as an eliminator of massively incoming information by rating it according to the degree of usefulness or relevance. The agent also

supports the tutors by grouping incoming questions which in turn facilitates the effective student guidance.

4.6 Evaluation of Courses

The administration and academic records together with the course evaluation made by both students and teachers contain useful data that can be used to refine certain aspects of the course. The current AI technology provides methodologies to automatically extract knowledge from data through Knowledge Discovery in Databases or Data Mining. Potential useful patterns in data may be identified. This process can be carried out by a KDD agent and it will result in the creation of rules that can be used by the provider to refine the course profile, admission requirements or even way of delivering the course.

intelligent agents can support both organisational and educational aspects of NL. The characteristics of the proposed intelligent agents, such as reactivity, autonomy, collaborativeness and adaptivity, give the potential of accomplishing the processes of NL in a more effective and efficient way.

In order to construct the architecture of the proposed system, the ontologies which participate in the overall process of NL have been identified. The resulting specifications about courses, learners and virtual classroom activities can also act as directives for providers which can be used to organise, develop, and manage distant learning courses in a better, more focused, manner. We finally believe that a future implementation of this multi-agent system will greatly contribute to the infrastructure needed to support a virtual University based on Internet/WWW.

5. Conclusions

- This paper described a framework for automatically assisting various stages of Networked Learning. We have looked at the problem by putting emphasis on how Artificial Intelligence technology through

Search Agent	It continuously seeks information about courses and updates the Course Global Index.
Match Agent	Based on a student profile, and a list of course profiles and by collaborating with the admissions agent, it produces a list of suitable courses for the learner.
Admissions Agent	Based on a course profile and a list of student profiles and by collaborating with the match agent, it produces a list of admissible candidates.
Book Keeper Agent	It acts as a personalised secretary for the learner.
Technical Support Agent	Based on a student profile and on a course profile, it produces recommendations-assistance for the learner on how to use the appropriate infrastructure.
Virtual Classroom Agentc	It supports tutor-learner and learner-learner interactions by improving the process of asynchronous communication.
KDD Agent	It produces rules for refining the courses, by extracting knowledge from data concerned with course functionality and evaluation.

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