

Distance Learning System: Multi-Agent Approach

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Abstract: *Focusing only on a knowledge delivery problem in distant learning systems, we can find course material selection with relation to an education level of particular student as a main shortcoming. The other equally week point to the mention above is immense burden for the course administrators, when number of students exceeds a few dozen or so. Then the number of people involved in planning, control, scheduling of classes and students' progress assessment, increases in proportion to a number of students. The remedy for the presented above distant learning inconveniences and a way to improve efficiency of knowledge acquire process could be application of intelligent multi-agent system. In the paper, beyond theoretical consideration of multi-agent usefulness, model of a real multi-agent system (in couple variants) based on agents along with performance comparison will be presented.*

Categories and Subject Descriptors

K.3.1 [Computer Uses in Education]: Distance Learning, I.2.11 [Distributed Artificial Intelligence]

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1. Introduction

Not infrequently distant knowledge acquiring process has worse effectiveness than traditional teaching – this is especially noticeable in case of the students that are not very proficient in operating computers. Main cause of this phenomenon is inability to select essential information by students from so called “informational noise” and the lack of the direct contact with a tutor and/or learning materials have been prepared in inappropriate way by the course organizers. Large problem lies, in most cases, in necessity of buying, usually expensive, new software and hardware. This situation is especially urgent problem, in countries that people do not have huge income to the home budgets. Focusing only on a knowledge delivery problem in distant learning systems apart from presented above problems - we can find course material selection with relation to an education level of particular student as a main shortcoming. The other equally week point, to the mention above, is immense burden for the course administrators, when number of course participants exceeds a few dozen or so. Then the number of people involved in planning, control, scheduling of classes and students' progress assessment, increases in proportion to a number of participants. During the work with the course, there is great need to draw special attention on a different time and manner of acquiring the knowledge by the particular students. It follows indirectly from a knowledge acquiring mechanism – that is individual for almost everybody.

In a conventional method of teaching all processes described above are being executed by a “human factor” [4] – what can cause (and usually do) crisis situations, e.g. loosing control over supervision how the students make their progress (due to tutor fatigue), inadequate materials preparation by the ignorance of students' skills/abilities what is tightly connected with loosing interest / willingness to learn etc.

The remedy for the presented above distant learning nuisances and a method to improve efficiency of knowledge acquire process, could be application of intelligent multi-agent system [1].

In this paper, beyond theoretical consideration of multi-agent usefulness, model of a real multi-agent system (in couple variants) based on agents along with performance comparison will be presented.

Distant learning, alone, is only the noble idea, theory that requires technology, in order to be put into practice. There are lots of working solutions on the market. They use dissimilar media, diverse approaches and are written in different programming languages. I would like to present, in this article, other approach, made on the basis, yet evolving, multi-agent systems and new style of programming, called agent oriented programming.

This new approach is not only another way of a programming. It is a superior layer, a methodology of designing systems that are fast, reliable, and what is more important, in the age of common Internet access and distributed systems.

We have to look on such systems in an unconventional way. They perceive a program as an autonomous unit, which possess some kind of “intelligence” and executes some actions based on environment analysis and stimuli from it.

In spite of the fact there is a distant future, the main of scientist it to make to these systems to act in a human manner.

Each day, more and more specialists perceive agents as a perfect tool for many disciples.

2. Agents and Distant Learning

2.1. What is an agent?

Speaking in most general terms, agent is a process, which operates in the background and performs some activities due to its own agenda when specific event occur.

In the Internet, agent is a system component that resides usually on a client side - in a user computer. It collects information about users' state and sends the data back to the server that should be perceived as repository of data and management system [5].

Agents' management system could operate on main computer on the net, though in case of distributed management systems, it can be also located in many nodes of net, and local harvesting data systems could also send periodically gathered data to the main node.

In a big simplification „agent” is a computer program, which is capable to execute and supervise complex operations such a retrieving data, control of industrial processes, “customer maintenance”, etc.

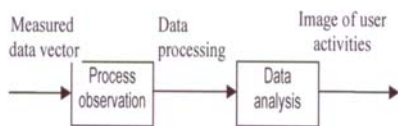


Fig. 1 Illustration of agent activities

In academics spheres, the term agent is still being discussed. Scientists cannot present one coherent definition for the agent. That is why this term is widely used for many, sometimes, different products and technologies. Some called agents just “robots”, abbreviate by “bots” – because idea of the agents is to help people out in doing their common tedious actions. What is more, agents are capable to perform their actions, even when users are temporarily not connected to Internet – agents’ autonomy is one of their fundamental features.

Multi-agent systems, as a rule, find application almost everywhere – nonetheless net applications of agents are the fastest developing domain of science. The agents are commonly used for collecting user data and for realization very complex tasks thru users’ activity analysis and adjusting its behavior to suit user’s needs. Such systems have a great influence on distant learning techniques where they are perceived as some kind distributed supervision over learners. Agents are capable of significant relieving human supervisor’s duties and help in a proper course content selection, in order to be optimal for every individual.

There is a need during the work with students to draw attention on a various level of knowledge absorption by particular individuals and it involves intelligent user profile calculation. One of the well known methods to determine person’s profile, its abilities, interests or weak points, is application of multi-agent system, which is one of many techniques that support e-learning [2].

The minimal aim, in this case is to create an agent that will navigate and select material within the one Web course page limits. This aim can be easily achieved after the users’ ability recognition and classification of learners. For example if system is able to differentiate at least two groups of students (bad or good learners).

First dilemma, which we encounter, is the problem how asses it if given portion of material has been well absorbed or not and next - what course level will be suitable as a next step.

These problems cannot be solved directly by the agents, but with its help tutor can get very useful hints for each individual. Assigning a proper level, on a basis of estimation previously established parameters, for each learner, is a right task for an agent. Next step that should be undertaken is the analysis of user interests, by the activity analysis in prior lessons. These steps should be performed in order to learning material not to be dull, but encourage them to further learning.

It can take place on the basis of complex synthesis of course movement path across course content on initial skill analysis. Each node in hierarchy could has ascribed some values that correspond to agreed – units that describe user skills. Thorough analysis of navigation process along with units counting and their proper interpretation reveals such desirable user profile. In further stages continuous analysis of user’s progress allow to automatic material selection and would relive supervisors’ duties in significant degree.

Both learner’s behavior and abilities analysis, made by agent, could be used by the other agents – for example “retrieving” agents, in order to find information that could be useful in the near future. Action of retrieving data is triggered by the learner and it is being done in the background, without his knowledge.

2.2. Characterization of user profile

Single agent or even groups of them could be scheduled to determine the users’ intellectual profile. Agent, that models user behavior, adjusts interface and marks nodes in the movement path in the knowledge tree. It passes information about material interest factor. All information are collected and passed on to a classification agent. It is the first step in ascribing one of possible advancement levels to a particular student. The analysis of collected data allows for general evaluation and assigning to one of three levels (e.g. basic, inter-

mediate, advanced). The qualification to one of these levels requires earlier selection of material in a knowledge base.

2.3. Navigational Hints

Navigational agent, as the name indicates, is responsible for the proper “navigation” across course material placed on the website. Materials could have placed on many locations – so that the task for such agent is to facilitate the access and collecting information about them, depending on a user profile. Thru material classification performed by mentioned above agent, the most vital materials or information are presented using interface agent. Materials strongly connected with course topic are in queue and wait for user’s access. Each time student made any choice, any movement, all is tracked and analyzed by the bunch of agents, which are keep trying to adapt course content to suit the user needs.

2.4. Harvesting Data

Finding materials useful in a given course / lesson is not an easy matter. Not only for the sake for its appropriate selection, but their placement. It is extremely seldom situation when complete course is placed on www site along with thorough set of materials concerning the course subject. Usually additional materials are placed on multiple web pages outside of course main page.

Process of retrieving such data, for the average user, is usually too much time-consuming and not always data found fully match the course subject. Harvesting agent could turn out be very exceptionally useful in such situation – it helps retrieve data and additional information gathered by the previously mentioned agents (info about type of user and his preferences).

Results of its work are strictly connected with performed (or not) tasks of other agents. The efficiency of the harvesting agents will be strictly dependent on them.

3. Distance Learning System

It is worth to consider some possible issues before we start the construction of distant learning system based on agents. These, given below, are some of them:

- Will the system be a part of an existing website?
- Will every user have an individual tutor, to whom all the questions regarding course material will be directed thru a “virtual agent” that watches over teaching process?
- Will user cover all consecutive course lessons, starting each lesson from revision of the most important and most difficult parts of previous lesson which he had most troubles with?
- Will user’s access to the next lessons be denied until he passes all previous ones?
- Will be any timeframes in which knowledge process should be finished?
- How many lessons’s units could be passed at a time and what should be the minimal time interval before consecutive learning sessions?

On this stage, precise plan of implementation must be built. One has to remember that user always ought to have access to help and possibility to get in touch with the real tutor (e.g. thru e-mail). If we want deliberately control learning process we have to build complex statistics based on the student’s learning results. If any user’s results are clearly different from the rest of group, this implies receiving much worse notes, the tutor should pick such person out and assist him in learning immediately. The system’s most crucial features ought to be, both, user’s knowledge level control and learning progress analysis to facilitate adjusting the difficulty factor of each following lesson. The conclusion is that we have to aim at full personalization of the learning process.

Each student should have a “virtual agent” that controls its learning process. It should be able to made history of the learning route, which ought to be the tool in long-term studying an individual scope of learning.

We have to aim at development such system, in order to user does not feel “forlorn”, but on the other hand not to feel excessively controlled.

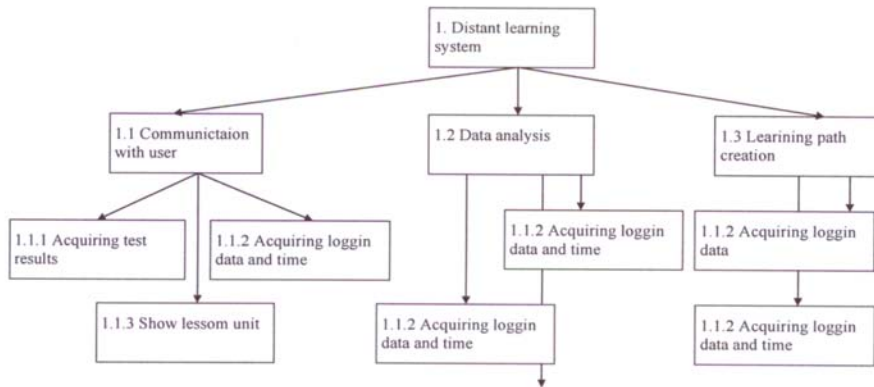


Fig. 2 Diagram of aims' hierarchy

It would be great success if we can develop a system with all features that were described above. We have to remember that the success of the system as a whole lies, not only, in a proper design of particular lessons, but the most important part of it is supervision and controlling part. On these parts the most attention must be drawn.

4. A Model Distant Learning System in Multi-agent Approach

There will be three types of agents in system that we are about to build:

User's Profile Agent – it directly communicate with user. It is a mediator between user and other agents. Its duties:

- receiving data from logging and verification process;
- presentation lesson units and tests, interaction with user.

Supervising Agent – it collects all data from the learning process. It receives messages mainly from User's Profile Agent. It prepares data designed for analysis to Tracking Agent. Its duties:

- receiving data and measuring time when user is logged in, stores all in DB;
- on Learning Path Agent's command collects data from DB required to learning progress analysis and next sends them to it;
- stores tests results, periods of learning and time when user exits the system.

Learning Path Agent – an agent that has some "intelligence" built-in, its main task is selection of lesson units. Its duties:

- performing learning progress analysis, on this basis selects material for particular students for the following lesson units.

It has been made several system variants, among other things, one with load balancing, in order to speedup system operation (mainly data analysis and material selection time). The most loaded agent as regards of number of connections was Supervising Agent. It was not under heavy computational load, because its main task was I/O operation (reading/writing short messages) on DB.

Learning Path Agent was the most computationally loaded agent. It was responsible for results analysis and it selected, on its basis, optimal learning material for each student and revision units. These agents' algorithms could be very computationally complex, and as a result they are very computer power hungry, they require lots of CPU power and megabytes of memory so that's way one should draw attention on load balancing in such system.

It focused, in the following part, on three system's configurations.

- Variant1 – distributed system based on a couple servers – in this variant particular "three" agents are located on the couple servers. If one of these reach the maximal (fixed in advance) throughput / capacity – other connections are re-routed to the other system,

- Variant 2 – all computations are passed on to other "computationally-free" agents within one agent's system dependence on loaded in given moment. The postulate of local load balancing is being put into practice in this variant thru the automatic agent's switching mechanism. "Task queue" of each agent is being analyzed and on its basis decision is being made to which agent (the least loaded) the computational task is being assigned,
- Basic variant – all agents are located on the same server, all participants allocated in one, central server.

The notion "learning cycle" - is a time required for a communication process between agents and time to harvest data required for statistics about students. The real student's learning time will be passed over for the sake of technical aspect of this publication.

From our point of view time of communication between agents and database are the most vital. It was conducted ten full "learning cycles" for different number of course participants. All results have been averaged (reduced to mean). All test scripts were prepared to be run in the same time, to force the maximal load of the Supervising and Learning Path Agents.

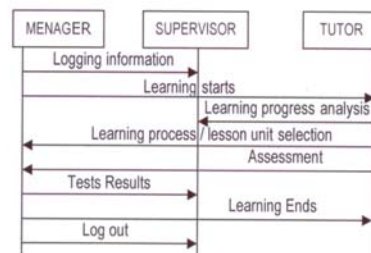


Fig. 3 Sequence diagram – messages passing between roles in the system.

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5. Results and Conclusions

Number of participants	Average time of „learning cycle“ [s.]		
	Basic	Variant 1	Variant 2
10	34,5	2,1	18,6
25	56,3	3,6	24,48
50	389,3	4,7	30,412
75	2304,4	5,9	36,32
100	n/a	9,5	42,24
1000	n/a	58,3	n/a ¹

Table 1 Shortened table of results

¹ n/a – not applicable, the system wasn't able to maintain do many participants

Test systems were four computers. Their configurations as follow: PENTIUM 4 3.0C HT (1GB RAM), ATHLON 2600+ (1GB RAM), 2 x PENTIUM III 500 Mhz (768 MB RAM), ATHLON 2200+ (512 MB)

As we can see in the table above, the best solution is passing computations over to the physical system that is under least load (Variant1). This solution is optimal for big and huge distant learning systems – one could notice great system's scalability.

Unfortunately, not every educational institution that would like to widen its offer to distant learning courses can afford to buy couple new servers. The remedy for the lack of funds could be, in that case, local load balancing that is being done by agents which are least loaded with computational tasks.

Distant education plays even more important role in process of education many social groups. Its importance is growing considerably year by year, among other things, thanks to spreading Internet accessibility. And its popularity, especially among students from large area countries (like Canada, USA, Australia), matches conventional one. Both in Europe and USA majority of well known universities started teaching using e-learning courses. For these reasons distant learning should not be consider as a margin phenomenon, and the interest of it should be aroused by academics. Agent's architecture used in e-learning solutions creates new possibilities of efficient and quick work in the distance learning area. Agent-specific techniques are mainly used for estimation of knowledge absorption, adjusting tasks to be suitable for an individual and optimization a whole process of gaining knowledge to be optimal for each student.

We should draw our attention to the fact that distant learning could be more effective and more profitable than conventional methods of teaching, but on one condition: well prepared and thought over learning material. Multi-agent approach, introduced in this article, is not only one and a legitimate solution for a numerous problems tied with preparation and putting into practice working distant learning system.

Presented approach that incorporates agents into teaching process may considerably shorten time of gaining knowledge by increasing efficiency and allow for increasing number of students without employing more human supervisors or even additional control.

Nonetheless it is alternative of some kind, which aim is the improvement of course management subsystem and also collecting student's activities and learning progress data, designated for the material selection algorithms which are dependent on student's knowledge and abilities. System based on the agents could significantly reduce administering duties connected with running course, relieve tutor of arduous progress tracking tasks, and focusing on preparing training materials or response on student's questions. Agents' architecture could be successfully applied in new, rich in multimedia courses from different disciplines.

So that we think that highly specialized distant learning systems with built-in agent's techniques are more effective for delivering e-learning multimedia content and solving distance problems than classical one.

Multi-agents systems, in near future, will most probably constitute the basis of the majority systems for distance learning education.

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