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CREATING A MULTIAGENT SYSTEM ARCHITECTURE USED FOR DECISION SUPPORT IN ADAPTIVE E-LEARNING

VALENTINA PAUNOVIC
Belgrade Metropolitan University, valentina.paunovic@metropolitan.ac.rs

SLOBODAN JOVANOVIĆ
Belgrade Metropolitan University, slobodan.jovanovic@metropolitan.ac.rs

KATARINA KAPLARSKI
Belgrade Metropolitan University, katarina.kaplarski@metropolitan.ac.rs

DRAGAN DOMAZET
Belgrade Metropolitan University, dragan.domazet@metropolitan.ac.rs

Abstract: *The objective of this paper is to design multi-agent system for decision support used in the e-learning architecture, which could be used at the Belgrade Metropolitan University. This multi-agent system can be used in solving problems that are proving too complex for the traditional monolithic systems. The main emphasis should be on creating agents that will be used for creating classes, using information collected from students. This information would be used to further improve learning objects that are required in order to create lectures. This approach would further facilitate the work of the teaching staff creating these lectures. Main emphasis will be thrown to create agents which can create classes using information which can be collected from students and that information can help to create learning objects which can be used for lectures in order to facilitate the work of the teaching staff when creating them.*

Keywords: *Multi-agent system, e-learning, architecture, learning object*

1. INTRODUCTION

There has been an increase of advanced information technology use in higher education, in order to make learning easier for students, but the systems used to support learning, learning materials and pedagogy do have their shortcomings. Applying similar strategies of learning for all students can be inefficient, so in order to create a efficient system, we have to introduce a system of personalised and adaptive learning, which presents one of the biggest challenges in both creating the software, and the learning materials used within it. People's way of learning differs. The term "learning style" was introduced by the teachers, and was defined as a description of attitudes and behaviours that define the persons preferred way of learning. It is believed that the same person may change the style of learning over time since we are dealing with topics concerning BMU, we have to focus on styles limited to students of BMU. This fact alone imposes a new form of adaptive and personalised advanced e-Learning, in order to adapt the lectures to each individual, by using multi-agents systems in combination with e-learning. In e-learning there is a need to implement new technologies and approaches to meet these requirments. As we said, People learn in different ways and therefore it is important to be aware of the differences between students, and this is especially important during the expansion of higher education. Due to the fast lives and the fact that people often work and study at the same time, distance learning has become very popular. In order to create adaptive learning, it is necessary to create a highly interactive teaching materials that students can master while dictating the pace of work.

There is a need for an intelligent, automatic and asynchronus systems for teaching. Such intelligent systems must be flexible, able to teach and be dynamic. Systems must be personalized and capable of providing a variety of students with an effective and efficiant way of learning. Agent technology can provide a dynamic adaptation of information and Internet technologies, as well as adaptation to the individual student. In order to create a personalized adaptive learning, a multi-agent based system use is proposed. If we start from the fact that the book authors, professional athletes, movie stars have their own agents, we can define an agent as someone with experience who is tasked with speaking in the name of their employer. The IT equivalent of these agents are programs that are tasked with making decisions using past experiences. Multi-agent-based systems are systems where multiple intelligent agents communicate with each other whereby the agent is a completely autonomous entity (a software program or a robot). Their interactions can be cooperative or independent. Case officers can share a common goal, they can pursue their own interests, which is very useful in creating a personalized adaptive system to support learning. The theory of learning styles is the foundation of all pedagogical multi-agent systems. Adaptivity at the conceptual level is achieved by the use of learning style schemes to modify the presentation of

learning objects to individual students. Inversely, thisadaptivity at the practical level is achieved by providing a set of agents that uses a combinationof prebuilt and acquired knowledge to determine the learning styles andlearning objects that are appropriate for individual students. [1]

This applies not only for web-based systems, but also a wide range of other technologies requiered for more complex tasks. Learning objects increase personalization, interoperability and flexibility. People have their own ways that allow then to learn effectivly and support the strategy for personalization of learning. Adjusting learning materials and learning objects can support students with different learning styles. Agent technology provides a dynamic support for distributed applications and solves key problems that can arise in E-learning, such as: distance, cooperation between the various entities and components, the integration of the various components in the system etc.

This paper presents and adaptive e-learning system that incorporates adaptive advanced technologies in e-learning technology to facilitate the achievement of adaptability. The aim of this paper is to initially introduce the adaptation of learning objects and then display the architecture of a multi-agent system used to support Internet learning mechanisms that incorporate artificial intelligence in order to provide students with the best possible studying techniques at the Metropolitan University. The main emphasis should be on creating agents that collect data from students, in order to facilitate teaching staff and make the job of creating teaching material easier.

2. MULTI-AGENT SYSTEM

This notion was clearly shown in the paper "Systems based on agent's technology" where agents represent the software with the ability to independently perform tasks and generate reports to the user, regarding the completion of the task or the occurrence of expected events, without any user intervention. Agent can be defined as follows: as a computer system that interacts with the environment, has the ability to react flexibly and independently in accordance with the objectives it has been set.

Classical expert systems have not been able to act upon the environment (at least not directly) or they had to do it through intermediaries (customers) who, depending on the obtained responses reacted to the environment. Autonomy means that the system is able to react without any user intervention (or other agents), and to have control over their actions and internal state. Such a system should be capable of learning from experience. The possibility of interactions with the environment, and the autonomy of computer systems is not a novel idea. There are already many such systems, along with programs used for controlling real systems that monitor the real world environment and perform actions in response to system changes in real time, or and programs that monitor the software environment and perform actions which act on the environment as conditions change (anti- virus programs). The examples have the characteristics of interaction with the environment and autonomy, but these systems cannot be considered agents as long as they do not have a flexible behavior when they find themselves in situations that are not planned when designing.
To be considered flexible, the software system must meet the following conditions:
• Agents needs to observe changes in the environment and to decide on possible action fast enough that such action can be deemed important for the system in which it operates,
• Agents should not just simply react in response to signals from the environment, they must be able to perceive opportunities and take initiatives in these situations, in accordance with its objectives,
• Agents should have been able to enter into communication, if necessary, with other agents and / or people to solve their own problem or help each other agents in their activities. [3]

Systems that use more agents to resolve common problems are called multi- agent systems. In such systems, it is essential that agents have the ability to communicate with each other in order to exchange experiences and "negotiate" in order to find the optimal solution. Multi-agent systems are ideal for the presentation of problems that have many different methods for troubleshooting, multiple perspectives and / or multiple entities for solving problems. They allow the creation of parallel computing systems, help in working with time-limited reasoning and robust systems - if responsibilities are shared. In a system made this way the process is governed by a complex agent, management is divided into more agents according to their specialties, who then assume jurisdiction over the control of complex processes. When designing a multi-agent system, it is necessary to define the number of agents, the critical amount of time to perform the task, dynamics of the arrival of goals, communication costs, the cost of failure, the impact of the user, the uncertainty of the environment. At the level of each agent the following must be defined: the initial state of the domain, possible actions of other agents and the output of the agents action.
We can identify the commonly agreed properties of agents, which include autonomy, proactiveness, responsively, and adaptively. Agents should also know users' preferences and tailor their interactions to reflect these. Agents, in the context of our education system architecture, provide a means to manage the complexity and uncertainty of the domain.

3. REVIEW OF MULTI-AGENT BASED INTELIGENT SYSTEM FOR SUPPORTING INTERNET LEARNING

The article "*Adaptive User Interfaces for Intelligent E-Learning: Issues and Trends*"[4] covers topics about creating an adaptive user interface using techniques of artificial intelligence, SC (soft computing), creating a GUI, Java programming, mobile services etc. Specifically, the paper discusses the ways to improve Web and mobile e-Learning systems in order to achieve the goal of adaptive learning. The success of such a

learning process, based on intelligent context-oriented classes and their adaptability in terms of complexity and granularity. Researchers were looking for ways to create a flexible user interface but, managing specific human behaviors, technological capabilities and contextual nature of information has made it a great challenge. Solving this required a great deal of creativity and the researchers designed a model of a state-of-the-art research adaptive user interface intelligent multi-media educational system and how it will continue to improve in the future of this research.
When creating adaptive intelligent interfaces, the following paradigms should be used:

- **User based interaction** - that dynamically reacts and adapts itself to the experience of students. It is necessary to understand the individuality of each user and work on adaptation and the dynamics of interaction. An interface consists of atoms that change in relation to user behavior.
- **Model-based interaction** - including the use of articulation models and knowledge that can be reused by encapsulating a whole range of details relating to the development of the user interface. This paradigm is used in order to reduce the time and effort, as well as implementing automatic decisions regarding the choosing of the interface.
- **Agent based interaction** - this paradigm involves using software agents to delegate tasks relating to the interaction of different aspects of the system.

In order to better develop a multi-agent-based intelligent system to support Internet learning, it is necessary to look at what was done in relation to this issues.
One of the most representative intelligent systems that use agents is inCA[5].
This intelligent adaptive learning system uses cognitive multi-agent architecture and relies on a personal agent who is familiar with the characteristics of the users needs in order to coordinate further series of specialized agents, as follows:

- Agents for storytelling
- Agents for simulation
- Agents for evaluation
- Auxiliary agents

The inCA architecture is applied in order to create K-inCA, a system for Internet learning that aims to help people to acquire knowledge and share practical experiences. the development of inCA itself was motivated by the limited success in traditional learning. Take, for example, people with special needs, most of these people would be more comfortable using e-Learning rather than the traditional approach.
The very architecture of InCA consists of models from the domain, as well as user models. The model domain is a set of structured knowledge elements (domain ontology contains learning objects, the principles of knowledge, and ways to acquire said knowledge) delivered to the user by the agent.

User model - based on the users ontology that covers elements such as: the level of learning exchange, learning objectives, the domain of interest. The architecture of inCA is given in the following illustration.

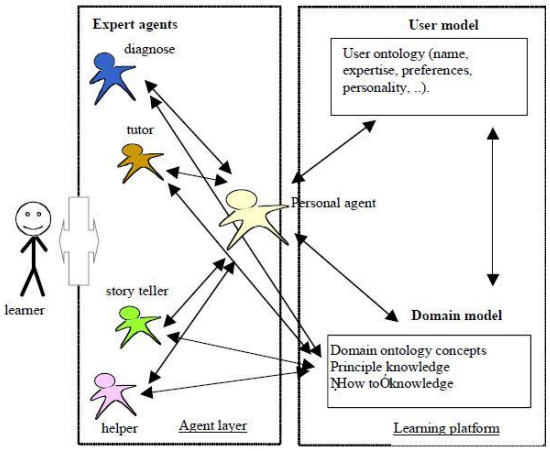

Image 1: InCA architecture

2. CREATING OF PERSONALIZED LEARNING OBJECTS FOR DIFFERENT CLASSIFICATION OF STUDENTS

Let us take, for example, that every student has their own style of learning that may change over time. Based on this, we will try to propose a multi-agent-based intelligent system. In order to create agents that will collaborate with the students learning scheme it is necessary to sort students by certain styles of learning, that many articles found a useful technique to begin creating a multi-agent system.

A more accurate survey would involve a huge number of questions, but this form of the questionnaire would be problematic when using our system, but the information would be more than useful, and the students could be more accurately classified. Specifically, there are students who do not belong to only one cognitive group, but are in between various groups (e.g. good overcoming of visual and tactile learning). It is necessary to create a simple algorithm to approximately determine the position of the students learning methods. In our case it would be a four-dimensional system (having visual, auditory and tactile classification) which would be created by using small groups of questions. One example of the use of this classification is the Felder-Silverman principle of classification and that is four-dimensional classification.[6] Felder-Silverman's learning styles questionnaire was used to devise questions that will be asked to a student, and an example that was used can be seen at the following link.[7]
The initial test would contain 44 questions that would rank responses of students from 11 to 1 and from 1 to 11. If the result was 1-3, you are pretty well balanced on both dimensions of the scale, if the result is between 5 and 7, you have the advantage in one dimensions of the scale and will find it easier to to learn in the school environment that favors this dimension, if the score is on a scale between 9:11 there is a tendency toward one dimensions of the scale.

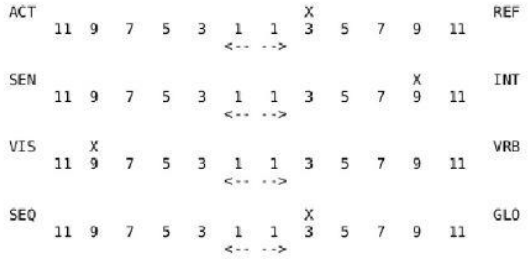

Image 2: Scaling in the Felder-Silverman principle of classification

Considering that the scaling of students from 1-11 would further hinder the job and programming of the agent, scaling is reduced by 1-5 (-2 to +2) modeled on research conducted by S.Shagua, M.Joy's and N.Griffiths- this has proven to be an easier way for further development. [8]

Sensing	-2	-1	0	1	2	Intuitive
Visual	-2	-1	0	1	2	Verbal
Active	-2	-1	0	1	2	Reflective
Sequential	-2	-1	0	1	2	Global

0 - Neutral 1, -1 - Weak 2,-2 - Strong

Image 3: Preview of short scaling

The scales of the dimension are: Active or Reflective, Visual or Verbal, Sensing or intuitive and Sequential or Global. The description of dimensions is given in the next illustration.

Image 4: Overview and description of the student classification dimensions

he relation between student clasification and creation of learning objects is shown in the Image 5.

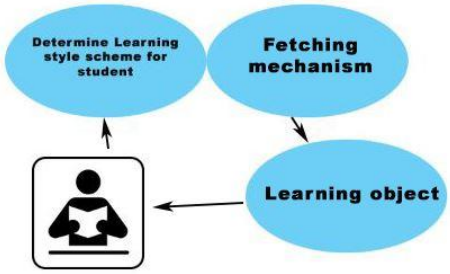

Image 5: relation between student clasification and learning objects

An example between students learning styles by using the mentioned testing and ranking:

Student I:

Sensing or Intuitive: Strongly Intuitive
Visual or Verbal: Strongly Visual
Active or Reflective: Weakly Reflective
Sequential or Global: Neutral

Student II:

Sensing or Intuitive: Neutral
Visual or Verbal: Strongly Verbal
Active or Reflective: Weakly Reflective
Sequential or Global: Weakly Global

In order to create learning objects, it is necessary to also organize them in similar ways as the classification of students. In order to achieve this we can use metadata. Seeing as the BMU used LOM standard Base Schema, we can use the following metadata: author, date, etc., as an example we can use the dimension description, submitted for each of the four dimensions using the scale that we used for testing students with levels: strong, weak, neutral etc. The proposed intelligent multi-agent system will store the current learning style of each individual student in the database as well as learning objects with their attributes. The algorithm that will be used to deliver learning objects to the student will analyze learning objects with their metadata related to the dimension description and will connect them with students learning style. Of course it is necessary to strive towards a lecture based on as many specific objects that are the right kind for the student. Let's say that a student got a result stating that the most suitable lectures for him are those that are visual, active, intuitive and global, Therefore, with the help of agents, we can automatically grant him the classes based on the given classification of students and learning objects. There is a possibility of organizing learning objects for the individual student who is nothing but a combination of five valuable points in four dimensions, and therefore there are 625 (54 = 625) opportunities that can be created. For example, strongly sensitive, strongly visual, strongly active and strongly sequential is one of the possibilities. As noted above it is necessary to keep the categorisation of learning objects and the students style of learning as similar as possible. Of course, some material withing the learning object simply cannot be adjusted to each specific student, and therefore it is needed to make lectures using

as many learning objects that are specific to the student. Let's say if the object of learning is a video game where you first need to look at the tutorial for problem solving, the facility will most likely fall to a student who is, acording to the visual test, an active type.

4. CREATING ARHITECTURE FOR MULTI-AGENT SYSTEM IN CONTEXT OF BMU E-LEARNING OBJECT MANAGMENT SYSTEM

Learning styles are the pedagogical foundation of a multi-agentive system, and the Learning objects themselves provide a way of organizing teaching materials for personalized adaptive learning. Using intelligent agents allows us to extract data at a higher level than by using conventional software technology while also allowing a more natural way to design the system. There is an autonomy of agents within the system - the ability to take responsibility for their own actions within its sphere of access. Reactivity and proactiveness characteristics provide a multi-agent system with maximal flexibility, which is to be expressed in special situations in learning, as well as a compatibility with different learning styles. [10]

System architecture shown in the illustration must include a semantic web ontology, a multi-agent system and an service oriented architecture. The concept of Service-oriented architecture helps the system to provide different components to a collection of services to other clients. In order to create interoperability between components the layers of SOA services are used, as well as in order to achieve interconnection with the LMS system - in our case the LAMS system of the Metropolitan University. Each LMS can be easily integrated into adaptive systems through Web services regardless of their platform. Next, it consists of the agent container, then a system for managing agents and an API interface. The expected benefits of agent technology are:

The ability of Agents to improve performance in relation to the client-server architecture, improved reaction to varying situations and learning to adapt to each particular student and an ability to return a learning resource to students. After designing an agent system, the system is likely to consist of: the agents for modeling objects, learning, presentation, ontology and so on. the very idea of creating mentioned intelligent learning objects allows us to create a intelligent agent (agent for preferences) that will create a setting based on some classification. The proposal of our multi-agentive system is based on five agents: *Student Agent, Record Agent, Modeling Agent, Learning Object Agent and Evaluation Agent*. Each agent is designed to meet the specific functional condition that contributes to the overall learning system, to create a personalized adaptive learning.

The Student Agent - responsible for communicating with students and providing an interface between the system and user. The interface adapts in a relation to the primary test.

The Record Agent - manages information for each student and works with the database which stores relevant information. It is also able to process and draw conclusions from the data given to other agents and intelligently provide information it considers relevant to other agents , without that information being requested

The modeling agent - responsible for generating an estimate in accordance with the general pedagogical approach of modeling (Bayesian networks or the fuzzy logic approach), creatin individual models for students so by gathering information from the Record Agent.

The Learning Object Agent - manages a set of learning objects and provides relevant learning for students considering their specific learning styles.

The Evaluation Agent - ensures that the learning objects are presented and creates adaptive pathways to each individual student.

Over time, as more students use the system, agents learn more about them, increasing their precision.

Another idea for the creation of intelligent agents is that the student take the pre-assessment test before the above-mentioned assesment test, in order to have access to the level of foreknowledge a student has, using an A B C structure. this is one of the earlier ideas BMU had in creating adaptive learning [9]. Based on the Felder-Soloman test, we would already have access to the profile of students, a pre assessment could only provide more details about them, but it is not necessarily for every course to have this ABC type of testing. For example, after working on a pre-assessment, a student who is ranked as a type I (of the mentioned 625 types) (strongly sensing, strongly visual, strongly active and strongly sequential) can provide us insight that his foreknowledge in the given area is strong and that it is necessary that the lectures he takes encompass a wider and better picture of the subject but still stay at the same level as the primary classification.

Compared to the tests that are done in our case, we have two levels of classification:

- Classification I - Includes the Felder-Silverman test as a basis for determining the type of a student. After the first classification, the agent should propose an adaptation of interfaces and classes for each certain type of student, if there is no foreknowledge test.
- Classification II - determines the level of foreknowledge. it can classify students in 3 categories: a, b or c, and the agent should further Adaptation lectures considering the level of students foreknowledge
- Classification III - includes the foreknowledge test whereby the agent should create a further adaptation of the system in relation to the progress of the student. A draft of the architecture is shown in the Image 6.

The goal of further work will be to create intelligent agents using artificial intelligence with emphasis on agents that create lectures based on information gathered from students, as well as agents that facilitate the work of teachers in creating learning objects

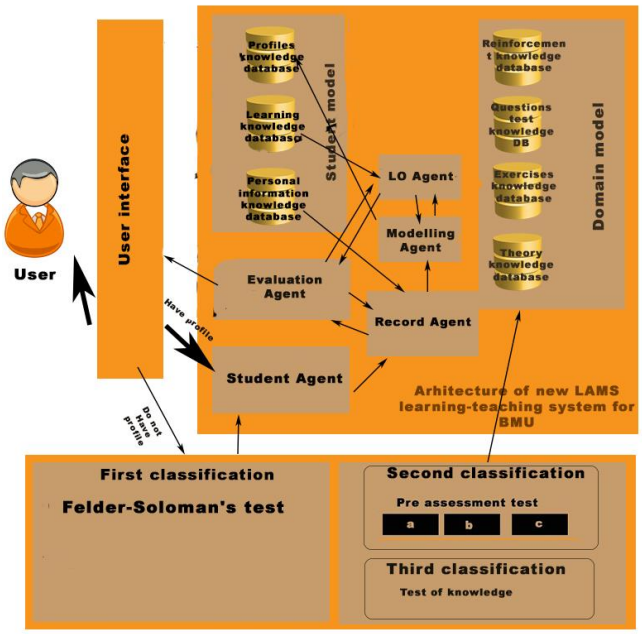

Image 6: Overview of the multi-agent adaptive learning architecture

5. CONCLUSION

The area of autonomous agents and multi-agent system is very diverse and is rapidly expanding. The methodology of creating programs based on these agents provides a range of effective tools and techniques that have the potential to significantly improve the technique of making software starting from conceptual design to its implementation. They represent a combination of several scientific fields such as distributed data processing, object-oriented systems, software engineering, artificial intelligence, economics, sociology, organizational science etc. During the past two decades, many scientific revelations were made in the field of design and implementation of autonomous agents, as well as the way in which they interact. Technology-based agents are marking an increase in use, especially in commercial products and software that is used in real-world environments.

Currently, it is very important to solve three problems:

- the lack of clearly defined systematic methodology for the development of agents in a multi agent-based environments,
- lack of widespread, accessible and standardized development application that can be used for creating a multi agent system.
- developing a functional agent using artificial intelligence

Most previous applications have been designed on the basis of methodologies borrowed from object-oriented programming languages. Currently there is no methodology that defines how to best structure a multi agent-based system, how to reconcile individual and / or collective goals of agents in communication, or what is the best structure of the individual agent in such a system. Development tools that enable easy definition of the behavior of the agents, as well as a way to develop principles upon with the agents interact and visualize, as well as debugging the behavior of agents in the entire system is essential.

When creating programs based on agent technology, a balance between constant interaction with the user (as it is the case with current applications) and the situation in which agents enforce decisions without consulting the user must be found. In order for individual agents to accept the idea of working with other agents, they must first trust them. It is necessary to pre-establish mutual trust, and this process may require time. As can be seen from the preceding paragraph, despite the obvious potential, there are many questions that still need to be explored and technologies that need to be developed. Their resolving will find agents a whole new range application in multiple areas. Only standardized, reliable, easily applicable and scalable solutions could fully exploit the potential of these agent based systems.

REFERENCES

[1] Peña, Clara-Inés, Jose-L. Marzo, and Josep-Lluis de la Rosa. "Intelligent agents in a teaching and learning environment on the Web." In Proceedings of the international conference on advanced learning technologies, pp. 21-27. 2002.

[2] Garro, Alfredo, and Luigi Palopoli. "An xml multi-agent system for e-learning and skill management." In Net. ObjectDays: International Conference on Object-Oriented and Internet-Based Technologies, Concepts, and Applications for a Networked World, pp. 283-294. Springer Berlin Heidelberg, 2002.

[3] Ilić, V., (2002): "Systems based on agent's technology", InfoM – Journal of Information Technology and Multimedia Systems, no 3-4/2002, Belgrade

[4] Ahmad, Abdul Rahim, Otman A. Basir, and Khaled Hassanein. "Adaptive User Interfaces for Intelligent E-Learning: Issues and Trends." In ICEB, pp. 925-934. 2004.

[5] Beer, Martin, Wei Huang, and Andrew Sixsmith. "Using agents to build a practical implementation of the INCA (intelligent community alarm) system." In Intelligent agents and their applications, pp. 295-328. Physica-Verlag HD, 2002.

[6] Felder, Richard M., and Barbara A. Soloman. "Learning styles and strategies." At URL: http://www. engr. ncsu. edu/learningstyles/ilsweb. html (2000).

[7] Index of Learning Styles Questionnaire, https://www.engr.ncsu.edu/learningstyles/ilsweb.html (online 30.8.2016.)

[8]Sun, Shanghua, Mike Joy, and Nathan Griffiths. "The use of learning objects and learning styles in a multi-agent education system." Journal of Interactive Learning Research 18, no. 3 (2007): 381.

[9] V.Paunovic, S.Jovanovic, D.Domazet, "Technology aided education of students with disabilities: a case study for students with cerebral palsy", elearning conference 2014.

[10] Ahmad, Sadaf, and M. Bokhari. "A new approach to multi agent based architecture for secure and effective e-learning." International Journal of Computer Applications 46, no. 22 (2012): 26-29...