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Challenges to the Virtual Educational Space

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Key Words: *eLearning environment, eTest, multi-agent system, active component, BDI rational agent, REST API, SCORM, QTI.*

Abstract. *In the present paper, the advantages of the intelligent personal assistants are presented which support the users' activities in the educational systems and environments. Approaches aimed at enrichment and development of their functionality through the use of semantic knowledge and knowledge extraction from the data are discussed. Ways for specification and measurement of a variety of personal qualities of the students are searched for through the personal assistants which have an impact on the learning process.*

1. Introduction

The contemporary educational space is based upon the integrated character of the high technology world in which people live and study. One of the main problems of the contemporary learning systems and environments is that they must be synchronized with the user in order to achieve various educational aspects such as: flexibility, repeated usage of education content and personalized representation of the education material. These systems should be capable of predicting the needs, the interests of the users, the causes for further activities and of proposing plans for achieving of the goal desired by the user. In order to be capable of acting in such an intelligent way, the systems must be capable of acquiring knowledge and to draw conclusions on the basis of statistics which in turn are based on the actions of the user and his/her interests. Or in other words, they must be able to become aware of the behavior of the user and to adapt their own behavior so that they act in coordination with each other.

One possible approach to the achievement of these goals is the use of intelligent personal assistants which can support users' activities in different areas of application. The use of semantic knowledge is one of the possible approaches to the enrichment and development of the functionality of the intelligent personal assistants. On the other hand, through the analysis of the accumulated data regarding the users, the personal assistants can search for ways of specification and measurement of a variety of personal qualities of the students which have an impact on the learning process.

The *agent* is an autonomous entity which perceives its environment with the help of sensors and can have an impact on it through its effectors. The behavior of the agent depends on his capabilities for inner reasoning, varying from simple reflex to intelligent, purposeful procedures for decision making. *Intelligent agents* are computer systems which can operate flexibly and autonomously in some environment for achieving of the goals set [2]. The intelligence of these agents is determined by several attributes: autonomy, reactivity, proactivity, sociality and capability of self-learning. Self-learning allows for the intelligent agents to adapt themselves to the dynamic environment in which they operate achieving in this way optimization of their functional process and the two-directional information flow.

Intelligent Personal Assistants (*IPA*) are software agents which support the users during the execution of specific tasks. Their interaction with people includes communication, cooperation, discussion and directing. One of the main differences between the Intelligent agents and the Intelligent personal assistants is that the latter interact with the users by hiding the complexity of the assigned problems executing them on their behalf [13]. One of the main tasks in the process of development of IPA is the constant improving of their behavior, based on previous experience, competency and interrelation with the users.

The paper's goal is to present some opportunities to enrich and implement the functionality of Intelligent Personal Assistant, as well as their integration in current educational systems and environments.

In this direction, we research and create a module for supporting the student during his/her learning at the university. Such module is created in the information system of the Burgas Free University but it just shows to the student his/her current state – exams passed and marks. The idea is

that this module can become intelligent and active through software agent which is independent of the platform and allows to be used self-dependently as well as by various systems for electronic learning.

In the architecture model of the agent-oriented applications every agent can initiate communication with other agent or can be an object of incoming communication at all times [12]. In this direction, we have implemented a simplified module based on this concept. The idea is presented in *figure 1*.

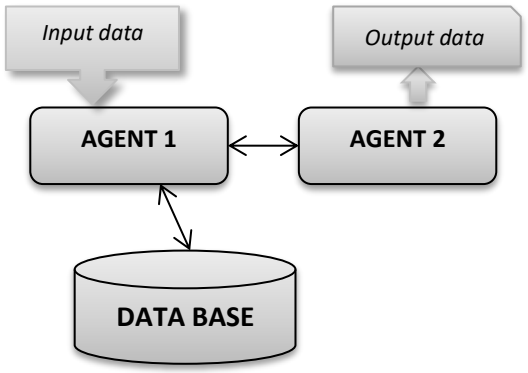

Figure 1. Conceptual model

The incoming information, obtained by the system, is connected with identification of the searched object (in this case a student) and with instructions for the required operation. They can be abstractions of all possible data which is written in the database, for instance faculty number, unique citizenship number, name, address etc. The role of Agent 1 is to obtain this information and based on the instruction in the request to complete the corresponding operation on the database (to find the corresponding object, to modify it, to add new object, etc.). After completing the operation, Agent 1 sends the results to Agent 2 whose function is to return the obtained information to the exit of the system. This can be information for an object, information for the way of executing of the operation etc. The format of the incoming and outgoing information is XML which is aimed at achieving of universality and possibility for communication with the module through Web Service.

Based on the accumulated data from the work of the system for electronic learning with different users, applying tools from the area of knowledge extraction from the data, different decisions can be made. Specialized personal assistants can determine and measure a collection of personal qualities of the students which have an impact on the learning. Analysing the data from the user profiles, it is possible to search for different ways of establishing and measurement of a variety of users' personal skills that affect learning, like: curiosity – the desire to change or perfect things that other people take for granted, connection – the capacity to make associations between data which seemingly are unrelated; persistence – the ability to pursue better solutions, even though satisfactory solutions already exist; complexity – the ability to process large volumes of information, as well as other personal skills.

On the basis of the derived knowledge, personal assistants can take concrete actions for adaptation and personalization of the learning. The interest of the students, their active participation in the process of acquiring of knowledge and skills, to a great extent, can be affected by the quality of the used learning environment.

2. Semantic knowledge about the work of the intelligent personal assistants

Semantic storages allow the preservation and the management of structured data which gives opportunities for automatization of the processes of decision making. These storages have the potential to propose easier integration of heterogenous data and more analytical possibilities. The use of semantic knowledge [3] is one of the possible approaches to the development of the intelligent personal assistants.

At the present moment, the technologies for providing of semantic knowledge during the functioning of the intelligent personal assistants are based on three main approaches for representation of knowledge: conceptual graphs, ontologies and neural networks.

- *Conceptual graphs*, developed by John Sowa [9] describe language for representation of knowledge which was initially designed for recognition of the semantics of the natural languages. The main idea is the meaning of a given notion to be revealed by the ways in which it is connected to other notions. On the other hand, they are effective algorithms for derivation of properties of an object on the basis of its belonging to a certain category. The multi-agent system presented in [15], based on conceptual graphs adds intelligent search, automatic notification, instruction and management of personalized information.

- *Ontologies* are a powerful tool for representation of semantic structured data [7]. They are used for separation of knowledge for the domain of operational knowledge with the aim of repeated use and analysis. Through ontologies knowledge for the area on the basis of some conceptualization is formally represented. It suggests description of a collection of objects and notions, knowledge for them and relations between them – roles. In this way, two components are openly separated in the structure of the ontology: names of existing concepts and links in the domain. Intelligent

agents, based on ontologies [10, 11] can provide different functionalities, for instance agent for generation and examination of tests, agent for personalization of profiles, agent for analysis and personal food regime, agent for analysis of existing and acquired knowledge, agent for management of fuzzy systems etc.

- *Semantic neural networks* are specific extension of artificial neural networks. Generally, a neural network is a connected group of simulation neurons which represent the computation model of the information process. In order for a neural network to be applicable to a given problem it has to be taught in advance. The teaching is performed through changes in the weights of the connections between the neurons. Gabriela Czibula in [2] presents an agent who uses neural network for self-teaching through observation and support of users during the execution of specific tasks.

The inclusion of semantic knowledge in the work of intelligent personal assistants can increase the level of reality in the interaction with the users, making it closer to the real interactions between people.

3. Integration of personal assistants into the virtual educational space

One of the most widespread applications of the intelligent personal assistants is in the area of the virtual learning. In [8] a context-dependent Virtual Education Space (VES) for delivery of electronic services and electronic learning content, satisfying the requirements of the eLearning teaching model is presented. In order to effectively build the electronic content, ensuring its portability, integration and reuse of the individual components in various learning situations, this content must be based on a certain standard. For this purpose, a study was conducted of the main concepts and ideology of SCORM [18]. For definition of the test elements which can be included in a test a QTI Standard is applied [19]. The characteristics of various types of questions correspond to elements of the standard and can be used for management of the learning and accumulation of statistics for the teaching process.

In [4] an approach to the full integration of components is discussed, following a general methodology for realization of functionalities in the form of microservices and providing the intelligent behavior of the services through the use of resources of the Belief-Desire-Intention (BDI) Rational Agents microservice. This microservice gives all agents' resources for the realization of intelligent behavior through REST API. In the program realization this is achieved through integration of the Jadex platform [16]. It is an extension of the Jade platform which provides tools for accumulation and sharing of knowledge between BDI agents and integrates the Active Components model. BDI [16, 17] is a classical agent's architecture which uses the model of human activity for representation of limited rationality. It is based on: believe (model of environment), will (tasks of the agent which are not yet transformed in specific intentions) and intentions of the agent which are equivalent to his existing engagements, including engagements with himself (*figure 2*).

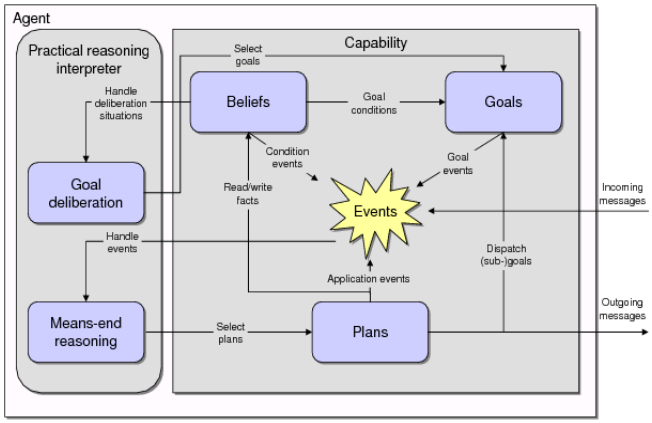

Figure 2. Concepts of the Jadex BDI Reasoning Engine [16]

The concept Service Component Architecture (SCA) determines a general approach to the defining of two key characteristics – way of creating of components and mechanism for description of the way in which these components function together [1]. The component provides functionality which has no restrictions about the technologies used for execution, processes or machines on which the component will exist. The interactions of the components are modeled as communications based on services. Thus the component is a software object designed to interact with other components capsulation certain functionality or a collection of functionalities. It has clearly defined interface and corresponds to a prescribed behavior which is general for all components of a single architecture.

Exemplary components which are integrated in VES are module for electronic testing [9, 10], module for observing and supporting of the activities of the student and the teacher etc. The methodology for integration of new components in the space which use their own model of data includes three base element which should be realized – a collection of microservices which model and offer the corresponding functionality, a separate microservice which guarantees access to data needed for the functioning and storage with data. Logically and functionally the components have to be defined in coherence with the overall concept of VES.

The virtual educational space is an information space which integrates heterogenous technologies and

pedagogical approaches. The integration of components in VES through experience and implementation of general architecture methods and approaches for the overall space provides intelligence, context dependency, aim-oriented proactive and autonomous behavior of the service. In this way, working in a connected environment makes the possibilities for conducting and management of various processes become greater. The space is open for new components which can provide their abilities as services, independently of the technologies used for their execution.

4. Virtual education space and Internet of Things

The different educational aspects (learning, assessment, self-education, etc.) are all interconnected and have an influence on each other and it must be made possible to create relations between them in order to fulfill a fully adaptive and user-centric personalized educational process. In VES the users, time, location, autonomy and context-awareness are basic concepts ensuring unified processing and interpretation of the information, received both from the virtual environment and the real physical world [4]. The Internet of Things (IoT) concept applies easily to such an environment.

The IoT is an extension of the Internet into the real physical world in which physical entities (objects, devices, and things) are interconnected. It defines an ecosystem consisting of things that can sense the environment changes, analyse them based on a shared gained knowledge and act or make appropriate plans, achieving a personal or a shared goal.

To be able to put education in the terms of IoT, a suitable virtualization of each and every aspect of the educational process must be defined. The models presented in [6] outline the key abstraction aspects that must be covered by an educational conceptualization and aim a more adaptive and agile learning process as well as sharing and reusing of the educational content. To represent education via a formal model on a meta level, it's base aspects (knowledge, processes and participants) must be modeled and formalized in a way that ensures the definition, finding and usage of relations between them, that provides their identification and definition of level of applicability into a specific educational context [5].

Considering the fact that the IoT paradigm brings the Internet to a whole new level of application, influence and usage, the elements of the virtual education space must evolve to become part of this new Internet environment. This will provide great opportunities and new perspectives for the development of education as an integrated part of the global ecosystem of the Internet of Things.

5. Conclusion

The advantages of Intelligent Personal Assistants and possibilities of their integration with virtual educational spaces are stated in this paper. Approaches to enrich and develop their functionalities, through semantic knowledge and data acquisition, are discussed. Without doubt, the intelligent personal assistants will be integrated in the modern educational space. In order for the concept of VES to continue its development in this dynamic and heterogenous environment, it must be capable of adapting to all characteristics and requirements which the environment imposes.

The Forth Industrial Revolution [14] is closely related to the next generation Internet, which has to guarantee that the enormous potential of the artificial intelligence, the virtual reality, the connection to the physical world, the machine learning, the ubiquitous networks of humans and machines are used completely for the universal improvement of the quality of life and add to the construction of steady societies.

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