ANALYTICAL LEVEL OF VELSPACE

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Abstract: *The article provides a general description of one part of the structure of Virtual eLearning space - VeLSpace, which is called Analytical level. The main components of the Analytical level and communication with other system components are described as well. All components are structured in three different levels of abstraction: analytical, semantic and sensory. The paper also presents some concepts related to the use of intelligent agents based on BDI architecture. Semantic level refers to the representation of knowledge in the system that agents use for the outside world and their inner beliefs. The knowledge is presented through ontologies.*

Key words: *virtual learning space, BDI agents, computer analysis, Internet of Things*

I. Introduction:

The rapid development of information technology in recent years led to the introduction and use of software in every sphere of life. The electronic learning and the long-distance education take an increasingly significant role. There are different models and approaches to learning nowadays. There are also various methods for evaluating knowledge in the learning process. Different systems for providing eLearning services are being developed, incorporating as many teaching materials and tests for assessment and self-assessment, and the consumers' expectations place higher demands on education systems. Therefore it is necessary to develop intelligent components that provide greater flexibility and proactive behavior by eLearning systems.

Some of the biggest software corporations oriented themselves in this direction and created commercial systems for provision of electronic educational services. These are systems such as Pulse Classroom of Microsoft [1], IBM Learner Portal of IBM [2] and HP Learning Center of HP [3]. There are also open source systems like Moodle [4].

At the same time different standards including various aspects of the educational process emerged. Some of them are Sharable Content Object Reference Model 2004 (SCORM 2004, created by the ADL [5]) and Question and Test Interoperability Standard (QTI 2.1, created by IMS Global Learning Consortium [6]).

For the last several years in our department an infrastructure is being developed as a response to the need for supporting learning using modern information and communication technologies. Its name is Distributed e-Learning Center (DeLC) [7,8,9,10]. At the present, e-Learning center DeLC is changing conceptually, and the dynamic distributed network structure which consists of nodes and relations between them [11], becomes a virtual e-Learning space (VeLSpace). VeLSpace consists of autonomous intelligent components with interactive, reactive and proactive behavior [12,13]. It is entirely based on SCORM 2004 and QTI standards.

II. VeLSpace

The virtual learning space consists of various software components for planning, preparation, organization and delivery of shared, context-dependent and personalized electronic educational services and eLearning content. The basic architecture of the space is shown in Figure 1.

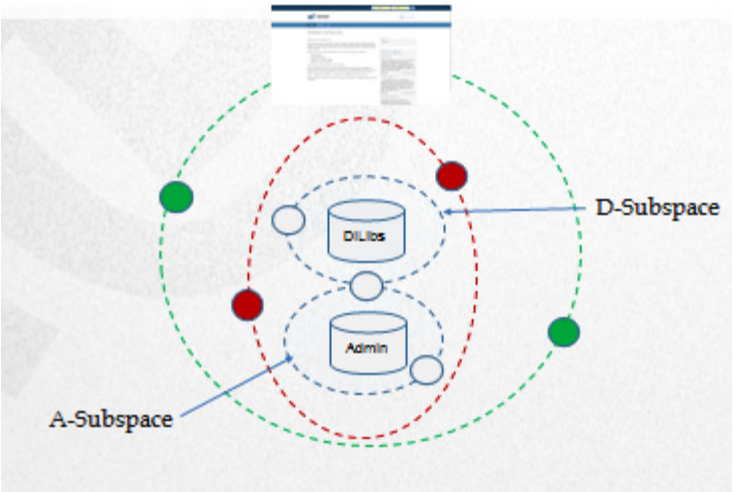

Figure 1. General architecture of a virtual learning space

VeLSpace is a system which is divided into three different logical levels. The first level consists of two subspaces – A-subspace and D- subspace:

➢ D-subspace contains all the learning material that is used in the system, which is a combination of various information resources such as databases, digital libraries and ontologies [13]. The learning material is structured in accordance with SCORM 2004 standard [5].

SCORM 2004 is the standard for learning content structuring. The standard enables learning platforms to provide, seek and share learning content in a standardized way. More specifically, the purpose of SCORM is to provide an opportunity for the creation of educational content with the following features:

- Reusability – content must be independent of the context in which is used;
- Interoperability – the content must be useable in different hardware and software configurations;
- Duration – content must not require changes in case of replacement of the used software system;
- Accessibility – content can be identified and located;
- Support – content can be easily modified or reconfigured;
- Adaptability – content can be adapted according to different individual and organizational needs.

D-subspace also contains all electronic tests, based on QTI 2.1 standard [6]. MS Question & Test Interoperability specification describes a data model for presenting the test data with different question types and for presenting the test results. The standard allows the exchange of these elements - test and result data - between different tools for editing,

banks elements, test design tools, training systems and systems for evaluation. The model data is presented by means of the Unified Modeling Language (UML) in order to facilitate connection to a wide range of tools for data modeling and programming languages.

➢ A-subspace is where many different active components operating in the information environment are located. At the present in A-subspace two components are being developed - Teacher's Notebook and Grade Book. In the future other components could be added, if necessary. In A-subspace operate agents - specialists - these are intelligent server agents whose the main task is to support the implementation of educational services.

The second level is a special level. Here are located guard-agents. They are agents which observe the university through different sensors for humidity, temperature, fire, etc. These agents are activated only in exceptional circumstances. For example, in case of fire, the guard-agents will notify other agents (e.g. the personal assistants) which in turn must take appropriate actions.

The third level is where the personal assistants (PA) are located. These are intelligent agents responsible for the connection between users and VeLSpace. Their purpose is to provide a completely transparent structure of the space to the consumers. The access to VeLSpace will be possible only with appropriate "entry points" implemented like personal assistants. PA can operate on different types of devices, including mobile telephones and tablets [14].

The behavior of autonomous components of VeLSpace is:

- Context-dependent – every component can adapt its behavior depending on its environmental status. According to one of the definitions of context-awareness this is an ability of the computer program to catch differents of its own conditions and those of the surrounding environment [15]. The term „context" refers to any information that can be used to characterize the situation of one identity [16]. „Identity" can be understood as a person, location or object regarded as essential for the interaction between the user and the application.
- Interactive, reactive and proactive – there is a relationship between the users and the space and the components of the space respond to the user requests. Furthermore every component is able to take a personal initiative and to interact with the users or with the similar components. The space is capable to adapt itself to other contextual features such as field of knowledge, discipline, type of user devices etc.

On the other hand the components of VeLSpace are structured in three different levels of abstraction - analytical, semantic and sensory. The analytical level consists of intelligent agents whose main role is, through analysis and self-education, to find and provide adequate solutions in a dynamically changing environment. The semantic level refers to the representation of knowledge in the system that agents use for the outside world and their internal beliefs. The knowledge is presented through ontologies. The sensory level affects the information that enters the system from the physical level, based on a network of sensors, built up within the concept of the Internet of Things [17].

III. Analytical level of VeLSpace

The analytical level has one of the main roles of the VeLSpace. The component establishes a connection between the educational process, the personal safety of students at the university and the personalization of the provided services for each specific user. The main responsibility of the Analytical level is to provide intelligent behavior of the VeLSpace. In this level operate agents-specialists. These are rational agents with limited liability, based on BDI concept.

In artificial intelligence, an intelligent agent (IA) is an autonomous entity (computer program) which observes through sensors and operates upon its environment. It is able to make decisions about its activity in order to achieve its goals. Intelligent agents may also learn and develop their abilities by themselves [18].

The most widely used architecture for developing agents is BDI (Belief – Desire – Intention) [19, 20]. BDI architecture is an abstraction where the Beliefs of an agent represent the information about the environment. The Desires are the objectives set to an agent and the Intentions are the commitments of an agent to achieve certain objectives. These are the plans that are currently being implemented. These types of agents are called rational and have reactive, interactive and proactive behavior.

We are currently developing the Teacher's Notebook (T-NB) system and in particular a module for analyzing electronic test results [21]. T-NB is one of the components of the Analytical level. It is a system whose main purpose is to assist the teachers in their daily activities. Some of the responsibilities of the T-NB are to analyze electronic test results for a particular course and to summarize the information in order to find where the students have difficulties with learning the material, how the educational units are presented and whether the students pass the learning material and the training tests. Finally the system makes conclusions whether the educational process produces satisfactory results. Electronic tests in the system are based on the QTI standard [6].

T-NB is a combination of multiple modules that provide informative, analytical, statistical and other services. Each module can be developed as a multi-agent system of rational agents and works independently with other modules. The Teacher's Notebook is being developed in parallel with the development of Grade Book, Personal Assistant for Professors (PAP) and Personal Assistant for Students (PAS).

Personal Assistant for Professors(PAP) is an application with a high level of customization, whose goal is the direct communication with the teacher. It appears as an interface of the Teacher's Notebook, but with additional features, which are responsible for the customization and personalization of the services provided by T-NB.

Grade Book (GB) is another application of the Analytical level that provides various services to students in order to increase the quality of their education. This system in turn communicates with the Personal Assistant for Students (PAS), whose architecture and first implementation steps can be seen in [22]. T-NB sends the particular student’s results to GB and, if necessary, GB makes further processing and sends the results to PAS.

According to [13] VeLSpace is envisaged to work as an application in Internet of Things. Figure 2 represents a model of the VeLSpace, following the IoT reference architecture which is described in detail in [23]. A high-level IoT reference architecture may include the following layers:

- External Communications – Web/Portal, Dashboard, APIs
- Event Processing and Analytics (including data storage)
- Aggregation / Bus Layer – ESB and Message Broker
- Device Communications
- Devices
- Cross-cutting layers (e.g. Device and Application Management and Identity and Access Management)

All of these components are part of the Event Processing and Analytical Layer and External Communication Layer and build VeLSpace as a large and complex multi-agent system, which intertwines analytical, sensory and semantic abstractions.

1. Analytical level of abstraction:

The core of the analytical level is built by BDI agents, divided into four multi-agent systems. On the one hand these are server agents of PAP and PAS which liaise between the various users and the rest of the space, and on the other hand there are Teacher's Notebook and Grade Book performing a very analytical part and providing individuality and dynamism of the space. Each of these multi-agent systems and constituent-independent agents react to changes in the environment – when a particular event occurs. The information for these events comes from a sensory level of abstraction.

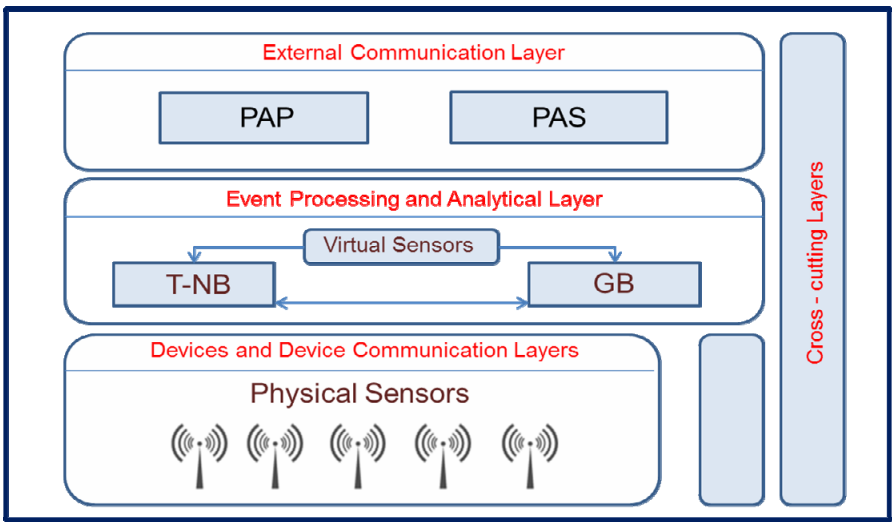

Figure 2. VeLSpace as IoT Application

2. Sensory level of abstraction:

The sensory level consists of various real and virtual sensors.

- virtual sensors – these are the calendar of VeLSPace, schedules of classes and exams, different domain events like lectures, workshops and more.
- real sensors – these are sensors for determining position, smoke, humidity and more. These sensors are related with agents-guards of the VeLSpace.

The analytical level monitors the sensor data and in case of change (respectively an event occurrence) an agent, group of agents or system is triggered. An example of such an event is the end of a particular exam. When the event occurs Teacher's Notebook activates itself in order to analyze the results of the exam [21]. Results of this analysis can activate Grade Book and Personal Assistant for Professor. PAP in turn sends the results to the teacher. Grade Book makes further processing of the results for a particular student and sends information to PAS, which in turn informs the students for their individual achievements and can provide various solutions in order to improve their knowledge.

At the analytical level the analysis process is not unidirectional. The results may lead to a recommendation to students to improve their knowledge of a particular discipline and a recommendation to the teacher to change the learning content in order to improve the understanding of the material by the students. The results of the analysis may also change the scenarios (plans) that agents are working with. For example one of the tasks of PAS is

to inform students when they have to start studying for an exam. On the basis of experience from previous exams and information about student activity in SCORM, that can be individualized for each student or each PAS respectively.

3. Semantic level of abstraction:

The semantic level of abstraction is built of different components providing educational and informative content. GB and T-NB are using these resources to provide optimal solutions for improving the educational process. There are also different ontologies which agents use as internal knowledge.

Ontology (Greek: ὄντος, ontos, „being", „existing" and λογία, logia, „science", „knowledge") is the philosophical discipline that deals with the study and understanding of the current reality and existence as a whole. In computer science the term ontology is used to name the presentation-of-the-world system. Although there are ontologies with general purpose, the widely-practiced approach is to model the world according to the purpose of the application.

The analytical level coordinates the work of all the constituent components and individual agents. As a result we have a multilayer network of relationships between sensors that provide information about occurring events, agents which evaluate events according to their beliefs about the environment and different ontologies and SCORM-based learning content that provide knowledge in the system. The purpose of this network is the continuous improvement of the learning process.

IV. Conclusion

The use of the means of analysis and self-learning in the contemporary software provides different options to improve the systems in various aspects, as well as allowing an increase in the interactivity with the users. Our research in this field aims at the transformation of the virtual educational space into a comprehensive complete system which is able through self-adaptation and customization to provide high-quality intelligent educational services to a wide range of users. Furthermore, intelligent architecture is open and allows adaptation of the space in different areas through its extension. Individual applications can operate as independent subspaces so the virtual space opens up new perspectives like extending the fields of delivered electronic services and expansion of the potential user groups.

ACKNOWLEDGMENT

The authors wish to acknowledge the support of the NPD –Plovdiv University under No. IT15-FMIIT-004 "Research in the domain of innovative ICT oriented towards business and education" of the Scientific Fund of the University of Plovdiv "PaisiiHilendarski".

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