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Analyzing the Results of Electronic Tests Using Intelligent Agents

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Abstract

This article presents the use of intelligent agents in analyzing the results of electronic tests, based on IMS Question & Test Interoperability (QTI) standard. The results of the analysis show the average assessment of the conducted test, sections of the study material and issues of the test that hinders students. The aim is to support the educational process by creating a personal assistant which will be in service to teachers. The assistant will be developed like a multi-agent system of rational agents or such based on BDI (Beliefs, Desires, Intentions) architecture.

Key words: *QTI standard, BDI agents, electronic test.*

INTRODUCTION

Nowadays, there are different models and methods of training. There are also different methods for assessment of the knowledge obtained in the course of training. Electronic education and, respectively, distance learning are becoming increasingly important. Various systems are being developed to provide electronic educational services containing a lot of educational materials and tests for assessment and self-assessment. The rapid development of technologies leads to greater dynamics and interactivity of the provided educational services. Therefore, it is necessary to create

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intelligent components ensuring greater flexibility and proactive behaviour of a system for electronic learning.

At present, the centre for electronic learning DeLC is changing its concepts and is making a transition from a dynamic distributed network structure, consisting of units and relations between them (Doychev, 2013) to a virtual learning environment. This virtual learning environment is intended to operate in the virtual world of the Internet of things and a semantic web. From a contextual viewpoint, the dependence will be maintained by autonomous components located within the internal structure of the environment which act reactively, interactively and proactively and are capable of maintaining different mental levels. Within the virtual learning environment, the assessment of the students' knowledge will be implemented by a system for electronic tests, which has been constructed entirely in accordance with the QTI standard. The QTI standard provides comprehensive and easy-to-analyze information about the results from each conducted test.

The purpose of this article is to present one of these autonomous components – an agent supporting the electronic learning by means of an analysis of the results from the electronic tests, which will be implemented as an agent with BDI architecture.

OVERALL ARCHITECTURE OF THE VIRTUAL LEARNING ENVIRONMENT

The virtual learning environment consists of different software components for planning, preparation, organization and delivery of shareable, contextually-related and personalized electronic educational services and electronic learning content (Orozova *et al.*, 2013). In order to ensure the better structure of the information resources, two standards are used in the virtual learning environment:

1. SCORM 2004 – this is a standard for structuring learning content[2]. SCORM is a set of specifications proposed by ADL. The standard enables the educational platforms to present, search for and exchange learning content in a standardized way. In particular, the purpose of SCORM is to provide an opportunity to create learning content that has the following features:

- Reusability – the content must be independent of the context in which it is used;
- Operational compatibility – the content must function in different hardware and software configurations;

[2] SCORM 2004 4th Edition. Retrieved from http://www.adlnet.gov/scorm/scorm-2004-4th/

- Durability – the content does not require changes to be made in case of changes in the software system working with it;
- Accessibility – the content can be identified and found;
- Maintenance – the content can be easily changed, reconfigured or recoded;
- Adaptability – the content can be adapted based on various individual and organizational needs.

2. QTI 2.1 – this is a standard for structuring electronic tests. The IMS Question Test Interoperability specification describes a model of the data for presenting a question (assessmentItem) and test (assessmentTest) data and their reports with the results[3]. Therefore, the specification allows the exchange of these elements, the test and result data between the tools used for editing, the elements banks, the test constructive tools, the educational systems and the systems for assessment delivery. The data model has been described in an abstract way, using the Unified Modeling Language (UML) in order to facilitate the connection with a wide variety of tools for modelling the data and the programme languages. The standard Extensible Markup Language (XML) has been provided to exchange the data between the connected systems and its use is highly recommended. The IMS QTI specification is intended to support the operational compatibility and innovations by providing particular extensions. These extensions can be used for packing specialized or private data in a way that will allow it to be used along with the elements that can be presented directly. The System for Electronic Testing has been based on the QTI standard.

The virtual learning environment consists of a number of different active components functioning within an information medium, which is a set of various information resources such as data bases, digital libraries and ontologies. These active components are:

- specialist agents – these are server intelligent agents whose main task is to support the execution of educational services(Orozova *et al.*, 2013);
- guarding agents – server agents that will become active only in extreme circumstances. For example, in case of fire they will inform the other agents who will have to take the necessary measures;
- personal assistants – these are intelligent agents that will establish a connection between the users and the virtual learning environment. The main objective is for the structure of the environment to become completely transparent

[3] IMS Question and Test Interoperability Specification. Retrieved from http://www.imsglobal.org/question/

for the users as the connection will be maintained by means of appropriate "entry points" implemented as personal assistants (Orozova *et al.*, 2013). The personal assistants can operate on various types of devices, including mobile ones. The personal assistants can be established as multi-agent systems whose purpose will be to provide support to the users with tasks related to finding out information, planning calendars and managing the educational process. Each personal assistant will have to be personalized for each individual user (Kehayova *et al.*, 2014).

Architecture of the agent

Figure 1 shows examples of results from a conducted examination. The exam test consists of four sections and each section designates a certain part of the educational materials. The average result from the examination is 5 based on the six-point marking system. This mark guarantees a high level of acquisition of the educational material but the graph shows that in section 3 all the students have achieved lower results compared to the other sections. The total mark cannot be used to make substantiated conclusions regarding the acquisition of the material. It is necessary to further analyze the data from each individual test from the conducted examination and also to analyze the activeness of the student during the process of training and his/her interim results.

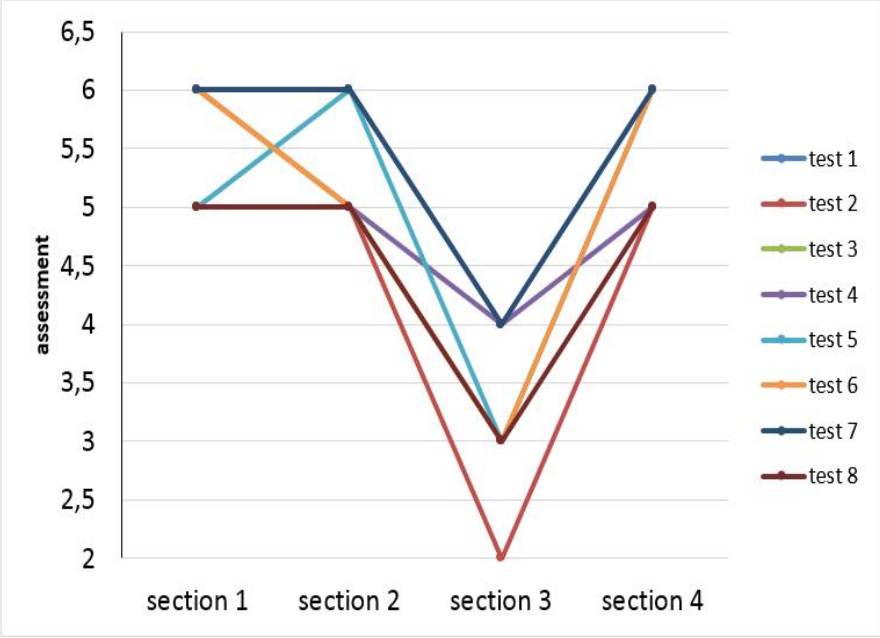

Fig. 1. *Sample results from a conducted test*

The results must be given to the teacher and the student so that they both will be aware of the existing gaps in the acquisition of the educational material. For that purpose, an agent will be created to analyze the results from the system for electronic testing. In accordance with the reference architecture of the virtual environment, this agent will be a specialist agent. The agent will be transparent for both the teachers and the students and will contact them through their personal assistants.

Main Functions of the Agent

We can distinguish between two types of functions depending on to whom agent delivers the information from the analysis and what this information is:

1. To inform the teacher's assistant about:

- the average mark of the student obtained from the conducted examination – submits to the teacher's assistant the average mark from the conducted examination.
- the sections of the educational material that the students find problematic – submits to the teacher's assistant information about the results obtained from the different sections of the examination by ordering these sections in an ascending order depending on the summarized performance of the students. It also provides the respective information about the activeness of the students in the SCORM player.
- those questions of the conducted test that the students find problematic - submits a list of the questions that the students most often mistake.

2. To inform the student's assistant about:

- the relevant mark from the examination – provides the respective student's assistant information about the mark from the analyzed test.
- problematic sections of the educational material – provides the respective student's assistant with information about the results from the various sections of the examination by ordering these sections in an ascending order depending on the summary of the students' performance.

Agent's Environment

Each agent operates in a certain environment for the purpose of achieving its objectives by interacting and influencing its environment with the support of its operators. Figure 2 shows the agent's environment which consists of:

1. The System for electronic testing – it provides the agent with information about the test results. Based on the QTI standard, the result from an electronic test contains information on several levels: a total mark of the entire test; a total mark of each section; the obtained result for each question. The result also contains metadata

providing information about the type of the question, the expected results (number of points – in case of a correct answer), which can be further analyzed if necessary.

2. SCORM player – provides the agent with information about the activeness of the student in the electronic content section, including the percentage of the covered material, the marks from the conducted control tests after each unit, the number of times each test has been done and others.

3. The teacher's assistant – this is the link between the analytical agent and the teacher. The agent sends the teacher's assistant a summarized analysis of the conducted examination and the activeness of the student from the SCORM player. The teacher's assistant then presents in an appropriate way the results from the analysis and if necessary (if the teacher requires it), it will turn to the agent again asking for additional information and analysis.

4. The students' assistants – the agent sends the students' assistants information from the analysis of the respective test, which is the intermediate unit between the students and the analytical agent. The student's assistant will submit the result to the student and if necessary, will offer the student additional educational materials.

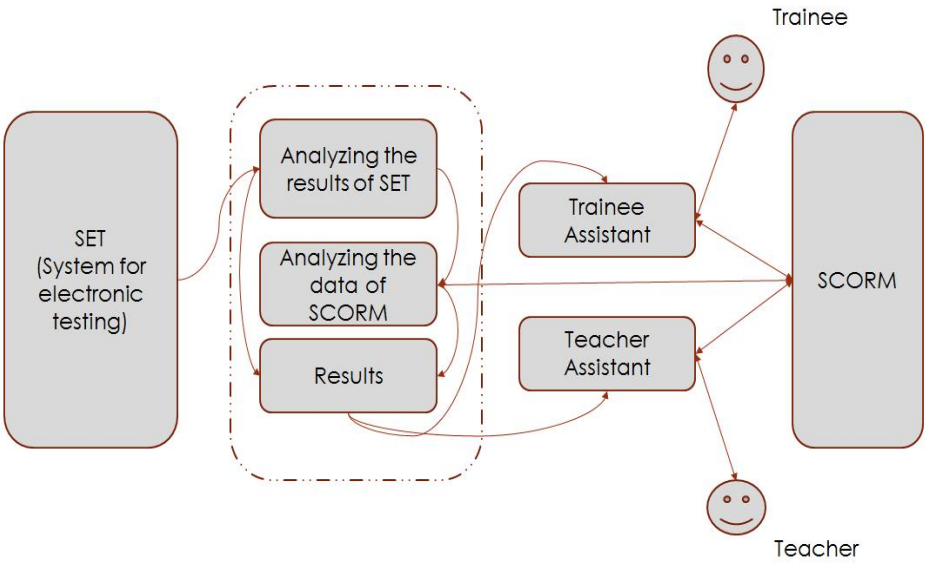

Fig. 2. *Agent's environment*

Agent's Lifecycle

The most widely used architecture for agents is BDI – Belief – Desire – Intention. BDI sets a high level of abstraction, which is extremely important for the design and

implementation of an agent-based system (Rao & Georgeff, 1995). The BDI architecture uses a model of human activity in which:

- The Beliefs of an agent is the information about the environment. It is subject to uncertainties and mistakes.
- The Desires are the objectives set to an agent.
- The Intentions are the commitments of an agent to achieve certain objectives. These are the plans that are currently being implemented.

The concept of the BDI architecture is that an intelligent agent will activate itself upon the occurrence of a certain event and a change in the environment (proactive behaviour), will evaluate the situation, will set an objective and will choose a certain action plan to achieve its objective. If this action plan does not achieve the objective set, the implementation of the next action plan will be initiated, if there is such.

The presence of electronic tests, which have not been analyzed, is the initial belief of the analyzing agent. The desires of the agent are generated depending on the interim results from the analysis. They can be various conditions in which the agent will have to intervene and initiate additional analyses. Depending on the circumstances, one of the desires will be transformed into an objective. The objective determines the respective intention of the agent. After completing the overall analysis of all the tests from the examination, it will submit the results to the teacher's assistant and the student's assistant. They will inform the teacher and the students about the achieved results.

Consequently, the analytical agent, whose internal architecture is based on the BDI concept, will go through several states:

1. Upon the occurrence of a change in the environment – if there is a definite end of the examination and tests to be analyzed, the agent is activated.
2. The agent activates a certain action plan.
3. During the analysis, when receiving certain results, the agent will set different objectives and will activate the respective action plans to achieve them.
4. It informs the student's assistant of the result from the analyzing of the test – upon the completion of the overall analysis of a test, the agent sends the obtained results to the respective student's assistant.
5. It informs the teacher's assistant of the results from the analyzing of the tests – upon the completion of the analysis of all the tests, the agent will send the summarized results to the teacher's assistant.

Implementation

Figure 3 shows a diagram of the agent's activities. Upon the occurrence of an event "the end of the examination", the agent is activated and performs a check in order to establish the existence of tests to be analyzed. If there are such, it takes a test and checks the final mark. If it is not satisfactory (an excellent mark has not been obtained considering the respective marking system), an action plan is selected to analyze the test. On the grounds of this analysis, results are obtained and if these results do not meet the expectations, the agent will proceed with the next action plan until satisfactory results have been achieved.

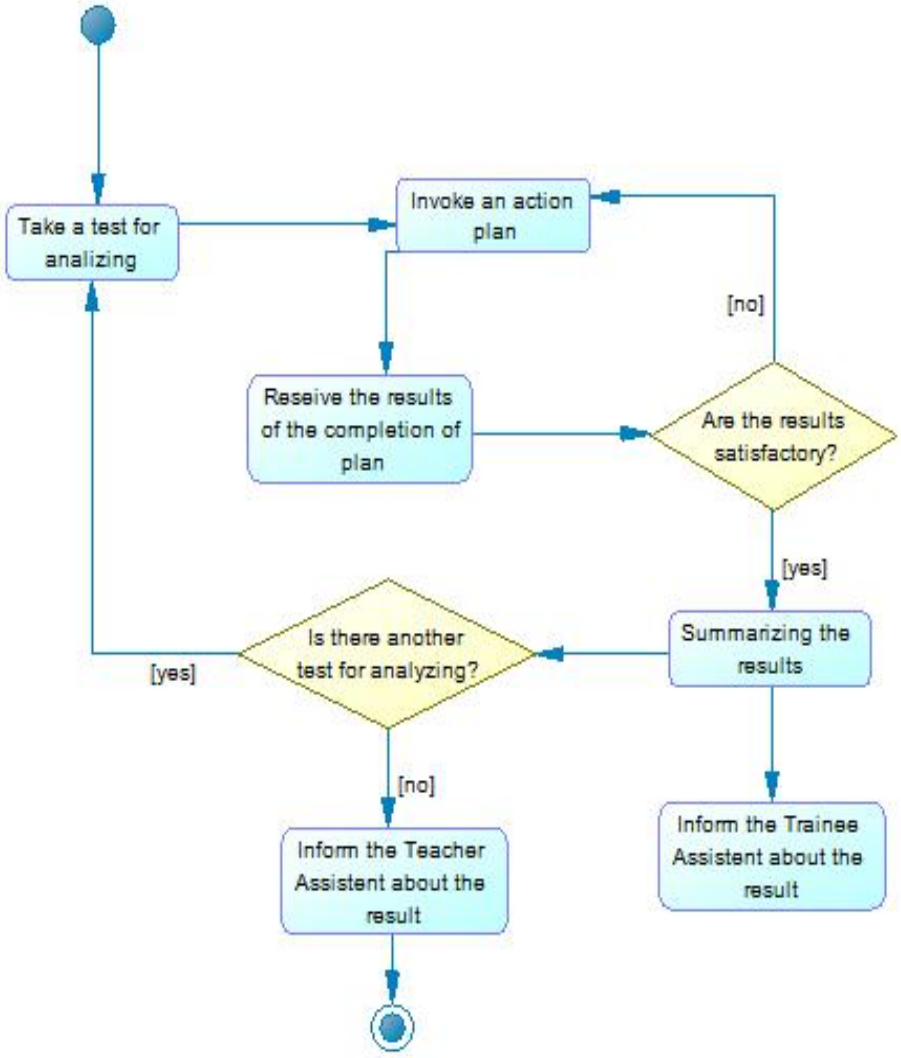

Fig. 3. *Diagram of the agent's activities*

At this stage, several action plans have been developed:

1. An inspection of a test mark – if the mark is excellent, it is not necessary to make any other test analyses.
2. Analyzing the results from a certain section – the agent checks the results from the separate sections of the test by ordering these sections in an ascending order depending on their results.
3. Analyzing the results from the separate questions – a list of the most commonly mistaken questions is made.
4. Analyzing the material covered by the student in the SCORM player – the analysis is made depending on the sections of the test.
5. Analysis of the results from the interim tests in the SCORM player – the analysis is made for the purpose of comparing the results from the System for electronic testing and the SCORM player.

Upon the completion of the test analysis, the agent proceeds with the summary of the results and sends the results from the analysis of this test to the student's assistant of the respective student. Then, the agent checks if there are still tests to be analyzed – if there are any, the action will be repeated. Otherwise, the agent will proceed with the sending of the summarized results from the analysis of all tests to the teacher's assistant.

As a result:

- the student receives detailed information about his/her performance at the examination as well as the performance throughout the entire course of training.
- the student's assistant receives sufficient information so as to be able to take measures for improving his/her knowledge, if necessary.
- the teacher receives detailed information to analyze his/her work and the motivation of the students.
- the teacher's assistant receives sufficient information so as to be able to offer the teacher concrete steps to improve the process of training.

The technology selected to implement the agent is JADEX. This is a project developed by the Distributed Systems and Information Systems Group at the University of Hamburg. The platform allows the programming of intelligent software agents in XML and Java which can be located on various types of middleware such as JADEX[4]. The project has an open code. The implementation of the JADEX agents is based on the

[4] Jadex Active Components. Retrieved from https://www.activecomponents.org/bin/view/About/New+Home

BDI architecture. These agents are capable of acting purposefully with the help of its beliefs, desires and intentions.

In addition to these cognitive means, which are particularly useful for doing complex tasks, JADEX also provides simple reactive micro agents that are similar to active objects and are very effective considering the low consumption of resources[5]. The platform allows the mixing of agents with different types of architecture into one and the same application. When creating the agent, different annotations are used to define the beliefs, the desires, the intentions and the plans of the agent.

In conclusion, we can use the example illustrated in Figure 1 to present a possible sequence of actions that the agent will perform for a lifecycle:

1. Upon the occurrence of the event called "the end of the examination", the agent is activated and checks the System for electronic testing for the presence of test results.
2. Checks the total mark of the examination → it is not excellent (5 based on the six-point marking system) and subsequently generates an objective: "To find the reason for the unsatisfactory result".
3. The purpose is to initiate an action plan to analyze each test separately, which in its turn will initiate a plan for analyzing the tests in sections. After the analysis, the results show that in section 3 all the results are low. It generates an objective "To find the reason for the poor acquisition of the material contained in the respective section".
4. Another plan is activated to analyze the material covered by the students in the SCORM player – this analysis is performed depending on the sections of the test.

a) The results show that the student has not covered the entire content. It generates an objective "To inform the student". The agent sends a message to the student's assistant, which then offers the student to read the learning content.

b) The student has covered the entire material → a plan for analyzing the results from the interim tests is activated. These steps will be repeated until all the available tests have been analyzed. When the results are summarized, the objective "To inform the teacher" will be generated.

5. The agent sends a message to the teacher's assistant with all the information from the analysis, which then presents it to the teacher in a comprehensible way and turns his/her attention to the sections with the lowest mark.

[5] *Ibid.*

6. The agent is in a position waiting for a new event, which will activate it again (a new change in the environment).

CONCLUSION

The use of intelligent agents for analyzing the test results gives us great opportunities for improving the quality of the offered electronic educational services. Using the QTI standard and SCORM 2004, we can trace in details the sections where the students make most mistakes and have greatest difficulties in acquiring the educational material. This provides important information to the teacher, who can then change the content of the lectures so as to make it easier to understand and more comprehensible.

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