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Development of Educational Web-Based Simulator and its Evaluation

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Abstract: This paper discusses the development of the educational simulator for All Armenian Internet University (HHH University) and Faculty of Organizational Sciences University of Maribor Slovenia. In the developed simulator, lecturers can set information related to educational fields and students can bid and examine the educational fields with lecturers. The developed application program is composed of the physical three levels where the middle level is logically divided into two kinds of application programs. The divided application programs are interconnected by using the Web-service based on HTTP (Hyper Text Transfer Protocol) which makes the distributed computing technology possible.

1. INTRODUCTION

Deregulation of the distance education is occurring throughout the world. Some competitive education markets have been established, and others are under design (Mkrttchian *et*. *al*. 2002)

Recently, because of limited experience and knowledge of the competitive education market, problems related to market operation can not be avoided. To resolve the market-related problems, market simulation approaches have been frequently used (Kljajić *et*. *al*. 2004; Mkrttchian *et*. *al*. 2002).

A well constructed market simulator may help students foresee the effect of new market structures or rules before they are actually implemented (Mkrttchian and Petrosyan, 2004a, 2004b; Mkrttchian and Yelchyan, 2004a, 2004b). They may also want to use a market simulator to develop and test their bidding strategies to maximize their profit. Thus, the market simulator has become an important tool in understanding the competitive electricity energy market (Golob *et al*., 2001).

In a competitive education market, the methodology will be the maximization of the total profit - the global social welfare - of market participants, compared to the existing monopoly market that pursues the methodology minimizing the study cost. Therefore, for a stabilized operation of the education system in a competitive market, students are needed in the education market. In the academic world and related organizations demand for education and desired increase of learning efficiency emphasizes the importance of the distance education addressing market theories. Here several methodologies and tools are created and released.

The educational market simulator is able of simulationg the distribution process and it is designed on an object oriented programming paradigm (OOP) so it is convenient to add new modules. Also, to let many participants bid at the same time, it is developed as a web-based application on a basis of TCP/IP. This paper discusses principle and experience of the educational simulator for All Armenian Internet University and Faculty of Organizational Sciences University of Maribor Slovenia. Although students have learned different context problem their common approach was the multicritera optimization trough simulation.

2. SIMULATION METHOLOGY PROBLEMS

The role of the simulation methodology in the decision assessment of complex systems is constantly increasing. Human knowledge, the simulation model and decision methodology combined in an integral information system offers a new standard of quality in management problem solving.

The simulation model is used as an explanatory tool for a better understanding of the decision process and/or for learning processes in enterprises and in schools. An extensive study on using the simulation methods in enterprises can be found in Mkrttchian and Kljajic (2004).

Currently the most intensive research efforts are concentrated on a combination of simulation methods and systems approach for different problems solving (Kljajić and Farr, 2007; Lazanski and Kljajić, 2006; Dijk et al., 1996; Hall, 1996). Although there is a considerable amount of work devoted to simulation methodology, there is a lack of its application in practice; especially in small- and mid-sized companies. The reason lies not in the methodology itself; the real reason is rather in the problems of methodology transfer to enterprises and the subjective nature of decision-making. However, there are several problems, objective and subjective, which are the reason why this well-established methodology is not used more frequently.

One of the objective problems is model validation, which is of primary importance for any model-based methodology. The validity of the model of a given problem is related to the soundness of the results and its transparency for users. According to Coyle (Coyle, 1996), a valid model is one that is well-suited to a purpose and soundly constructed. According to Forrester (Forrester, 1968), it is pointless to discuss validation without reference to a particular situation. There is no way to prove the usefulness of the model in advance of complex systems such as enterprises (Forrester, 1994). Coyle and Exelby (2000) stressed that there is no such thing as absolute validity – only a degree of confidence, which becomes greater as more and more tests are performed. According to methodology, a valid model is an objective representation of a real system. According to the system approach paradigm, Barlas and Carpenter (1990) have suggested that model validation cannot be completely objective, quantitative and formal. Since validity means usefulness with respect to a purpose, model validation must also have subjective, informal and qualitative components.

The second problem, the subjective one, is related to the transparency of the methodology and data presentation (Kahneman, and A. Tversky, 1979), preferences of the decision-maker to use a certain decision style and poor communication between methodologist and user. The simulation methodology is a paradigm of problem solving where the personal experiences of users as well as their organizational culture play an important role (e.g., in transition countries: market economy, ownership, etc.). Some of the encountered problems could be overcome with a carefully prepared modeling methodology and selection of a proper simulation package as well as a readiness of the user to explore simulation opportunities. Such is the simulation with animation, which demonstrates the operations of the modeled system and helps participants to recognize the specifics of the presented system.

This article describes experience in teaching of modeling and simulation course for students of school for organizational sciences (Kljajić et. al., 2007). Our course consists of continues simulation based on systems dynamics and discreet event simulation (DES). The course is in the 3rd year and students have by then already taken courses from mathematics, statistics, theory of systems, as well as organizational and economic courses. The final grade of the course consists of students' project and written exam. In this paper we will discus method of teaching SD. Of course by definition simulation represents experimentation on computer model. It is typical virtual reality methodology which can alienate student from real management problem. In order to attract students to learn and understand many authors had developed some kind of business simulator. One of most popular is the bear game simulator developed at MIT (Sterman, 1994). Therefore, we have also developed the simulation model in order to explicate the usefulness of the simulation in solving management problems. Students had to take part in an experiment where they had to solve the managerial decision problem supported by the simulation model. They were assigned to work under the three experimental conditions. Experimental results were than analyzed and discussed in the students' projects. Students' contribution was rewarded as a part of their final grade. Also, students were kept motivated all along the course, by special rewards for their in-class participation. After the experiment students had to fill in the opinion-questionnaire. The results show that management students, taking the course of Modeling and Simulation, thought that application of the simulation model do contributes to a greater understanding of the problem, faster solution finding and greater participants' confidence. All participants agree that clear presentation of the problem motivates participants to find the solution. However, only the participants supported by simulation model and without group interaction agreed that application of simulator helped to understanding of the problem. Participants who worked with simulator and group information feedback agreed that simulation model together with application of group interaction contributed to higher criteria function determination.

3. SIMULATOR MODEL

The model developed by the SD method, which was used in the experiment, is shown in Fig. 1. The model described in (Škraba *et al.,* 2003) consists of: production; workforce and marketing segments, which are well known in literature (Forrester 1973; Hines 1996; Sterman 2000). It was stated that product price (r_1) positively influences income. However, as prices increase, demand decreases below the level it would otherwise have been. Therefore, the proper pricing that customers would accept can be determined. If marketing costs (r_3) increase, demand increases above what it would have been as a result of marketing campaigns. The production system must provide the proper inventory level to cover the demand, which is achieved with the proper determination of the desired inventory value (r_4). Surplus inventory creates unwanted costs due to warehousing; therefore, these costs have to be considered. The number of workers employed is dependent on the production volume and workforce productivity, which is stimulated through salaries (r_2). Proper stimulation should provide reasonable productivity. Participants had the task of promoting a product, which had a one-year life cycle, on the market. They had to find the proper values of parameters r_i defined in the interval $r_{min} \leq r_i \leq r_{max}$. The model was prepared in the form of a business simulator (Škraba *et al*., 2007). The participants changed the parameter values via a user interface, which incorporated sliders and input fields for adjusting the values. After setting the parameters in the control panel, the simulation could be processed. The end time of simulation was set to twelve months. Output was shown on graphs representing the dynamic response of the system and in the form of a table where numerical values could be observed. Each participant had no limitations of simulation runs, which he/she intended to, execute within the time frame of the experiment. The parameter values for each simulation run were set only once, at the start of the simulation. It was assumed that the business plan was made for one year ahead. The criteria function (CF) was stated as the sum of several ratios, which were easily understood and known to the participants. It was determined that Capital Return Ratio (CRR) and Overall Effectiveness Ratio (OER) should be maximized at minimal Workforce and Inventory costs determined by a Workforce Effectiveness Ratio (WER) and Inventory / Income Ratio (IIR). The simulator enabled simultaneous observation of the system response for all variables stated by the criteria function during the experiment.

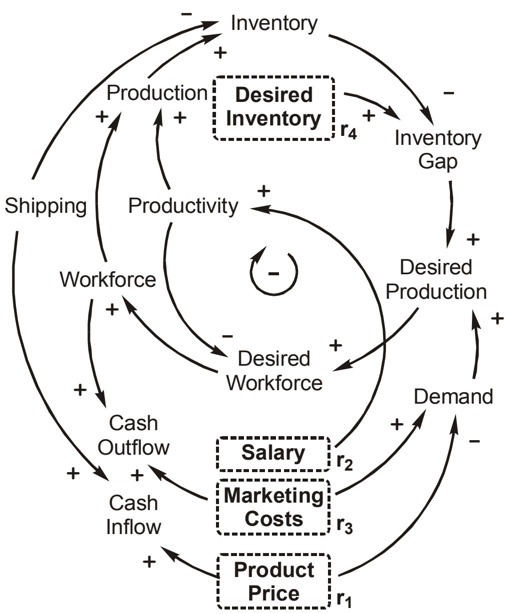

Fig. 1. Causal Loop Diagram of Production Model

4. SIMULATOR ARCHITECTURE

A straightforward way to create a distance learning course is to build a web site consisting of dozens of web pages written in Hypertext Markup Language (HTML). However, this is not an adequate solution for a course like Modeling and Optimization due to two reasons: course material is mathematically oriented and interactive demos are an essential part of the course (Mkrttchian and Petrosyan, 2004b).

Only very simple mathematical equations can be written using HTML. More complex equations are often included as images. However, this is not a flexible solution if the number of equations is large.
Another solution would have been to use Mathematical Markup Language (MathML), which is intended to facilitate the use of mathematical and scientific content on the Web. Unfortunately, MathML is still not a mature technology. This means, for example, that browsers can not render MathML without special plug-ins.

Our solution was to use Adobe Portable Document Format (PDF) when a page includes complex mathematical equations. PDF files can be shared, viewed, navigated, and printed by anyone with free Adobe Acrobat Reader software. PDF is probably the most widely used format for mathematically oriented content on the Web.

The web pages of the course are partly in HTML, and partly in PDF format. The remaining problem is that these are both formats for static web content.
Dynamic content in the form of interactive demos is important for the course. One can add dynamic content to web pages using languages like Perl, Java, and JavaScript. However, this can take a lot of effort because those are more or less general-purpose languages that do not specifically support modeling and simulation applications.
Recently, solutions have been proposed that make it possible to run Matlab and Simulink applications from web pages (Hassan et al., 1999; Mathworks, 2000c). Matlab and Simulink are widely used and well suited for modelling and simulation.
The interactive demos of the Modeling and Simulation course are implemented using Matlab, Simulink and Matlab Web Server software. System architecture is depicted on Fig. 2. Simulink and Matlab Web Server software run on a server. Several copies of Matlab can run concurrently. Students communicate with the server through their web browsers. Students do not need any special software besides a web browser. In the developed simulator, lecturers set information related to educational fields and students can bid and examine the educational fields with lecturers.

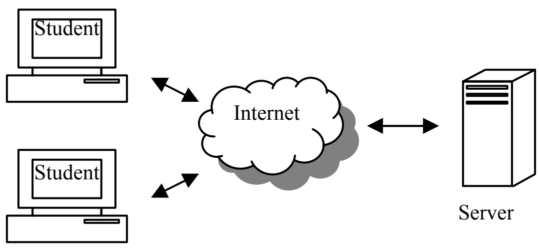

Fig. 2. Simulator architecture

Interactive demos typically consist of two HTML documents and one Matlab M-file. The first HTML document is for collecting data from a user. The data is collected using HTML forms. Then the data is sending to the server, where it is extracted from HTML documents and transferred to a Matlab program (M-file), which performs necessary numerical computations. An HTML document containing the results is generated by the Matlab Web Server. This document can contain both text and images. The document is send to the client and displayed in its web browser. Fig. 2 shows how data is moved between the students and the server.

5. STUDENT FEEDBACK

During the development of the material feedback was collected from students who had taken the course earlier.

That was a good way to find out the main problems and see how different students understand various things in the material. The feedback from testers was very good and they considered the web site to be easy to use. They liked the idea that users can independently choose what they want to do and in which order. Ease of navigation is also considered very important, and this emphasizes the logical structure of the site.
The material was in actual use for the first time during the autumn semester of 2004. Feedback from the students was mainly positive, although some technical problems were encountered. Matlab Web Server occasionally stopped working, which meant that at these times the interactive demos were out of use. This was, naturally, a cause of frustration for some students, although the rest of the material was still available. A summary from the student feedback is that it is a good idea to make some material available on the web, but it is, at least at the moment, impossible to totally replace traditional teaching, like lectures and exercise, with distance learning material.

On the other hand, senior graduate students from the University of Maribor participated in the business simulator experiment in order to meet the requirements of their regular syllabus. The students were randomly assigned to eight groups with 14 to 15 subjects, who were then assigned to work at one of the four experimental conditions: a_1, a_2, a_3, and a_4. The subjects who participated in the experiment became accustomed to the business management role facing the stated goal objective, which was in our case presented in the form of criteria function. The presentation of the decision problem was prepared in the form of uniform 11-minute video presentation, which differ only in the explanation of experimental condition at the end of each video presentation. The problem, the task and the business model were explained. The structure of the considered system was presented and the main parameters of the model were explained. The evaluation criteria for the business strategies were also considered. The work with the simulator was thoroughly explained in the video. A printed version of a problem description was provided for each subject as well. The participating subjects were familiar with SD simulators; therefore, working with the simulator was not a technical problem. Subjects were awarded by a bonus grade for their participation in the experiment.
Participant's opinions about their involvement in the experiment were solicited by questionnaires. Participants filled in the questionnaires via a web application. Questions were posed in a form of a statement and agreement to the statement were measured on a 7-point Likert type scale, where 1 represents very weak agreement, 4 a neutral opinion, and 7 perfect agreement with the statement. From the opinion questionnaires, we can make some general observations:
a) 99% of the participants agreed on the general quality of the experiment.
b) 84% of all participants agreed that the use of simulator contributed to understanding of the problem.
c) 63% of all participants agreed that they were motivated for solving problem.
d) 88% of all participants agreed that they benefited from participating in the experiment.
e) 92% of all participants agreed that use of the simulator contributed to better decision-making.
These are the across group averages and represent the overall agreement to the statements. We can say that, in general, students were satisfied with the experiment as a method of teaching and the use of simulation in decision support.

6. CONCLUSIONS

This paper discusses the development of the educational simulator for the electricity spot market in Korea and business simulator on the school of organizational Sciences University of Maribor. In the developed simulator, lecturers can set information related with market and market entities and students can bid and examine the market with lecturers.
The interaction between lecturers and users can be much enhanced via the web-based programs which result in the student's learning effectiveness on an electricity spot market. In this developed simulator, the system and database are developed efficiently to treat the plenty of the data and a lot unexpected users' access.
Unlike the existing educational simulators, the one we developed in this paper has a strong point by allowing the students to have an opportunity of being an owner of an electricity utility and can make some bidding strategies just like in a real market. That will make the students know how the real electricity market runs and can experience the process how market participants make their revenues. Evidence of students' grade from course of modeling and simulation, where students took part in simulation experiment were high (First attempt: average grade=7.08, Std. Deviation=1.78; n=118) and student was motivated to visit lectures and seminars. The course where experiment was omitted, the attendance of lectures was rather poor (attendance is not obligatory) and the grade was lower (First attempt: average grade=3.38, Std. Deviation=1.96; n=91).

So, in the future, use of realistic yet sufficiently simple business models is essential, if one wishes to close the gap between business processes and the role of modeling and simulation.

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