Virtual laboratory as a tool to increace student's research work

Ivan Pankov, Evelina Karaminkova

INTRODUCTION

The use of virtual educational research laboratories is necessitated for the following reasons:

- The classical laboratories are equipped with expensive apparatuses and require highly skilled research teams, and that leads to their restricted use in technical colleges and high schools.
- The substantial financial investment, which is not readily available to professional education, reflects also on the tutorial documentation (plans and programs), corresponding to the technique and the technologies of the obsolete material equipment.

The use of a standard educational laboratory could be regarded as a sequence of the following stages:

- Precursory preparation of apparatuses and facilities for the experiment;
- Preparation of a schedule for their use by educational groups and control of the access for trainees;
- Analyzing intercourse between tutor and trainee, processing of obtained results and keeping records of them.

STRUCTURE OF THE VIRTUAL LABORATORY

The use of a virtual laboratory is characterized by similar stages. For this purpose, the following modules are developed:

- Software and interfaces for remote access to real apparatuses and facilities for input and output information of the experiment;
- Software programs for preliminary preparation of input data;
- Software programs for processing, analyzing, visual presentation of the obtained results;
- Software programs for control of the access to laboratory resources;
- Libraries of software applications and methodological materials;

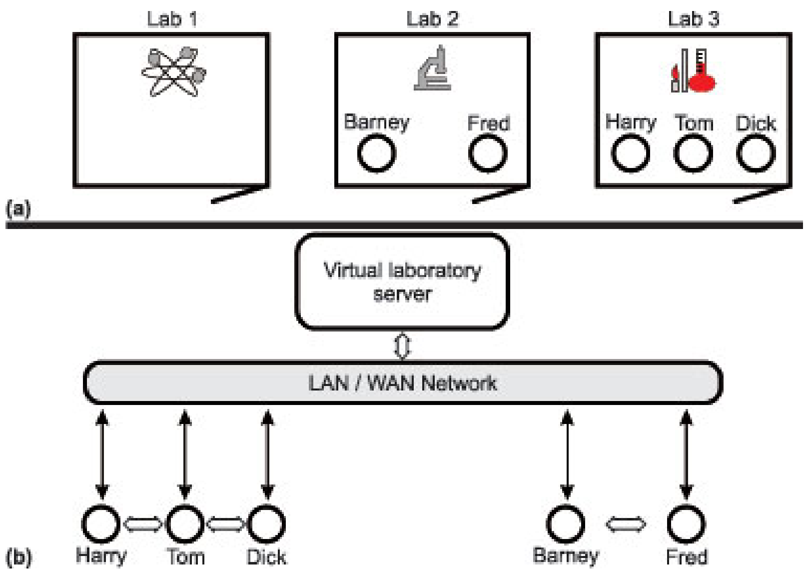


Figure 1

The structural diagram of a virtual laboratory is illustrated on Fig.1.

The illustration shows three classrooms, in which a particular experiment is performed.

The students have access to them and can work together on the particular task.

In this case the trainees are linked via Internet with the server of the virtual laboratory, where various parts of the experiments are performed. Each of the participants in the laboratory can, by using special interfaces, send data or test programs and see their actual application in the experiment. Applications, called simulators, interpreting the real technical equipment, will be developed.

Another aspect that could be reviewed is the organizing of a collection of applications, simulating separate stages of the experiment.

The basic calculation in the experiment is performed on the server, where by means of user application, presenting the view of the laboratory, is monitored the work on the experiment and the interaction between separate trainees, who could use tutorials, published on the server.

FUNCTIONS – ACCESS MANAGEMENT

Various groups of users, such as school administrators, teachers and students, have access to one and the same virtual laboratory. Teachers monitor the status and the performance of the experiments. Students are organized in small groups and study the experiment together. The detailed customer information is stored in a database, which is used to identify the different users. Access control protects the virtual laboratory from unauthorized persons.

COMMUNICATION AND COLLABORATION

In the virtual laboratory, small groups of trainees jointly study and research a variety of objects and materials. The trainees are able to discuss problems and possible solutions via Internet by means of video, audio communication or can use the so-called 'chat-rooms'. The work group analyses the measured data and at the same time each user operation is reported to the associates.

MANAGEMENT OF THE PREPARATION FOR AND CONDUCTANCE OF THE EXPERIMENTS

The well-known basic characteristics, physical parameters and abnormal conditions of a particular experiment after its completion in a virtual laboratory, should lay down the basis for integration of a new tool in the user's interface.

The hierarchy of the user interface enables to propose various types of information services such as:

- materials and guidelines for introduction of the theoretical essence of the experiment;
- user interface for preparation of data for the experiment;
- user interface for processing, analyzing, visualization and storage of the obtained results;
- methodological materials and guidelines for the tutor.

The implementation of the virtual experiment includes a complex of information packages about the particular technical field and systems, and the interconnections between users. In the report we are outlining the basic structure of an object-orientated model of interactive physical experiment, including control and communication channels.

The structure uses collections of objects, created to be of use in the virtual experiments. The characteristics of this structure are developed to cover the following problems:

The objects used are subject of succession, which makes them easy to use in various types of experiments.

Cooperative use of the experiment.

Maintenance at starting, tracing and managing the experiment.

BASIC ARCHITECTONICS OF A VIRTUAL LABORATORY

The basic architectonics of a virtual laboratory is the Client-Server Technology shown on Figure 2.

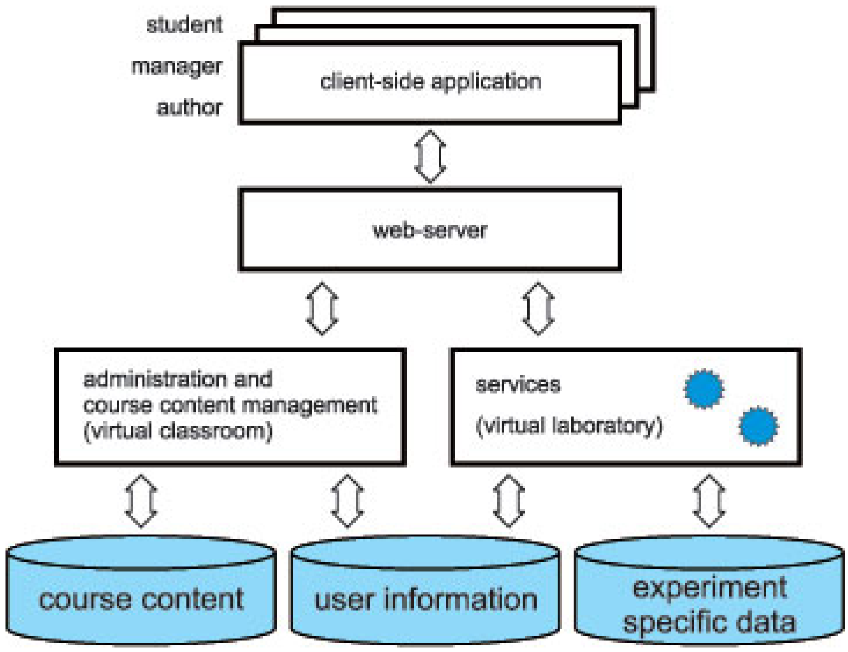


Figure 2

The server consists of two subsystems – a virtual classroom and a virtual laboratory, which share and are responsible for three types of data – course contents, user information, and data of the experiment.

The user has access to the virtual laboratory by means of a standard browser. Each user has at least three different access ways:

- by means of an author's tutorial program, which is stored in the database;
- by means of user and group profiles;
- by means of trainees participation in the experiment.

The dialogue part of the laboratory (e.g. the experiment) contains the simulation and service options of the interface.

Plug in software components (such as java servlets) require a flexible and structure-orientated system. The information contained in the course and the user administration (access, notes, etc.) is a part of the contents management system, which controls the access to the basic database. The additional services (search and other recommended services) could be implemented by means of modules in the information management system. In the users database must be stored their rights of access and the level of their knowledge. The specific information of the experiment is stored in the experiment database.

It is performed at physical level, where the simulation component represents the effect of the experiment. The physical level contains also a simulator and a simulation control component, which are fully separate.

The communication and the collaboration tools are located at the second layer, where a command parser controls and manages the orders of various users and controls the access to the user database.

The link of users with the communication level is achieved by means of XML. Data fork gets information of the users, which are connected to the experiment database. This sets user channels and executes communication channels between users.

PROBLEMS

In the process of work we found some problems:

- There are a lot of fields of sciences and it is necessary to develop a different unify special protocol und application for each experiment. That supposed a large number of people which will create, develop and work in one science's experiment.
- Also we must narrow the connections between Universities and Bulgarian Academic of Sciences in our country. The students need a more practical experience and they are going to have a strong background and will be ready for the real work.

THE VIRTUAL LABORATORY IN THE GLOBAL PRACTICE

This type of laboratory provides opportunities for professional and practical education. The expensive equipment and apparatuses that build the experimental stage in a particular standard laboratory will be used by many other research teams, and also for training of future technical staff.

Virtual laboratories of various subjects could be implemented in universities, technical schools and colleges. The development of TPP and NPP management simulators will provide an opportunity for training of new personnel or for preparing university students to solve particular tasks.

We could see examples about education in nanoscience :

- **An instrument of high complexity**

An atomic force microscope (AFM) is an apparatus of high complexity designed to get maximum resolution and accuracy in scanned surfaces.The individual build scientific microscopes used in research are not designed to introduce nano technology to students. Operating such an instrument needs a lot of know-how and a lot of very specific experience. It can be compared to learning to fly an airplane. This might be the reason, why nanoscience is not yet educated although a lot of universities do a comprehensive research in this field.

- **How to teach nanoscience?**

We took a look at the well-experienced team of educators in the field of very complex instruments: The Swiss Aviation Training Center (SAT).

Swiss International Airlines uses a concept of three steps to introduce their students to a state of the art airplane. First they are trained in the basic things e.g. aerodynamics or the language used in flight. For that purpose SAT uses computer based training methods and classical class room lessons.

In a second step skills are trained interactively using computers. The use of the navigation system is taught in a especially implemented simulator software. This is done to reduce cost of education, because time in a full flight simulator is very expensive and only used for specific topics like the handling of malfunctions and emergency situations.

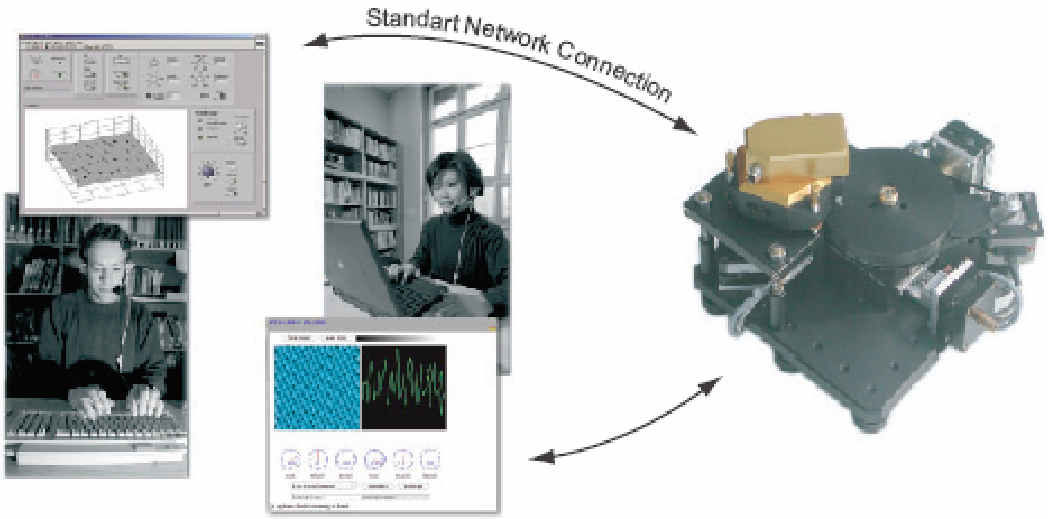
We tried to use the same concept for our instrument to achieve the maximum efficiency in our courses.

- **Nano-World the e-learning solution in nanoscience** (example from a Swiss virtual campus project)

Nano-World is a learning solution that allows students to get information about nano technology in addition to classical lessons in physics. Students using our platform are able to perform various real nanoscientific experiments in a university or high school environment. Our learning concept is kept closely to the one, used by Swiss International Airlines. Students are first guided through basic lessons where they get theoretical information about nano instruments and the measurement process. In a second package skills are trained on interactive simulators.

Finally the students are ready to do real experiments and to measure real surfaces.

The last stage in virtual e-learning environment is accomplished by a microscope which we designed fully remote controllable. Students can work on real experiments from multiple clients anywhere, anytime collaboratively. One single remote, multi-accessible apparatus keeps the time of support at a minimum level and offers a maximum of usability. In addition our remote atomic force microscope (RAFM) features an automatic positioning robotic to allow students to choose from different samples automatically. This means various experiments can be done using the same instrument without the need of an operator.

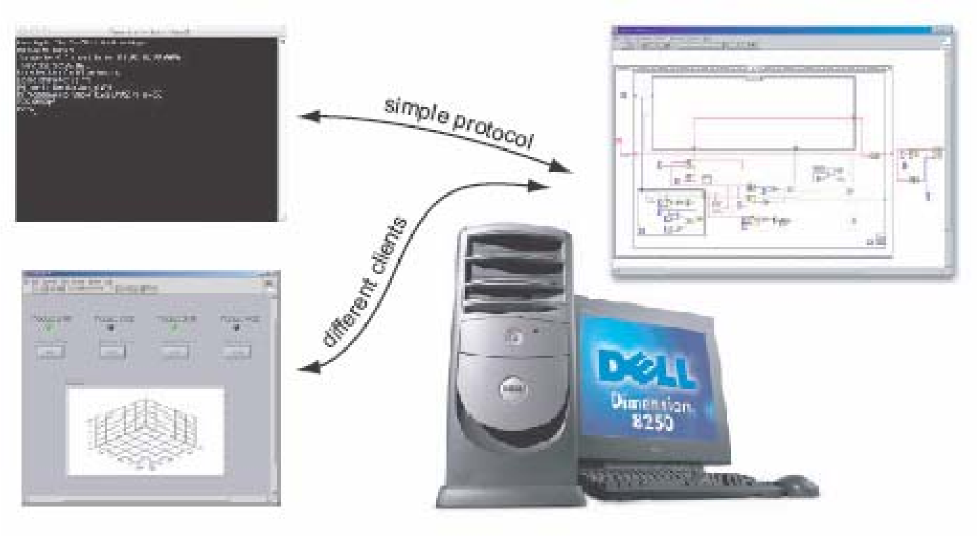


The RAFM is designed for the use in an e-learning environment and fully remote controlable. A server manages the connection to the various clients. Because of the easy protocol the clients can have customized skins. This means the look and feel can be adjusted to the actual user and the specific application. (Examples from

The RAFM represents a state of the art system using modern internet technologies and a robust, accurate and easy to handle robotics.

The instrument is controlled by a LabViewTM server that manages the robotics as well as the remote accessibility. LabViewTM is an industry standard graphical programming environment. The implemented server supports a simple and open command line language. This keeps the accessibility very flexible. For the use as a e-learning tool the graphical user interface (GUI) can be customized to fit the needs of students with various knowledge levels. This feature is interesting for the industrial user as well.

The GUI can be adjusted to a specific application or experiment within minutes.



(top left) The fundamental protocol is based on a command language. Every operation like changing the sample or starting a scan can be executed using the corresponding command line.(bottom left) A LabView user interface as it could be used in a industrial application. Every element of the front panel can be customized and the executing command can be defined autonomously. (right) The microscope server runs multiple LabView applications for the networkconnection and the hardware control.

CONCLUSIONS AND FUTURE WORK

The virtual laboratory aims at uniting a group of students or already trained staff for the purpose of solving particular tasks. In the process of work we are proposing following solutions:

- As a first step- collections of libraries with applications for modeling and simulation systems (like MATLAB, Lab View, DERIVE etc) in different subjects to be spreadsheet between universities;
- Developing a interface for management and control де the research apparatuses (lasers, telescopes, robots EST.);
- Developing unify special protocols for data transmitting to help the communications between users of virtual laboratory via Internet ;

Researchers expect an impact for different fields like chemistry, medicine and information technology. New synthetic materials for textiles, construction and engineering will be developed with astonishing properties. Tiny robots might be used as sensors within a human body and even might help surgeons in difficult operations. Maybe quantum or DNA computers will be developed with computing capacities of thousands of today's PCs on one single chip.

REFERENCES

[1] O. Abou Khaled, M. C. Pettenati, Y. A. Rwkik, and C. Vanoirbeek. MEDIT: Structuring Documents for Web Based Teaching. CIDE, 1998.
[2] F. Fl¨uckiger and L. M¨uller. CLASSROOM 2000 - Towards Management of Life Long Learning using New Learning Technologies. proceedings of SEFI annual conference, Espoo, Finland, pages 1–3, 1998.
[3] P. Joye. TELELABORATORY: A Generic Approach to Distribute Protocol Measurements. proceedings to ICTE conference, 28. March, Edinburgh, U. K.,1999.
[4]. Trajkovic. Virtual Laboratory. Proceedings of the IASTED International Conference APPLIED INFORMATICS, page 596, 2001 Innsbruck, Austria.
[5]Virtual Physics Laboratory. http://www.phy.ntnu.edu.tw/java/index.html.
[6]E. Ong, A. Razdan, A. Garcia, V. Pizziconi, B. Ramakrishna, and W. S.

Glaunsinger. Interactive nano-visualization of materials over the internet. Journal of Chemical Education, 77:1114–1115, 2000.
[7] Network Virtual Laboratory. www.vvl.de.
[8] Red rover goes to mars. www.planetary.org.
[9] E. Gamma, R. Helm, R. Johnson, and J. Vlisides. Design Patterns: Elements of Reusable Object-Oriented Software. Addison-Wesley, Reading, MA, 1994.
[10] Zope, a framework for building web applications. www.zope.org.

ABOUT THE AUTHORS

Assoc. Prof. Ivan Pankov, PhD, Department of Programming and Computer Technology, Technical University of Sofia
Phone: +359 888 80 19 98,
E-mail: panko@tu-sofia.bg panko@bgcatalog.com

Eng. Evelina Karaminkova, post graduate student, Department of Programming and Computer Technology, Technical University of Sofia,
Phone: +359 899 94 49 11
E-mail: evelina_h_h@hotmail.com