Remote Laboratory Development for E-Learning in the Field of Electronic Measurement

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Abstract – **The progress of the information and telecommunication technologies, based on multimedia and Internet, opened up a new field in the area of measurement and education. This paper presents the model of a remote measurement laboratory, which provides students of electronic measurement course to access measuring system via Internet and directly carry out real experiments, without their physical presence.**

Keywords – **Remote measurement laboratory, remote experiments, Internet, virtual instrument.**

I. INTRODUCTION

Nowadays, in electronic measurement teaching the main problems are increase in student numbers and in instrument cost and complexity, on one side, and the limited budget for the laboratory technicians and equipment, on the other side. The development of telecommunication and information technologies has opened new possibilities in realisation of experimental teaching in the field of electronic measurement [1]. Low price of microprocessor's components and systems, made possible the realisation of remotely accessible laboratories, which can be used for e-learning. Therefore, the remote control of instrumentation for real experiments via Internet is a topic of interest for many researchers.

A remote laboratory for teaching purposes in the field of measuring experiments was activated [2]. That laboratory provides students to access measuring system via Internet using only a simple Web browser and directly carry out real experiments without their physical presence. The concurrence of more users on the same measuring setup is allowed. In [3] the authors present the realization of the virtual laboratory by WWW technology and program language LabVIEW.

Suggested technique for remote control of instrumentation [4] is based on client/server architecture and it allows the multi-user access and several instrumentation sessions using the determined demand procedures and instrumentation locking. Combination of interactive systems based on Web technology and systems for remote control is presented in [5]. The structure of the distributed teaching environment, based on Web technology and remote measurements, which flexibility allows variable didactic activity is explained.

In paper [6] authors present the e-learning measurement laboratory, which involves about 20 Italian universities and provides students of electric and electronic measurement courses with access to remote measurement laboratories delivering different didactic activities related to measurement experiments.

The laboratory model, which is explained in this paper, has been realized as a distributed measurement system. The distributed measurement systems, as it is known, are the systems where it is possible to realize the network by linking a great number of remote subsystems, and where it is possible to change theirs software. If access to these distributed measurement systems are allowed via Internet, we have remote measurement laboratory.

System is realized as a hierarchical structure on few levels. Students can access through the application level. We used client/server architecture, which holds a lot of advantages in efficient resource usage in compare to all previous architectures [7]. Nevertheless, it requires user identification with a password and other authentification methods., where the student's computers are clients, and the computers in the measuring laboratories are servers. System is based on standard protocols and features, and can be easily expanded [8].

Main server manages the whole system. It allows access to the laboratory and the experiments, on one side, and forwards the assignment to the features which are in the environment, on the other side. The instruments in the laboratory are connected to the main server over standard interface RS-232, which routes the instructions and results of the experiment.

II. APPLICATION FOR THE REMOTE ACCESS

Laboratory consists of the virtual instruments, which are realized by program language LabVIEW. Through LabVIEW application students can access measuring instruments and acquire data. It is needed to have input parameters for each measuring instrument in the laboratory in order to carry out the desired measurement by virtual instruments. Input parameters are the parameters which set the start values of the measuring instruments. When the measurement equipment is connected to the computer and all parameters are set, the LabVIEW application carries out the desired experiment and generates the output file. All results of the carried expriment are placed into the output file.

Software solution, which connects the user and the appropriate LabVIEW application, is realized by standard procedure languages [7]. In concrete system architecture, the Internet Information Server (IIS) is used as a web server. Student accesses the laboratory by standard browser and web address of the remote laboratory. Student requires the laboratory access by identifying itself through Login and Password. After that, browser forwards the requirement to the

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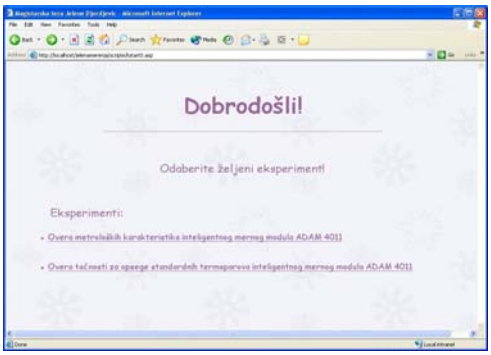

Fig. 1. Page for the experiment choose

server. The Internet part of the software solution is written by using the ASP (Active Server Pages) technology in Java Script language and by using the CGI (Common Gate Interface) scripts. Web pages are written in ASP. The server checks added personal data and allows student to access the system only if the student exists in data base, which is created by the teacher or administrator. All information about the students who may access the laboratory, and all information about measurements which are made (including the measurement parameters and results) are placed in the data base. If student doesn't exist in data base, server refuses that student with a note to try again.

When the student's identification data are checked by the application and access is confirmed, the new page appears (Fig. 1). Student has to choose a measuring experiment. When the choice is maden, in the next page (Fig.2) the student has to enter specific set of data (range, sample rate, number of measurements, etc.), which is necessary for laboratory setup.

Based on this set of data, the input file of virtual instrument will be create. By pessing OK button, the proper LabVIEW application runs up. LabVIEW application carries out measurements with given parameters, and the acheived results puts into output data file. Based on this data file, web page with the measurement results has been generated and the results are shown to the student.

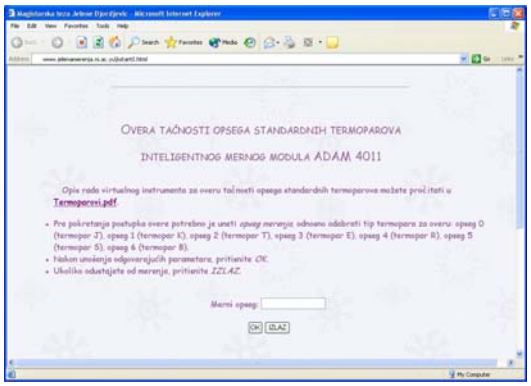

Fig. 2. Page view for parameter determination

Important functionality of all standard programming languages is a possibility to make an external call of another program application on the computer. This functionality is used here for the calls of an appropriate LabVIEW application. When the input file is created, the CGI script goes into a waiting state, while the appropriate LabVIEW application is running and the output file is not created. Then, a HTML file is created and transferred to a student [9] (Fig. 3).

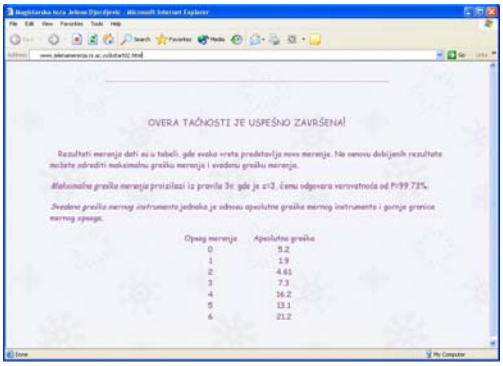

Fig. 3. Report which student gets on the end of the measurement

An application which controls the execution of the appropriate LabVIEW application, as well as it's shut down when a measurement is over and an output file is created, is developed in programming language Delphi. In other words, this application has a position of a trigger of the real physical measurement process for the current equipment configuration. Ones a CGI script creates an input file for the appropriate LabVIEW application, the Delphi application detects that input file and starts up a LabVIEW application. When the measurement is done and the output file is created, the Delphi application shuts down the LabVIEW application in order to fulfill demands for the next measurement. In the meanwhile, the CGI script is blocked in the while loop which is aborted when the output file is created and there are no other constrains, and then the HTML file can be created. In this case, the measurement results are given tabelary, thus the student can perform the required calculations and present the results graphicaly, if it is required from the teacher.

The concurrence of more measuring requirements on the same measuring system at the same time became a problem, and that can be solved in two ways. The first one is not to allow any new student login while the laboratory is occupied by the student who is already logged and performs measuring. The second way is to put all logged students in a queue. When a single measuring is done, the next student from the queue gets the laboratory for use. The second solution is more practical because the laboratory occupation is splited between all logged students. In this way, increase of students number increases the waiting time in the queue, but it is equal for everyone who is in order to login.

III. Conclusion

Nowadays, a computer is an essential tool in a number of areas. They became irreplaceable in the process monitoring, product quality checking, automation, process control and

management, realization of the measurement systems, distance education, etc. The development of information technologies has opened new possibilities in realisation of experimental teaching in the field of electronic measurement.

Remote measurement system is often accessed through the global Internet network. The laboratory heart consists of a group of specialised and/or general instruments, conected to the Internet through the PC. Within a remote measurement laboratory, students can use all laboratory resources, even they are on geographicaly distant places. On the other side, it decreases the charges for laboratory technicians and equipment

Suggested system is based on client-server architecture, it is easy to expand and it makes possibilities for distant students to access the instruments. CGI scripts, written in C^{++} program language, generate the measurement input file based on the data achieved from the current user's Internet page. Laboratory, which is realized in LabVIEW, is started by application written in program language Delphi, immediately after the input file is created. Delphi application terminates the LabVIEW application when the measurement experiment is done and an output file with the measured data is created. Then, a CGI script generates a HTML file with the results for the user.System expanding can be shown with the increasing number of laboratories, which are connected to the system. Every laboratory needs a different LabVIEW virtual instrument. In the case of increasing the number of connected laboratories, the application has good bases for further development, which is related to easy handling and to the possibility of easy upgrading and interface changing.

REFERENCES

[1] Jelena Djordjevic, Miroljub Pesic and Miodrag Arsić, "An Approach for Distributed Measurement Systems Development", Metrological Congress 2003, Conference Proceedings on CD, Belgrade, Serbia, 2003.

[2] Pasquale Arpaia, Aldo Baccigalupi, Felice Cennamo, Pasquale Daponte, *"A Measurement Laboratory on Geographic Network for Remote Test Experiments",* IEEE Transactions on Instrumentation and Measurement, Vol. 49, No. 5, pp. 992-99, October 2000.

[3] Alessandro Ferrero and Vincenzo Piuri, "*A Simulation Tool for Virtual Laboratory Experimentation in WWW Environment",* IEEE Transactions on Instrumentation and Measurement, Vol. 48, No. 3, pp. 741-74, June 1999.

[4] M. Bertocco, F. Ferraris, C. Offeli, M. Parvis, *"A Client-Server Architecture for Distributed Measurement Systems ",* IEEE Transactions on Instrumentation and Measurement, Vol. 47, No. 5, pp. 1143-1148, 3. October 1998.

[5] L. Benetazzo, M. Bertocco, F. Ferraris, A. Ferrero, C. Offeli, M. Parvis, V. Piuri, *"A Web-Based Distributed Virtual Educational Laboratory",* IEEE Transactions on Instrumentation and Measurement, Vol. 49, No. 2, pp. 349-356, 3. April 2000.

[6] G. Andria, A. Baccigalupi, M. Borsic, P. Carbone, P. Daponte, C. De Capua, A. Ferrero, D. Grimaldi, A. Liccardo, N. Locci, A. M. L. Lanzolla, D. Macii. C. Muscas, L. Peretto, D. Petri, S. Rapuano, M. Riccio, S. Salicone and F. Stefani, *"Remote Didactic Laboratory „G. Savastano", The Italian Experience for E-Learning at the Technical Universities in the Field of Electrical and Electronic Measurements: Overview on Didactic Experiments",* IEEE Transactions on Instrumentation and Measurement, Vol. 56, No. 4, pp. 1135-1147, August 2007.

[7] J. Djordjevic, *Remote Measurement Laboratories-Distributed Measurement System Based on Client/Server Architecture,* MSc thesis, 2005.

[8] Jelena Djordjevic, Milan Jovic, Dragan Zivanovic and Miodrag Arsic, "An Approach for Development of Measurement Laboratories for Remote Experiments", ICEST 2006, Conference Proceedings, pp.340-341, Sofia, Bulgaria, 2006.

[9] Jelena Djordjevic-Kozarov, Milan Jovic and Dragan Jankovic, "An Approach of Application Development for the Virtual Laboratory Access", ICEST 2007, Conference Proceedings, pp.691-692, Ohrid, Macedonia, 2007.