Foundations of Making Virtual Laboratories in Engineering Education

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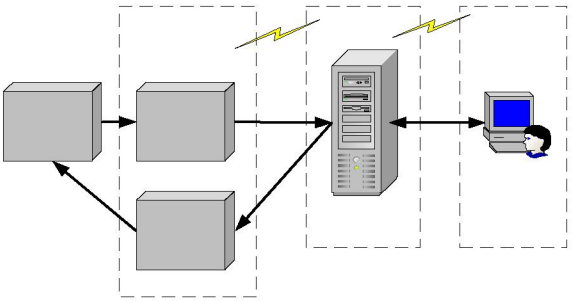
***Abstract*– The article discusses of foundations of making virtual automated laboratories for providing student's laboratory work using Internet network.**

IN DISTANCE FORM OF EDUCATION construction of laboratory training basically differs from traditional ones. A student has to have own laboratory in domestic conditions. One of new line of investigation is development virtual automated laboratories with remote access. Here the word «virtual» does not mean a demonstration of model or simulating experiment, it just means that control panel of laboratory stand is replaced by computer visualization, i.e. device controls and indicators "are drawn" on the student's screen, but measurement equipment remains realistic ones.

Making such laboratories assumes to train practical specialists with skills of working with devices; it assists in experimental attaching for studied sources. Laboratories with remote access are not only intended to duplicate laboratory training of internal education, but permits to work with unique or expensive equipment and make a real experiment from every spot on the globe. Also possibility of working multiple students with one laboratory stand may be realized.

There are tendencies of industrial automation for a long time. The first step of industry progress was to unite all authorities of workshop equipment into single switchboard. The next step was using computer to control the production process, and its display becomes a control panel. Because of using computer there is no need for operator to work directly on a workshop, it is enough to connect operator's computer and workshop computer into the single local area network. The tendencies are that in the near future operator may work at home over the Internet.

It is quite reasonable to use similar foundations for making laboratories with remote access. Structure chart for such laboratory looks like this:



The main unit of system is some experimental plant (studied device or some physical process). Information about executing process is received by data acquisition system by set of sensors which transform measurement units into the voltages. This system generally is represented by microprocessor that controls a multi-channel ADC.

Then digital data come to computer via any interface: COM, LPT, USB or even PCI. Interface should be chosen from considerations of speed (which depends on the size of transmitting data), hardware and software complications, and costs of needed components.

Further data processing (their structuring, analyzing, preparing for transmitting to client) is handled by server-side code. Then data are sending to client software via the common Internet well-provided for delivery protocol TCP/IP. In this software incoming data are indicated in the form of meterages and graphs of virtual measurement instruments which look like real ones.

Generally user should be able to change experimental conditions (or operating mode, of exploring device). In this way, the user's client software has controls (regulators, switches, and so on). Software handles their changing and sends corresponding query to server. Query is processed by server-side code and, if request was proper, appropriate command is sent to control system. Control system may be represented by set of DAC, commutating switches, mechanical drives, and so on, i.e. any device that changes parameters of exploring system and can be operated by voltage.

It is advisable to combine data acquisition system and control system of laboratory stand into single device. Then it is enough to use single

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microcontroller with appropriate periphery, which is connected to computer via single interface.

To develop such system the next tasks should be solved first:

- setting up a goal of laboratory;
- choosing an interface;
- choosing microcontroller, sensors, and control devices if needed;
- developing data and command transport protocol between microcontroller and server;
- developing data and command transport protocol between server and client software.

Under these foundations in laboratory of electronic tools for education of Siberian State University of Telecommunication and Informatics we have developed and introduced in educational process a laboratory practical work "Physical fundamentals of electronics", which includes works on investigating characteristics of semi-conductor diodes, bipolar transistors, and FETs. In these laboratorial works students make measurements of direct and reverse currents of diodes, characterizations of transistors in different circuits. As data acquisition system and control system of laboratory the DAQ device NI-6008 of National Instruments is used. It has four differential 12-bit ADC, two DAC, twelve digital I/O lines, and USB interface. Server-side code is written in Delphi 7, and the client software — in LabView 7.1. LabView have been chosen because of its large quantity of well-visualized virtual instruments that make intuitive user interface for student.

Because of using ready-to-use DAQ device there was no need to develop a protocol between microcontroller and server, it was enough to take advantages of software and drivers from producer which supply all needed functionality.

Client-server protocol was developed by analogy with FTP (file transfer protocol). At first client sends some request and waits for answer. As command is received, server application processes it and sends appropriate response (including measure data if needed). Received data is rendered immediately on a user's screen by virtual instruments. It was paid much attention to minimizing of traffic via Internet since many students still have slow modem-link connections.

One of the delivered tasks in front of laboratory was to achieve possibility of simultaneous work for some students with different (or the same) laboratory work items. The deciding consists in temporal distribution of queries from client applications due to using a non-blocking socket. In this way, queries are organized into queue by mean of operating system owing to specificity of TCP/IP protocol, so total amount of simultaneously comfortably working students with this laboratory stand achieve more than ten persons.

To accommodate a quality control of laboratory work implementation by student, server application stores in special database information about who, when, and what items of laboratory work had done, and how much time it was spent for this. This data are available for teacher via the web-interface.

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