AN EDUCATIONAL APPLICATION OF DISTRIBUTED MEASUREMENT SYSTEMS

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Abstract

this paper describes an educational application of distributed measurement systems for the tutored and self-educational process that has been designed and applied at the Department of Electronics and Multimedial Telecommunications, Technical University of Košice for students at the senior level of their study. The main goal of this activity has been to improve and spread our students' knowledge beyond the traditional university education in the area of measurement and communications. The students involved do not only play a passive role in the usage of a ready-made distributed measurement system by executing a remote measurement but they have the opportunity to participate in the process of design, carrying out and supervising an own simple distributed measurement system. To simplify their task, they may either use the graphical programming environment LabVIEW or the standard ANSI C language based on the programming environment Labwindows/CVI with ready-made instrument drivers (GPIB, serial and plug-in multifunction boards) and basic software skeletons. The overview of the students' resources, task-solving steps and goals as well as the present results, experience and the expected future extensions are presented, too.

Keywords

Education, Virtual instrument, Internet, Distributed measurement system, LabVIEW, LabWindows/CVI

1. Introduction

The wide and fast development in networking and telecommunications together with industry's needs of data acquisition and supervisory control over long distances tend to the closer and closer linking of networking technology and instrumentation in measurement. This global trend has been a challenge for universities who have to mirror it in their curriculum [1]. The present student and the specialist for the next millennium should be not only focussed on a single, rather narrow career area of technology, e.g. telecommunications, computer or measurement science, but he or she should be familiar with interdisciplinary questions. Especially the future telecommunication expert should have at least a basic knowledge from measurement science and instrumentation as well as computer science and vice versa [2]. Only such a "new-way-created" graduate, who meets the wide range of industry needs, has a good chance in the labour market.

Another, strongly appreciated feature of the new engineers is their practical experience in the planing and the realisation of measuring systems using modern communication tools. The next, not less important character of nowadays' and the next century's engineers is their ability to work in a team and to co-operate with people of different specialisation at solving tasks.

The general trend in teaching measurement science is the preference of simulation to practical experiments, which results in a lack of practical skills. That effect has been mainly caused by a university budget restriction, unfortunately especially in transforming countries such as Slovakia. In order to meet all the needs, we tried to create an educational project focused on master degree students in their final years of study, which should enable them to deal with all aspects of a real distributed measurement systems from its planing, through realisation to its management. The project was established in the end of 1997 [11] and is now being in the testing and evaluation phase.

2. Background of the project

The effort to reduce additional expense tensed and tenses us still to utilise the momentary measurement laboratory equipment at our department. It led to the decision to establish the educational distributed measurement system on LAN and particularly on the Internet. The Internet as a modern multipurpose and popular communication tool has opened many new opportunities for personal computers across every application area. Many important functions, such as searching, publishing, displaying data, etc. can be performed across the Internet. In addition, the Internet allows that various virtual, remotely addressed measurement instruments and the distributed measuring applications can be created [3], [4], [5], [6].

These facts and the great popularity of the Internet among students predestined it to become the communication base of our distributed measurement system. This idea is not a new one; the Internet based distributed measurement systems in education can be found at any university [7], [8], [9]. But all laboratories, we have had an opportunity to get acquainted with, have been fully designed by the university staff and they have been focused on, either a distance education, or teaching subjects as signal processing, electronics, measurement, etc. The students play only a "passive" role by practising ready-made services.

The project prepared at Technical University of Košice has different aims. It is not only to enable students to use a distributed measurement laboratory and execute a remote controlled measurement across the Internet but also to enable them to meet actively with the background of the Internet communication as well as with the remote controlled measurement. Moreover, they can set up their own measurement task on both the hardware and the software sides. Of course, the complete development of such a complex measurement system is rather difficult. Therefore, the students are divided into small "research" teams of 2 - 3 persons, who have to co-operate on their own research way. Each student solves and is responsible for a part of the common task. This enables the students to detect the advantages and the disadvantages of teamwork and teach them how to co-operate in such a working environment. The students' activities are tutored by the teacher who supervises and helps to co-ordinate each task-solving step.

2.1 Laboratory structure

The present part of department equipment laboratory configuration dedicated to the project is shown in fig. 1. It consists of three parts:

1. The measurement laboratory, where two Pentium based PCs, outfitted by common measurement GPIB instruments (multimeters, sources, generators, digital scope, etc.) and multifunction plug-in boards with DAQ Signal Accessory by National Instruments, have been dedicated to the project. The computers are destined, essentially, to be the measurement servers but to simplify the software development, the students can simultaneously use them as the clients (Web browsers). The operational system installed on the PCs is Windows95/98 and Windows NT 4.0.
2. The telecommunication laboratory, which is equipped with generally used Pentium based PCs linked with the ATM network and a special telecommunication server and switcher. It enables students to test their developed server/client applications over the network.
3. The department server, which is playing only a passive role in the system, is creating a gateway linking the internal LAN and the global Internet network. It provides students with the remote access to their projects and in the future it will be the global gateway to present a choice of finished students' projects.

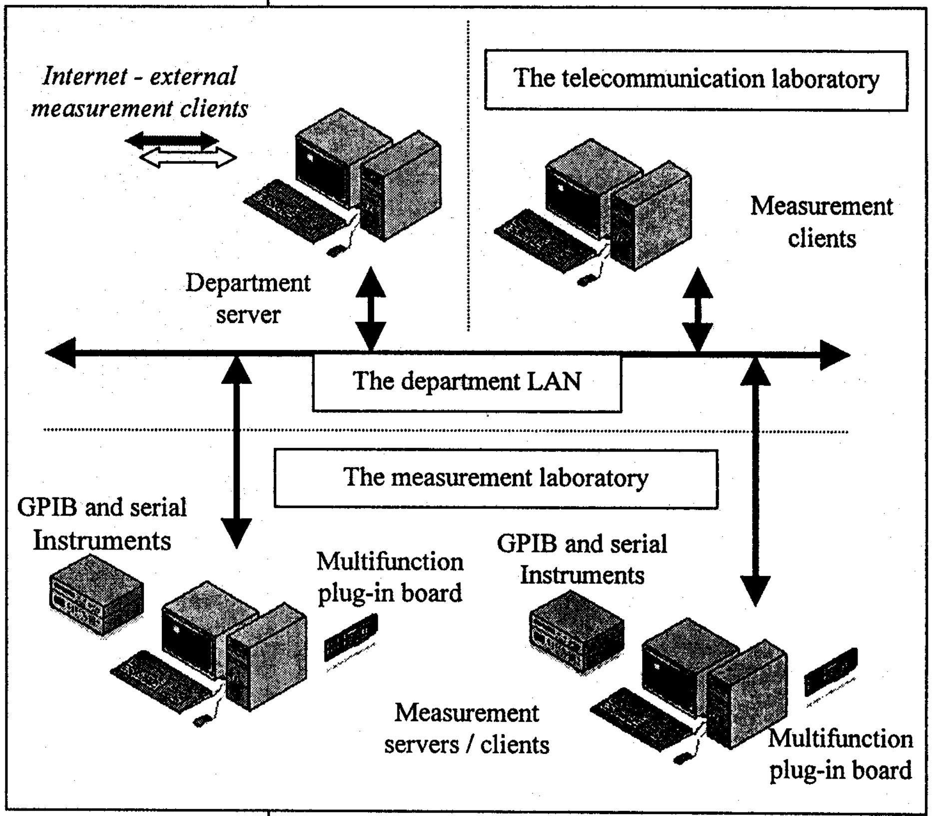

Fig. 1. The present laboratory configuration.

The main part of the students' work has been performed in the measurement laboratory. Here the measurement stands have been designed, built and linked to the computer and then the software has been developed and debugged on the computers. The other laboratory and equipment serves as an additional testing and presentation tool of the students' projects only.

2.2 Software tools

Software plays a vital role in developing automated data acquisition and instrument control systems. The latest programming environments offer users a wide suite of various tools to build the automated measurement systems as well as to control the communication across the Internet. For developers who are not professional programmers but who need to create software for their application, the software developing tool vendors offer special user-friendly environments.

The students involved in the project can choose between the graphical programming language LabVIEW and the interactive ANSI C programming environment LabWindows/CVI; both have been created by National Instruments [10]. LabVIEW (versions 4.1/5.0) and LabWindows/ CVI (version 4.0/5.0) have been preferred because they offer simple and very efficient way how to constitute even more complex application software for not much trained programmers. They also have integrated tools for measured data acquisition, data processing and presentation and sending/receiving across the Internet. LabVIEW, as a graphical programming environment, is especially convenient for students who are not very well acquainted with C language programming. Usually after one or two weeks of self-studies, the students are able to create a complex program in LabVIEW. Students, who have gained an experience in any C language programming environment, prefer LabWindows/ CVI, and also after a short time period they are able build their own quite complex applications. LabVIEW and LabWindows/CVI have another, very advantageous aspect for their applications in education; both of them are offered totally free by National Instruments in the form of the evaluation package [10]. The package is fully working and permits the student to instal the developing environments on their home personal computers. This results in the fact that the students can carry out partial works anywhere and allows students individual preparation. Only the final steps of their work are performed in the laboratory.

2.3 Students' advance

Our effort to present to the students all process of design, development and application of a distributed measurement system has resulted in the preparation of basic project steps which have to be taken by the students solving their tasks. The advance is illustrated in fig. 2.

First of all the students being part of a team have to set up a simple measure goal, for example to measure some characteristics of an electronic element or a circuit, or generate, acquire and analyse a signal waveform, etc. The next step is the selection of the software developing environment either LabVIEW or LabWindows/CVI. After the choice of the software tool, the students are to decide about the philosophy of server-client communication platform they wish to work on with two options allowed:

1. The HTTP protocol compatible with any ready-to-run web browser on the client side. In this option, the student task is to create a simple HTTP server including local communication subroutines for local attached instrumentation (plug-in multifunction boards, GPIB instruments), according to their selection in the first step.
2. A student designed communication protocol based on the Internet TCP/IP protocol, which offers a much more efficient, safe, and faster communication but on the other hand needs to develop both the client as well as the server software.

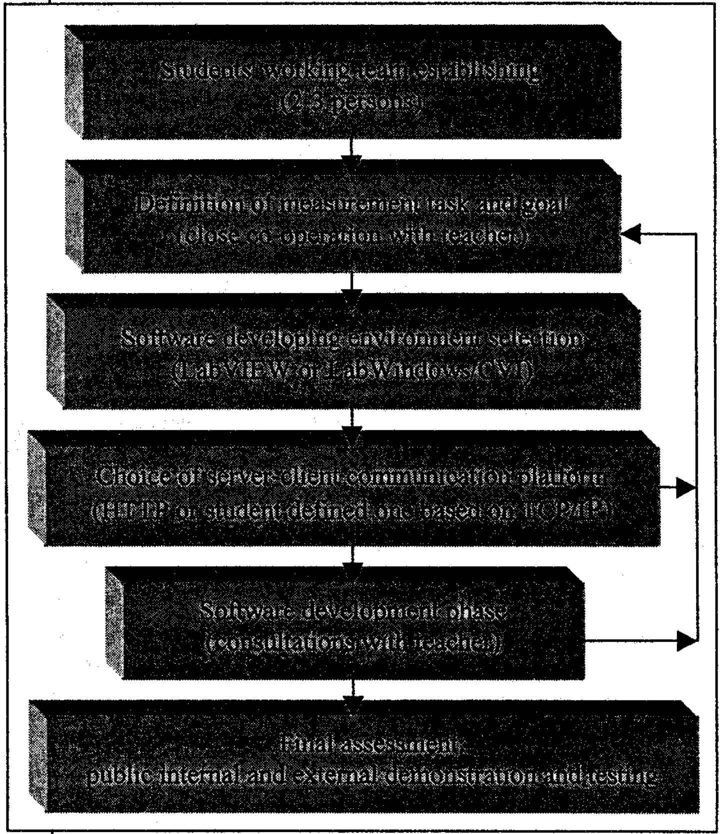

Fig. 2. The students' steps to be taken in solving the tasks.

Having pased the experiment planning stage, the students start software developing and debugging. To simplify this rather difficult task, some skeletons of servers and client programs have been prepared. The skeletons contain basic ready-to-run programs, which perform basic TCP/IP server and client communications. The students are allowed to exploit, rebuild them and add some needed subroutines to create a fully working measure server or data presentation and processing client side. The assessment of the achieved students' results consists of two steps:

1. The demonstration of the fully functioning results to the teacher and to the other groups of involved students as an examination with a final assessment,
2. The exhibition of the best results with the public access on the department server.

3. Results and conclusions

The leading idea of our project has been defined very widely and it is still in the process of testing and improving. Three groups of students test two branches of the project in very close cooperation with the teacher - tutor in the form of diploma thesis with deadline in April 1999. The chosen branches cover:

1. the development of the HTTP and measure server side realized in LabWindows/CVI
2. the development of the TCP/IP server and client with an own communication protocol in LabVIEW.

3.1 HTTP server

This branch of the project is tested by a group of two students. One creates the Internet part of the software and the other develops the local communication software between computer and measurement stand. The goal is to create a http server which enable a distant client to test an ADC linked to the measurement stand. The stand consists of programmable double DC source to supply the test ADC, DDS precise test generator generating the input test signal and plug-in multifunction board to acquire the ADC digital output.

The client using any WWW browser is allowed to get basic information about the measuring stand, to set up the test conditions (test signal parameters, power supply, sampling frequency, number of acquired samples, etc.) and to choose a form of result information (acquired digitised samples, number of effective bits, etc.). The server has been fully developed in LabWindows/CVI.

3.2 Special TCP/IP server and client

The goal of this tested branch was to create both sides - the Internet server and client application software. To simplify the task, the graphical programming environment LabVIEW has been chosen. The branch contain two independent students' tasks:

1. The development of server/client software that enables client to follow and to control all function implemented in the DAQ Signal Accessory by National Instruments.
2. The development of server/client software which enable client to link with PCLs series SLC5xx by Allen-Bradley to inspect and to set up input/output signals and some internal PLCs program constants.

3.2.1 Remote access to DAQ Signal Accessory

The DAQ Signal Accessory made by National Instruments is a comprehensive device devoted to education in computer data acquisition and processing. It contans a function generator, a microphone jack, four LEDs, a solid state-relay, a thermocouple jack, an IC temperature sensor, a noise generator, a digital trigger, access to two counters and 24-pulse per revolution quadrature encoder. It can be linked to a computer by means of a National Instruments multifunction plug-in board. A group of two students has built the server on a computer equipped with the Lab-PC-1200 multifunction card connected to the DAQ Signal accessory. The developed server/client software enables client to measure the signal of the function generator and its parameters (frequency, amplitude, etc.), to measure the temperature in the server location with the IC sensor as well as by K type thermocouple (with a software compensation of cold junction), to measure the frequency of an external signal etc. The results of this task could be applied in distance education - they allow distance clients to test their theoretical knowledge of data acquisition and processing.

3.2.2 Internet access to the PLCs

The goal of this branch was to create a server/client software which should allow distance client to follow the activity of two PLCs - SLC 500 and SLC 50/3 by Allen-Bradley and partially to control the internal PLCs' software by changing some parameters and constants. This task has been solved by a single student only. Because we have no real industry environment for the application of the PLCs the input/output signals were generated/indicated standard measurement intruments (function generators, voltmeters, etc.). A few versions of the server/client software have been developed and tested. A virtual instrument panel and program diagram of a version are shown in fig. 3 and 4.

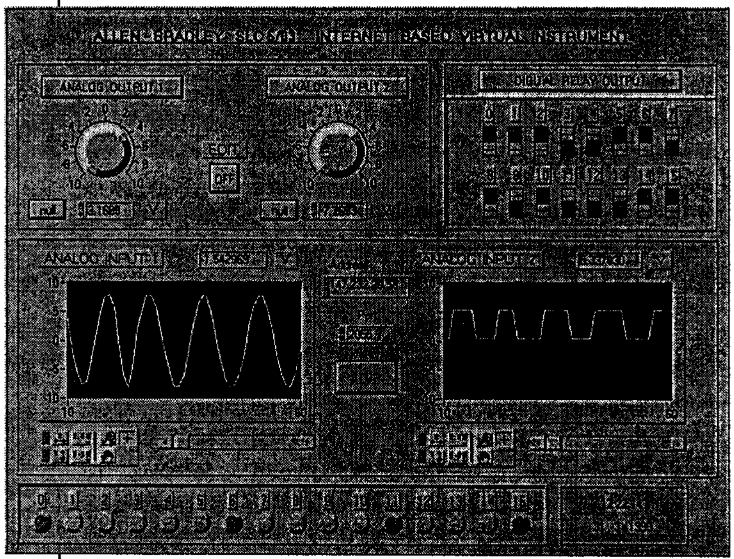

Fig. 3. Panel of virtual instrument created to control the SLC5xx.

4. Conclusions

The goal of our effort was to create an open system of hardware and software that enables students to be acquainted with distributed measurement systems based on the Internet and later on the other means of communications in a new way. The students are familiarized not only with characteristics, using and applications of systems but they are also involved into arranging and developing their own applications. The testing phase of the project has brought following educational outcomes:

- Expansion of students' knowledge beyond the traditional university education in the area of measurement and communications.

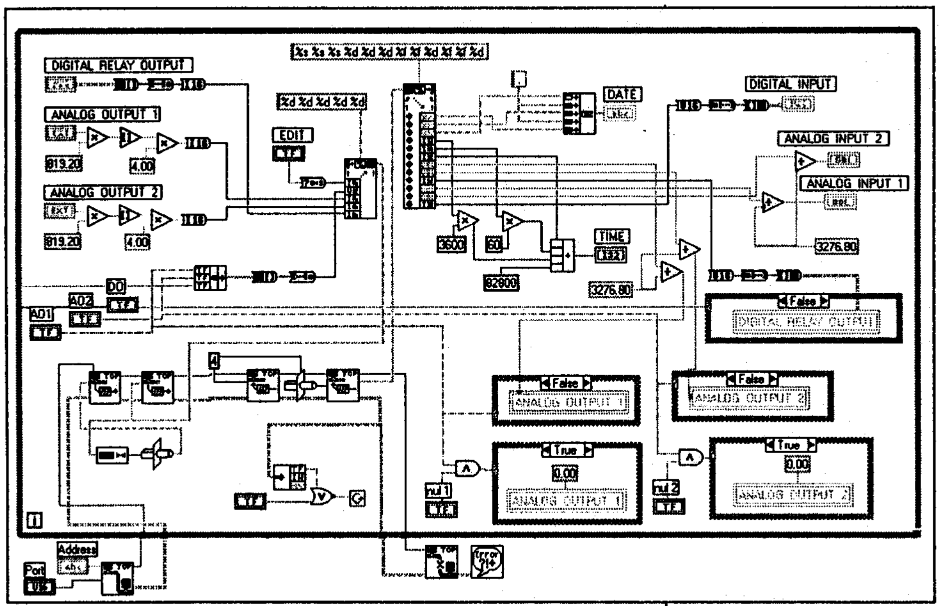

Fig. 4. Diagram of the virtual instrument shown in fig. 3.

- Improving students' practical skills in programming and using distributed measuring system based on the Internet.
- Achieving basic experiences in teamwork by the cooperating students.
- Potential applications in the Internet distance education

The main problem, which has been recorded, is that such complex tasks require theoretically good prepared students. The long-term students' preparation phase can be shorten by improving ready-made program skeletons

In future, after recovering initial problems, the project and its results shall be more widely spread among students at the Department of Electronics and Multimedial Telecommunications within the subjects "Electronic measurements", "Computer interfaces" and "DAQ systems". Soon, some of the students' results mentioned above will be accessible across the Internet on http://www.tuke.sk/fei-kemt/. The access will be allowed to visitors on demand. The authors kindly encourage the readers to visit and to test the pages.

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