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Virtual Measurement System for Distance Education and Training

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Abstract *– This paper deals with the project and the development of remote-controlled measurement system designed for distance education and training in instrumentation and measurement. This virtual laboratory system is based on IEEE 488.2 (GPIB) and client-server architecture.*

Keywords *– measurement system, virtual laboratory, distance education, IEEE 488.2*

I. INTRODUCTION

The main goal of the virtual measurement system design was to reach the maximal universality. To guarantee it, it is recommended to fulfill following conditions:

· Minimal demands for the client's software and hardware equipment as a controller of the system;

· Multi-control feature, i.e. one measurement system controlled by more client computers or more measurement systems controlled by one client computer;

· Universal and simple communication with remote devices;

· Implementation of the majority of PHP commands for the simple programming of measurement tasks, e.g. program loops, conditional statements etc.

II. PROJECT

The conditions listed above were fulfilled by the communication protocol based on the client-server architecture. The whole system consists of the following three parts:

· Measurement computer – PC with OS Windows and a GPIB card enabling the communication with connected measurement instruments;

· Client computer – PC with a WWW browser supporting Java connected to the Internet;

· Server computer – PC with OS Linux and WWW server, which supports PHP, connected to the Internet; it provides interconnection and communication between the measurement computer and client computer.

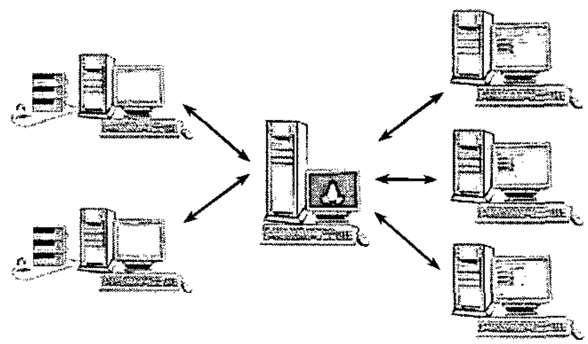

Fig.1. Block diagram of the measurement system design

The measuring process is started by the client computer. It sends a user commands to the server computer, which partly preprocesses the requests and redirects them to the addressed measurement computer.

The whole system is controlled through a web browser. The communication between the client computer and the server computer, as well as between the server computer and the measurement computer, uses a TCP/IP protocol. SCPI (Standard Commands for Programmable Instruments) messages are used for instrument control.

III. IMPLEMENTATION

A. Measurement computer

This computer receives commands from the server computer and sends them to the addressed instruments via GPIB bus. It also sends the measured data back to the server computer – it is the data source of the measurement system.

There is a special MS Windows program running on this computer providing the communication channel between the measurement instrument (connected to GPIB bus) and the server computer. This program has to be set up at the beginning and then it runs resident on the background. It is mostly waiting for the commands from the server computer or response from a measurement instruments; thus it needs a minimum of the processor time.

Excepting standard SCPI commands, the program can process special commands (e.g. "Delay" or "Trigger") – see below. The program is also able to recognize an incorrect command and recover from the error state. Thus, no assistance is needed and the measurement instruments can be remotely controlled without local supervision. If a web-camera is available, it can be connected to the measurement computer.

Limiting condition for hardware is installed GPIB interface card or RS-232 serial line in the measurement computer for the communication with the remote devices. Web-cameras usually need a USB interface.

B. Client computer

Any computer with any operating system located anywhere in the world can serve as the client computer (tested on the PC with Microsoft Windows 9x/2000/XP and Linux RedHat 8.0). There are only two conditions to follow: first, the computer must be connected to the Internet; second, a web browser with Java support has to be installed.

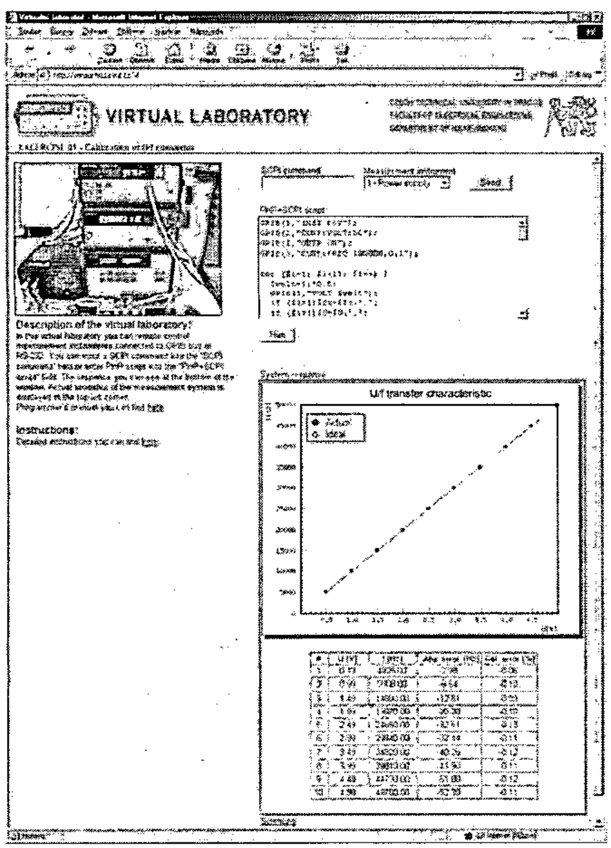

Fig.2. Main window of the virtual measurement system (client program)

The main window of the virtual measurement system is logically divided into two columns. The snapshot of the measurement devices is displayed on the left side of the client page using a web camera (see Fig.2.). The measured task is described below this snapshot. The visual information is quite important, because it allows to verify the functionality of the instrument or the complete measurement system (according to setting of the camera viewpoint). The visual information also proves that the users communicate in a real time with real devices and not just with a simulation program.

The communication part of the client program is situated on the right part of the window. The simplest way of the communication are SCPI commands addressed to a specific measurement instrument. The user has to write a SCPI command into the "SCPI command" field, choose the desired device from the roll-up list and send the message by pushing the "Send" button.

If the command requires a response from the addressed device (e.g. "READ?"), the response is redirected to the server. In case of an unknown command, the device cannot reply and the error message is sent to the server. In both cases the response is displayed in the web browser window on the client computer.

More sophisticated device control is enabled by the implementation of the PHP scripting language to the system. The PHP language allows to use variables, constants, data fields, conditions, cycles etc. in measurement programs (scripts) and to translate the output data to the form of web pages using HTML tags as well. The graphic library JpGraph for PHP (http://www.aditus.nu/jpgraph) enable the measured data to be displayed in a variety of graphs. Measurement scripts in the PHP language can be written into "PHP+SCPI script" field. Pushing the "Run" button, the script is send for execution.

C. Server computer

The server represents a key part of the whole system. It intermediates the bidirectional communication between the measurement and the client computer.

The communication is enabled by a resident C program. It works parallel to other system programs (called daemons) running on Internet web server (Apache, MySQL, FTP etc.).

This intermediate program enables measurement computers to be connected to the system, to preprocess and to send the commands received from the client computer, and to store the measured data on the server computer. These data are processed by the PHP script and displayed on the WWW page in the table or in a graphical form according to the users request.

Fig.3. shows the login of the measurement computer to the server computer. First, the communication channel ID#9 is assigned to the client computer, then the SCPI command "*IDN?" is sent to the measurement computer to its

instrument No. 1 (multimeter Agilent 34401 A, GPIB address 22), and after that the response of the addressed instrument appears.

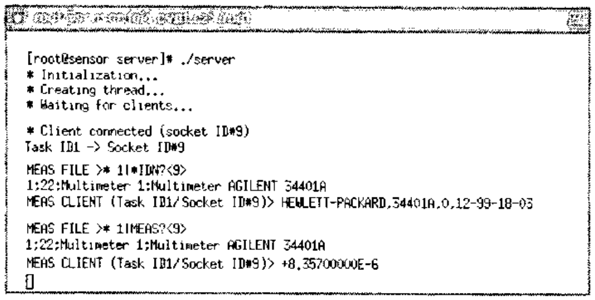

Fig.3. Server communication program

IV. SYSTEM FEATURES

A. SCPI commands

The virtual measurement system is controlled by the SCPI commands (see IEEE 488.2) through the WWW interface. On the WWW client page there is an input field "SCPI command" for a single command.

If the user intends to send more commands or to input a script, there is a special function *GPIB(deviceID:int, command:string)* available for these purposes. The first parameter "deviceID" is the number (identifier) of the measurement instrument and the other "command" is the SCPI message. The return value of this function is the response of the remote measurement instrument.

B. Trigger

An important function of measurement instruments is the function of group triggering. This function is implemented by the *Trigger()* command in the virtual measurement system.

C. Delay

In some cases there is an extra time needed for setting the measured values, particularly in the circuits with longer time constants. For these tasks the function *Delay(sec:real)* can be applied.

D. Multiuser access

The measurement system is programmed also with respect to simultaneous work of more users. The control program is equipped with the system of locking access for the case, when the device performs instructions sent by another user.

E. Outputs

Measured and preprocessed values are mostly needed in a table form or in an acceptable form convenient for the transmission to another program (e.g. values separated by the semicolon for the import to MS Excel). Since the complete communication with distant measurement system is initiated by an Internet browser via HTML pages, it is advantageous for the user to get the output formatted by HTML symbols (called TAGs) in combination with the PHP language (very similar to the C language). For advanced output it is possible to use functions from the graphic library JpGraph.

V. CONCLUSION

Described virtual measurement system was successfully implemented and applied for the distance education and training. All possible applicants can find it on the Internet address http://sensor.feld.cvut.cz/vl.

Different types of tasks require different time of execution. Some task might require longer execution time, e.g. measuring of temperature stability. Therefore, an extra upgrade of this virtual system is planned. The upgrade will enable the client computer to send the task to the server computer to initialize the measurements and store the measured values for further download by the client computer.

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