An Environment for Remote Control

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Abstract. This paper presents an environment for monitoring and control of remote systems. The aim of this work is the development of software for virtual laboratories, and e-learning. The architecture based on a server and multiple clients, runs on a LabView® platform. Remote clients can monitor and control remote process models or real systems linked to the server, via the TCP/IP protocol. The Environment for Remote Control (ERC system), under development, is appropriate for control education and allows the use of different type of controllers, such as PID, Fuzzy, and others, implemented in the Matlab® language.

1 Introduction

Since the beginning of the Internet there was been steady development of technologies for Internet-enabled instrumentation. Remote process monitoring was the first type of application in networked instrumentation. However, the remote control technologies attract most interest in both industry and academic institutions.

Laboratory experimentation is a very important part of the curriculum of many engineering courses. The price of instruments and experimental equipment is very expensive. In most university laboratories does not exist the desirable number of equipments. For this reason, laboratory in the most time are full or restrict [1], [2].

Work in a real laboratory imposes time and physical boundaries both for students and for academic staff. It requires significant scheduling effort and financial investments. Lately, universities are strongly advocating for the introduction of modern education technologies, and the option of online delivery of courses both for internal and external students [3].

The proposed ERC system implemented based on the LabView platform, presented in this paper, allows the implementation of client-server architecture for real and virtual laboratories [4]. A real physical system or a process model can be remotely control from a personal computer (PC) via the Internet using virtual instruments. The system allows experimental data to be collect and transfer to the remote user for further analysis. The user would then be able to view experimental results and analysis outcomes on a computer screen, display the results on the screen, or submit the results in electronic form for assessment.

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This kind of remote control systems can be build using other technologies, such Common Gateway Interface-CGI, JavaScript or Active Server Pages – ASP using a HTML browser for a simple interface. The complexity of the controllers need a technology based on measurements and controls. The LabView software, from National Instruments, which support the TCP/IP protocol and the integration of Matlab scripts, is a powerful tool for control techniques [4], [5].

2 ARCHITECTURES OF ERC SYSTEM

In this section, are present the hardware, the server, and the client architectures of the proposed ERC system. All these architectures are implementing based on the LabView.

2.1 Hardware Architecture

Figure 1 shows the hardware architecture. The server is link to a real process with a DAQ board. The DAQ board interfaces to the real industrial processes and laboratory equipments.

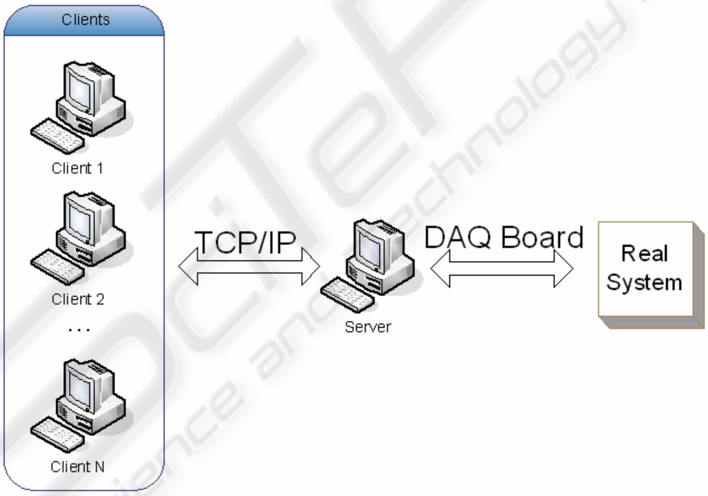


Fig. 1. Hardware architecture.

Both Server and Clients have links to the Internet via the TCP/IP protocol. They communicate between them, changing information (variables, time, process features, etc). The base of this system is the LabView, which have the TCP/IP protocol implemented.

The server runs independently of the clients and can supervise all of them. Through a data acquisition board (DAQ), the server can collect all real system data. Instead of the real system, the server can simulate a model.

Each client has a limited time attributed by the server to run the several control tasks. The main tasks are: a) define the reference signal (set-point to the controller); b) tune the controller; c) upload the code of a new controller; d) test the algorithms.

The clients can visualize the results of the experiment on the local screen. The ERC system has a user-friendly interface, which is very easy to use.

2.2 Server Architecture

The server architecture is depicting in Figure.2. The LabView software implements the communication protocol and hardware drivers. Via an interface, the user of the server can visualize the different signals, monitor the client's activity, and control their activities [6]. The real process or the simulation models are test by the client, but when the server user wants it can pass to the front of client list.

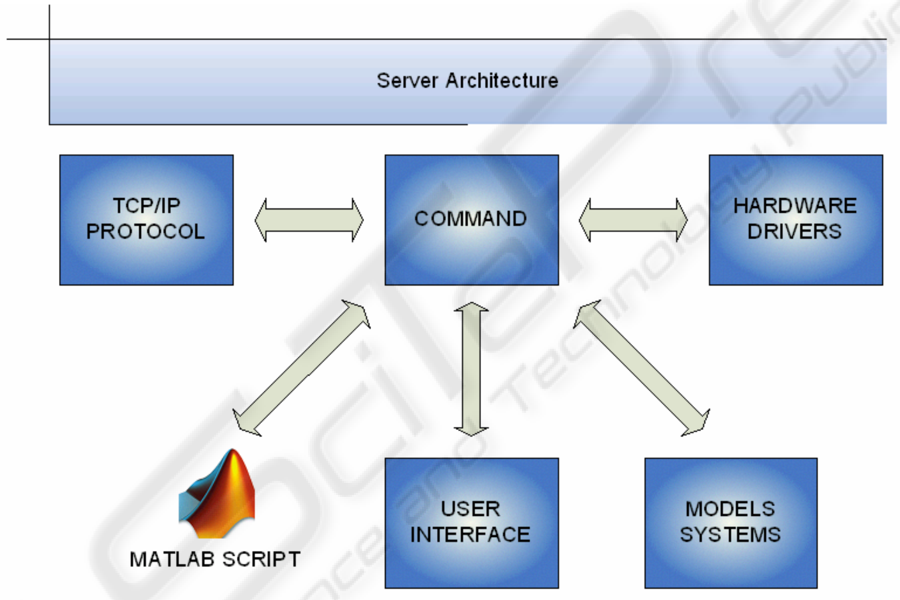


Fig. 2. Server architecture.

A model build in the server can simulate the real system.Controllers can be implementing on the Server or on the Clients. Through Matlab scripts, the user can implement its proper controller, or runs the controllers previously implemented on the server. The Matlab scripts are implemented in M-File editor for better easiness implementation and need to be a regulated file with several variables. These scripts are upload for Labview code, in the client or in the server PC.

A supervisor controls the time allow for each active client, putting their in a list by order of entry. The server controls the process or model. When a client connects, the process control can be passed to the client.

2.3 Client Architecture

The client architecture is very similar to the server architecture. However, the client works with Matlab. The interface is build in that tool and calls another interface made in Labview tool. This interface can run a controller on the server; the controller can be one of the available on the server, or a new algorithm (Matlab script) uploaded. Nevertheless, it also run an owner controller implemented in the client tool.

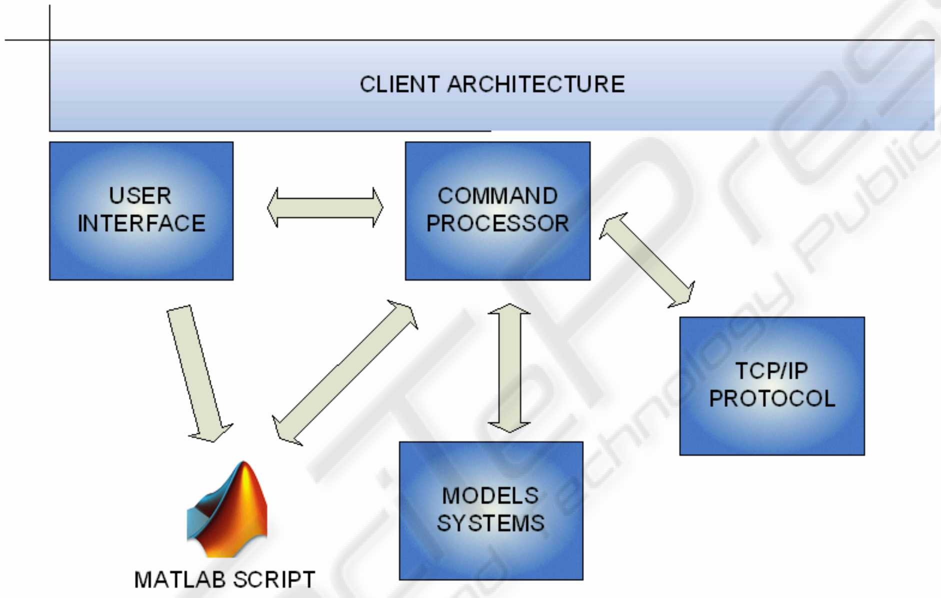


Fig. 3. Client architecture.

The experimental results are saved in a MAT file; this file saves variables with system information (process model, times, controllers gain, etc). The user has a limited time supplied by server supervisor to use the real system, or process model. If the user connected to the server has no activity, the server can disconnect and connect another client in the waiting list. The ERC system allows users to visualize the results of others active users, but not their MAT file with controller and process parameters.

3 Experimental Results

In this section, since the ERC system is under development, only some preliminary results are present. Some experiments were done in order to test the performance of the ERC system. Remote monitoring and control algorithms were implemented and tested.

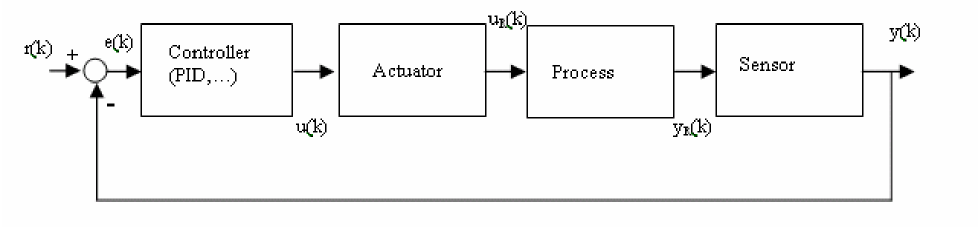
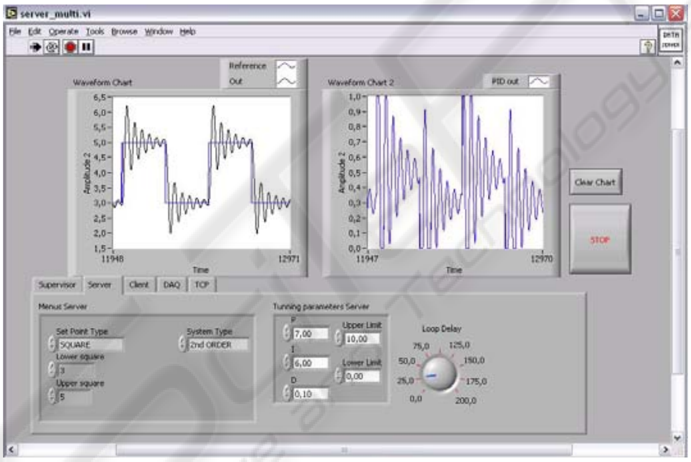


Fig. 4. System control closed-loop architecture.

Figure 4 shows the general architecture of a closed-loop control system. The different systems (controller, actuator, process, and sensor) are show, as the many signals. The main signals are: the reference signal r(k), the control error e(k), the input u(k), and the output y(k). The results presented in this section (figure 5 and figure 6) are due to the PID control of a second order system [7].



Menus Server

Set Point Type: SQUARE

Lower square: 3

Upper square: 5

System Type: 2nd ORDER

Tunning parameters Server

P: 7,00

I: 6,00

D: 0,10

Upper Limit: 10,00

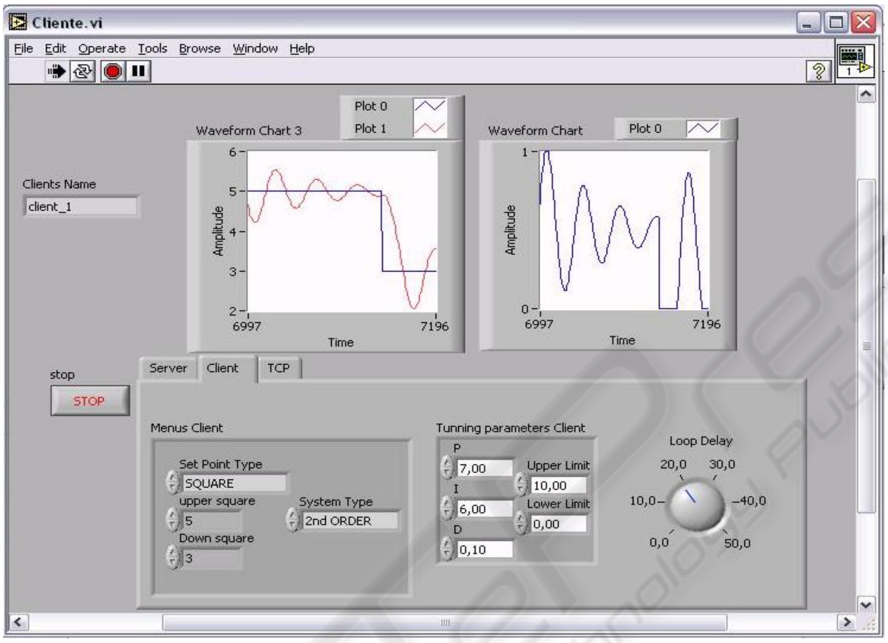
Lower Limit: 0,00

Fig. 5. Server interface.

In Figure 5, is depicted one of the interfaces running on the server PC. As can be observed, are shown the reference signal r(k) (square wave) and the output signal y(k) of a second order system. In this interface, the user can tune the parameters (Kp, Ki, Kd) of the PID control, and the reference signal r(k). The server interfaces change according the type of controller in use.

A supervision algorithm running on server allows the execution of different tasks: a) monitoring all the connected clients; b) shutdown one client; c) run the real system, or the process model.

In the client interface, the parameters of controllers implemented on the server are available, as are in server interface. In both interfaces, is possible to implement new controllers using Matlab scripts.



Clients Name: client_1

Set Point Type: SQUARE

upper square: 5

Down square: 3

System Type: 2nd ORDER

P: 7,00

I: 6,00

D: 0,10

Upper Limit: 10,00

Lower Limit: 0,00

Fig. 6. Client interface.

Figure 6 represents the client user interface in Labview platform. As referred, the user can work with the process or model implemented. After the client use the process, he can use the data extracted from the experiments to implement the control algorithms.

4 Conclusions

An environment (ERC) for monitoring and control of remote systems is proposed and described in this paper. The ERC system is appropriate to be use in virtual laboratories and e-learning platforms.

The proposed ERC system, implemented on a Labview platform, runs on client-server architecture. The remote clients can monitor and control, via TCP/IP, process models or real systems linked to the server. Only one of the clients can control, in real-time, the remote system during a pre-determined time duration.

Monitoring and PID control algorithms were implemented and tested, and shown good performance.

The future work relates to the development of new process models, new control algorithms, and the improvement of the interface capabilities.

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