

NetLab : A Real Internet-based Laboratory

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Abstract: The paper presents a remote experiment system based on Internet: NETLAB. Users can do experiments via Internet. Comparing with other virtual laboratory, the system has these attributes: 1) all the experiments in this system are based on real physical equipments; 2) over 30 experiments for EE undergraduates or graduates; 3) NETLAB encourages experimental design ability, not limited to only “push button” or validate experiments. 4) NETLAB allows students to test their own algorithms. User can do experiments via application software package or web browser. Two strategies of experiment flow such as synchronous experiment and asynchronous experiment are provided to improve the experiment efficiency.

Key word: NETLAB, secondary development interface, synchronous experiment, asynchronous experiment

Introduction

Practical experiment is a very important part of engineering education. Student can improve creativity via experiments. With the popularization of high education, the conflict between student and experiment resource become critical, especially in remote education. Today's new information technologies provide an alternative tool to solve it. The virtual laboratory is the best solution. With virtual laboratory, student can be anywhere and anytime. In a classical laboratory, the experiments are limited with field, time, and instruments. With virtual laboratory, experiment resources are highly shared, and the cost of experiment are reduced.

Developed at Zhejiang university, NETLAB is a network application and provides remote users the opportunity to conduct the

experiments. We recognize that no remote system will provide exactly the same feeling obtained by students sitting in the laboratory, however, NETLAB attempts to reduce the difference as much as possible. All experiments in NETLAB are based on real equipments (no virtual realization or simulation on it). NETLAB owns rich experiment resource and most experiments for EE undergraduates or graduates are covered.

In this paper, the content and attributes of NETLAB is presented in section ii. The implement of NETLAB are introduce in Section iii. The flows of experiments in NETLAB are outlined in section iv and at last a conclusion is given.

Content and Attributes of NETLAB

NETLAB is a complex remote experiment system but is easy to operate. All experiments

in NETLAB are based on physical devices. User can remote operate the equipment and collect data from those real equipments. NETLAB contain more than 10 experiment groups and every experiment group contains more than one experiments. All experiments' client programs are embedded in the client framework to make the switching among the experiments easy. By single-clicking the item in the experiment list tree, the GUI of corresponding experiment will be shown. All common operation like "start experiment", "stop experiment" are implemented on the framework of the client side. User need to learn the operation only once. Every experiment has a hello window and the operation specification of this experiment is mentioned in this window. In the help menu, detailed help document are available. User can finish the experiment without consulting teachers.

All experiments can be roughly divided into four groups: control group, electrical and electronic group, electric power group and electromotor group. These experiments cover most of the experiments for undergraduate and graduate courses for electrical engineering students.

Control group

There are seven experiments in the control group: inverted pendulum, tank level control, typical process response, frequency response of typical plants, servo motor control system, step motor control and elevator control.

In the control experiments, the most important goal is how to design the controller. In NETLAB, we provide a second-development interface for custom designed control algorithms. The interface is easy to master. It only requires user to know C program

language. Users only need to implement three functions in C defined by the users and compile it into DLL. Then, NETLAB will transfer the file to remote control site and execute it. The DLL file will be checked before executed. If any dangerous function is found, the control program will refuse to execute it. This solution gets rid of a common defect in a virtual laboratory which is normally a delivery-based system to verify the result therefore it can't impulse the student's creativity.

In control group, many experiments contain movement equipments. It is exciting for students to watch the movements directly. So we provide an independent video server for these experiments. Student can watch the motion of the equipment directly via web or the embedded window in the NETLAB client. It greatly improves the efficiency of the experiments.

Electrician and electric group

Analog circuit and digital circuit experiments are the most important part of this group. These experiments are designed according to the bachelor's courses. So the goal of these experiments is to master the typical circuits. NETLAB forces students to draw circuit before they do the experiments. And the designed circuit is checked in the client site. If the circuit coincides the desired experiment and is in the range of the equipment's ability, the arguments of the circuit are send to Netlab, otherwise, student are required to redraw the circuit.

Electric power group & Electromotor group

There are three experiments in Electric power

group and Electromotor group. In these experiments, the circuit can work on the different parameters by changing the switches on the circuit. And all these experiments need expensive equipments. NETLAB provides student an opportunity to operate these devices and sample the real data.

Implementation of NETLAB

Topological structure

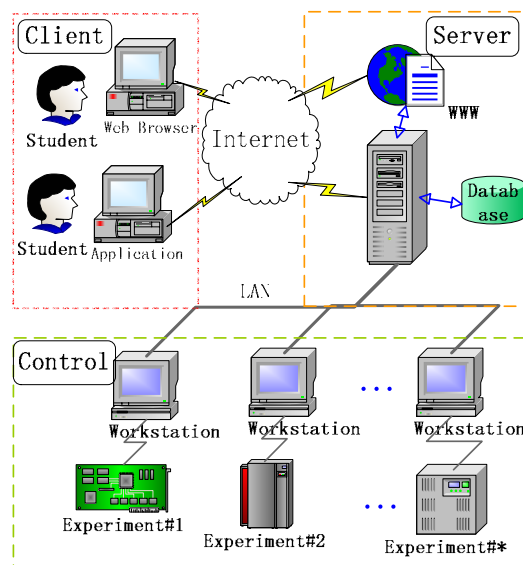


Figure 1: The topology of NETLAB

Figure 1 shows the topology of NETLAB. It has two C/S structures include three sites: control site, server site and client site. Controller and server compose a C/S structure, and client and server compose the other C/S structure.

The control site and the server are in the LAN (local area network), using SOCKET to communicate each other. Students has two ways to access the NETLAB server either by application software package or browser.

The Server site is run on XEON 2G*2 computer with 2 G RAM. The control site is run on PIII 1G computer with 256M RAM and the client site is developed by visual c++

on windows2000 so the client site can only be run on the windows operation, including win98, win2000 and winXP.

In the NETLAB, Students design the experiments in the client site, and the design is translated to commands and sent to the server. The server site is in charge of communication with client and controller. Control site receives the commands and does the experiments. The detailed relations of these three sites are shown in figure 2.

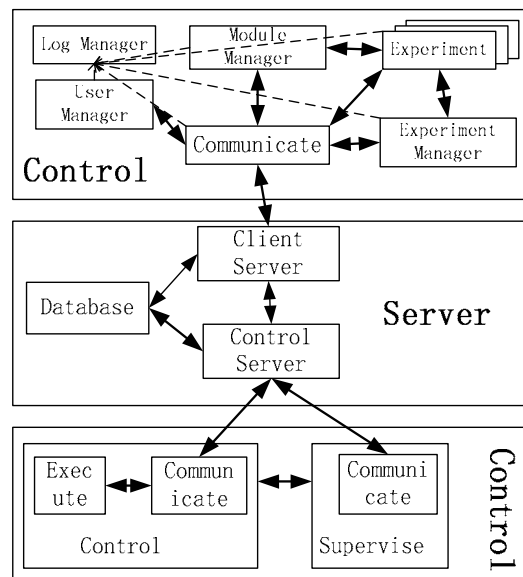


Figure 2 The detail relation of NETLAB

Client

The client site is the most complex among the three parts. It can be separated into six parts: experiment client, experiment client manager, experiment communication manager, user manager and log manager.

Communication part provides the ability of communication with server for other parts. It is the base part of the others.

Experiment client is the kernel of the client. This part provides the specified GUI of experiment design, analyzes and shows the received experiment result via figures, animated images and so on..

Component manager manages the experiment

client, including download the client module from the server, installs and removes the module.

Experiment manager is in charge of the common experiment operation, such as experiment start, experiment stop and experiment booking.

User manager and log manager compose the security system for NETLAB. User manager provides the ability to create, delete and modify the users. Log manage records the users action for diagnose the fault of system when the system was broken down.

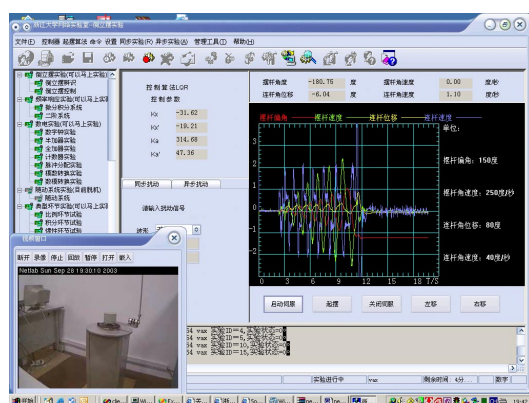


Figure 3: The default GUI of the client site.

Server

The core of the server is the client server and control server. Control server maintains the control list and communicates with control site via socket. Client server maintains the queue of the users who are online and communicates with client site via socket. The two servers can exchange data if they need. All user information, experiment information, experiment request data and experiment result data are stored in the database. The two servers can get the information they need via database.

Some simple manage tools are embedded in the client site. They mainly include three tools: result manger, request manager and user manage. The request manage tool manages the

records of asynchronous experiment request which explained in section IV. It queries and deletes the records. The result manager tool manages the asynchronous experiment request. It provides the ability of query, download and delete of the results. The user manage tool is a powerful tool for user management. It can create a batch of users, query user info via three methods, modify and delete the specified user.

Control

Control site is composed of control program and supervision program.

Control program includes communication part and execution part. The communication part receives the commands and the execution part analyzes it and then control the device according to the received commands and sample the data. All data are sent back to the server.

Supervision is an independent program and it can check the control program and the server. It makes the NETLAB a highly automatic and robotic system. There are three guide lines in the supervision program: socket existing, control process not finished, control process active. If the failure check time reaches a defined number, the control computer will be rebooted and every thing is initialized. Server also can start or stop the controller via supervision program if it needs. Because of the supervision program, controllers will connect to the server automatically when the server is rebooted. The stabilization of the control site is therefore greatly improved. Administrator does not need to supervise the control machine all the days.

The flow of the experiments

The experiments in NETLAB are different

each other. To enhance the efficiency of the equipments, we designed two flows for the experiments: synchronous mode and asynchronous mode.

Synchronous mode

In this mode, the server creates a virtual link for the client and controller. Client and controller can communicate transparently. The flow is shown in figure 4

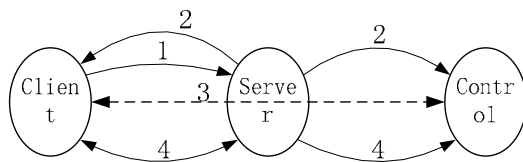


Figure 4: Synchronous mode

- 1) The user registers or dates experiment on server via client and the server put the user request in the queue;
- 2) When it is user's turn to do the experiment, the server notifies the user to start the experiment. When the server receives the response, the virtual links are created and then all control command and experiment data are transmitted automatically by the server.
- 3) Client and controller communicate transparently. The user can interact with the real device on real time.
- 4) User can stop the experiment initiative, but if the experiment time exceeds the prescript time limit, the experiment will be forced to stop by the server and the client will receive a notification for that.

Asynchronous mode

In synchronous mode, the user may often repeat the experiment or forget to stop the experiment. It reduces the efficiency of the equipments. Asynchronous mode can avoid these shortcomings. In asynchronous mode, the user designs the process of experiment in

the client site before he does it. Control site finishes the experiment independently. The flow is shown in figure 5

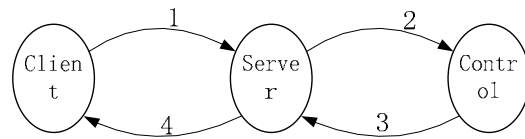


Figure 5 Asynchronous mode

- 1) User designs the experiment on the client site and after passing the check, the design is sent to the server as a single command.
- 2) The server sends the command to the controller when the control site is free.
- 3) Controller does experiment independently, and sends the data back to the server
- 4) If the server finds the user is on line, the server sends the result to the user. The user can also query history data and download again by the tools in the client.

Due to no interaction during the experiment with the Asynchronous mode, asynchronous mode experiment does not require high net speed which fit well especially for the area having no wide band. In the extreme, the user can do experiment via email.

Conclusion

Comparing with normal virtual lab, NETLAB are more creditable, covers more widely and has more ability to impulse the creativity. The structure of NETLAB is simple and open. Every experiment is an independent module and all module are developed by a second-develop interface. The number of the experiment can be increased continuously and easily. The NETLAB increases the efficiency of the experiment resource greatly.

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