Research and development of comprehensive communication experiment teaching system

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Abstract

This paper has developed a set of management and experiment system for communication laboratories. Its development platform is Visual Basic 6.0, using access database, winsocket programming and multicast technology. Including several sets of software and using C/S architecture, the system can jointly work with data network configuration system so as to achieve the communication experiment of data network. It can conduct VLAN isolation and IP filter using right management switch, which can make multiple servers connect to the device simultaneously and completely control the numbers of computers entering the system at some point. By off-line configuration technology and shared online database technology, the system can make the device resources be assigned automatically to solve the basic problems of many people doing experiment at the same time.

Keywords: comprehensive communication experiment teaching system, access, winsocket, multicast

1 Introduction

Currently, there are many problems in the electronic information experimental teaching process of many universities. The first problem is shortage of device for more users. The communication devices the operators use are very expensive. A set of device costs a minimum of 300,000 Yuan and may cost more than 5,000,000 Yuan. In general, a university buys one set or several sets of devices. However, after nearly 10 years of university increase enrolment, there are much more college students. These have brought out the problem of device shortage with more users.

The second problem is system stability. Many students use one set of device by plugging and unplugging the lines to switch between different users, making the operation very confusing and the laboratory full of network cable. Besides, a lot of data device configures through the serial port, which does not support hot plug, and the transmission distance is limited.

The third problem is the heavy burden of teachers' management. When having classes, the teachers need to coordinate multiple students to use one set of device simultaneously. In addition, in order to increase the device utilization, they definitely increase the device use time. However, the teachers would not always be able to supervise in the laboratory for long [1-5].

To solve these problems, this paper has developed a comprehensive communication experiment system (CCS). The system uses special access device to manage authorization, which is adoptive to the management of all communication devices.

2 The network structure of CCS

The system should support the shared or exclusive standing-in-line for a large number of students, including various modes of control, the port control, the IP filtering, the hybrid filter between IP and port, and a specific packet filtering. Being able to authorize for each port of every device, and allocate time automatically and support the queue management, time management and equipment management. The system has three teaching modes, namely, the study of configuration software, the controller's programming, and the adjustment of control system. So the network structure of the system is shown in Figure 1. Data network configuration system uses C/S architecture, managing the entire experimental devices at a unified platform to provide configuration and testing for the students. All computers are configured with two network cards. One is the management net with its IP locked, so it must be able to connect to the CCS2000 server and all gateways. Via RS232- Ethernet gateway, the computer can access the CONSOLE port of the data product by Ethernet to obtain the configuration capability of the lowest level. The system does not have the issues of short serial port cable, not supporting hot plug or unplug and others, so a computer can configure multiple devices at the same time.

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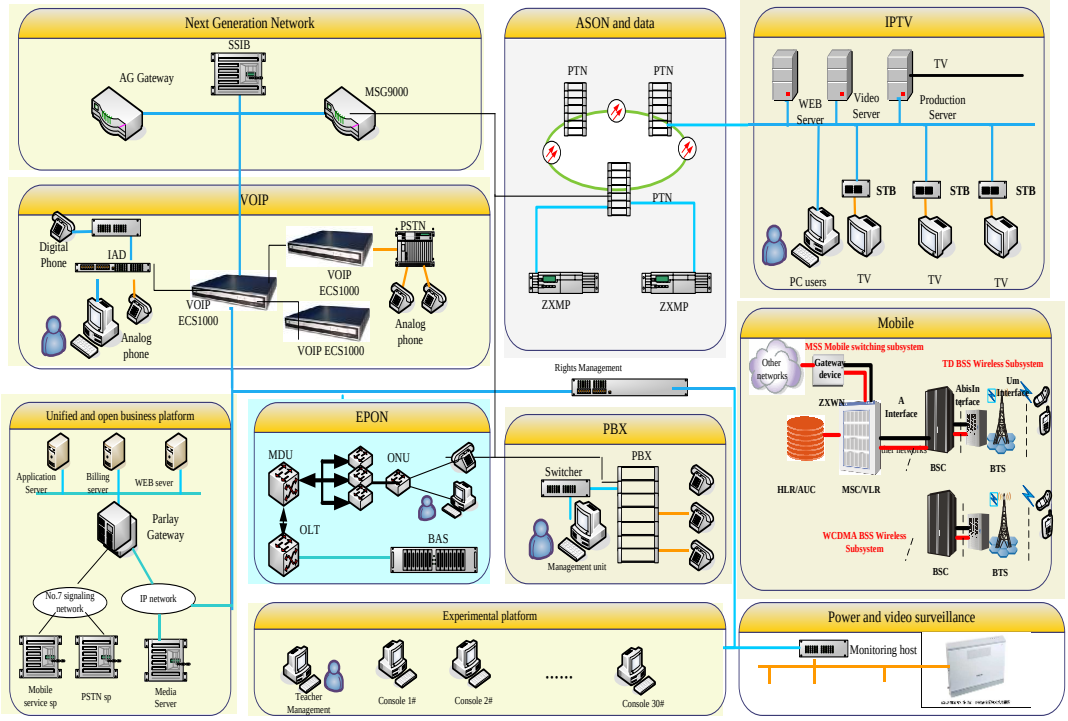

FIGURE 1 The overall structure of the system

One networking example is shown in Figure 2. All computers are configured as 129 servers with the same IP address. By CCS2000, they will not encounter IP address conflicts. Then, multiple students can make offline configuration. When the configuration is complete, they can successively connect to J10 to configure in turn. If there are multiple J10, the students can choose any one to queue [6, 7].

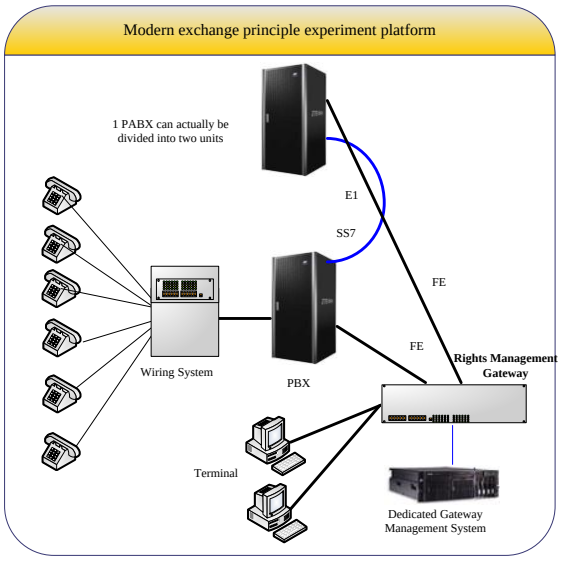

FIGURE 2 Networking example-J10

Another networking example is shown in Figure 3.

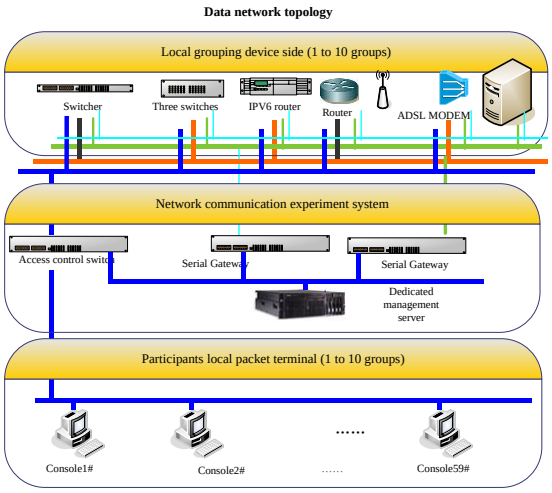

FIGURE 3 Networking example- data products

Topological graph can be divided into three layers, the upper is for experimental subjects, the middle is for the control layer, and the lower is for the student server.

In accordance with the test object, the experimental approach can be divided into two categories:

1) Those that can be classified as one category include the layer 2 switch in the middle, layer 3 switch, IPv6 router, the router, AP and ADSL MODEM. This class has a network equipment with a console port. As doing experiment, it needs to provide IP-to-serial function with serial gateway. In addition, the student port can complete the configuration of data network equipment only if it has a super terminal end.

The networking mode is to install all the student ports and the configuration of serial gateway in the same

network. The student port has access to the address and port of serial gateway by applying super terminal through TCP/IP (Winsock). CCS2000 software of serial gateway will assign a unique gateway to each student as access to the data network equipment's console port

2) Another category is the device for the server. To access such device, it requires student to have a client to the server.

The idea to access this kind of device in upper layer is: the student ports are connected with the right control switches in the middle layer, and each of them is in a different vlan for isolation. While doing the configuration experiment, student sends his/her request to a dedicated server in a queue (to access dedicated vlan communicating with the experimental object), and at this time the dedicated server will verify the student port's permission; if permission meets with the requirements, the dedicated server will allow the student port to communicate with the experimental object with the right control switch.

The dedicated configuration server controls the power gateway and the automatic hardwired gateway, which completes all kinds of networking construction and subsidiary occupation to experiments. The power gateway is an automation equipment controlled by stm32, which can complete the control over power switches of the experimental object. The automatic wired gateway is actually a switch with multi-ports (two or more layers), to which a number of data network equipment can be connected. Through the configuration of the automatic wired gateway's vlan, it can combine various topological graphs to the connected data network equipment and can accomplish various experimental networking constructions and enrich experimental content.

3 The software and hardware modules of the system

3.1 SOFTWARE OF THE SERVER SIDE

Before the whole system can be used, the system database needs to be set according to the conditions of the networking mode, the laboratory devices and the experimental curriculum. Users can enter the editing interface to form the entire lab environment, including devices, curriculum, experiment and the students' computer information. The entire database includes the following sections: device library, gateway library, user library, curriculum and experiment library, queue library, administrator library and system data. In order to design, the system makes the following definitions:

Device group: a group of devices, which are generally not used to do experiments jointly.

Device: a network element with a separate communication port. For example, a program-controlled exchange MP, a net managed switch, a device with RS232 or RS485 port; or a device without communication, even a multi-meter.

Curriculum: the experiment courses the laboratory needs to open.

Experiment: the experiments of an experiment course.

Queue: a combination of some devices needed to complete some experiments. The queue is divided according to the device group and curriculum. A student selects one experiment and the experiment needs a queue which includes all the devices needed to complete the experiment.

Auxiliary queue: to connect the network cables of some devices. Currently, only the soft connection (VLAN connection), not the hard connection between devices can be provided. Network experiment, free of cable connection, can be achieved.

User computer: the computer used by teachers and students.

User: including user ID, user name and user password. The specified users can only use the computers belongs to them, but they can choose only one computer to log in. Users are divided to teachers and students. Teachers can manage the queue, but cannot select queue to do experiment. Students can choose experiment and queue, do experiments, but only can control whether to line up or not.

Teachers group: teachers dedicated to management. The group ID is 0 and can't be deleted.

Administrator: can get into the database to modify and increase administrator user as well as other teacher and student users.

When normal server software is in the running state, you can see the queue status, computer status, device status and gateway status.

The displayed items of the queue state can be filtered according to the device groups and courses. For example, if you select the program-controlled switch device group, only the queue of this device group is shown below.

If you select a queue in the list, the specific information of the queue is displayed on the right, including the name of the current student, the remaining time of the current student and the total remaining time of the entire queuing. If the queue is shared, the current student is defined as "all" and the total time of the queue is the remaining time of the student who has the longest remaining time.

The computer status includes the login name and the connection status. When not connected, the user name is shown as "not connected". If connected but not logged in, it shows "not registered". And after login, it will show the user name.

The connection status includes: no connection, connected but no registration, already logged in, waiting in line and being testing.

The device state is shown as "device free" or "device occupied".

Related gateway information includes "online", "connected" or "no connection". The gateway states include "right control" or "control error".

The change of the state may take up to 1 minute for the refresh utilizes cycle approach.

3.2 SOFTWARE OF THE USER END

First, enter a start interface to check the network settings for all users. The communication IP is required to be set correctly to decide whether the user is a teacher or a student. The operation content of a teacher is more than that of a student and a teacher can do experiments as a student. Many attributes of the user have been identified when the server database was created.

The queue status interface of the teachers end is shown in Figure 2. Except can't operate queue and enter the pages of teaching property, the students end is the same as that of the teachers. So the additional introduction is not done here.

Select a user, a teacher can do following operations:

Click < Force to Quit >, then the user is forced to quit and this status will be displayed within one minute in the classroom end.

Click < Force to Shit Forward >, the user is forced to move to the front of the front person. If the chosen user is after the third person, it will show an error. For a shared type queue, this operation has no meaning.

Click < Force to the Front >, the user is forced to move to the second position. If the chosen user is after the third person, it will show an error. For a shared type queue, this operation has no meaning. If you what the selected student can do experiment immediately, you can force the first user to exit.

By increasing time, you can increase a certain period of time by minute to the chosen student.

User actions include selecting queue and exit initiatively.

Select one course and select one experiment, then you will see the queue in correspondence of the course and meeting the experiment. Then click <Join the Queue>, if the devices of the queue have been occupied by other queue, you cannot line up and the server system will give you a feedback of error message. Otherwise, the information of the selected queue will be displayed within one minute. Currently, a student can select only one queue to line up at one time.

Select a queue and then click <Exit the Queue>, waiting for response of the server and then you can exit.

If you select a serial port to Ethernet gateway, then it will show the devices of the selected queue. If the device belongs to serial port, you can control the serial by console command, which is especially useful for data products. For the internet access device, if it supports Telnet, console can also be used.

Using the serial port gateway, you can configure the serial port of a product through network not connecting a dedicated serial port, which can get the ability of the bottom control device and provide possibility for remote experiment. You can do operation free from cable connection with the additional help of auxiliary queue. By command, you can make the product back to the factory state.

The special operation for teachers can select optional courses, experiment and queue. The optional and not optional content can be selected to the list below. The entire program can also be saved to an external file or restored and sent to the server, so all the courses, experiments and queues optional for the students are within the control of the teachers.

3.3 HARDWARE OF THE SYSTEM

The system uses dedicated experimental servers, supporting for the unified clearance function of the configurations of "a specified device", "a few specified devices" and "all experiment devices" of the experimental devices. GW2112/16 supports power-on-clearance, having good ability of device identifying, able to identify the type, quantity, location, port status and other information of the second and third level switches and routers of ZET. It supports a user to connect up to five devices simultaneously by network, using simple and intuitive graphical management interfaces. Besides, it supports up to five users simultaneously to connect the configuration ports of a device over the network. Managing the devices using queuing, you can see the queue status of the device, including the information of the queuing computers and queuing time. Also, the teachers can manage the queue.

The system directly uses ZXR10-2826S and ZXR10-2852S, supporting the simultaneous management and control of 46 network elements as well as up to 10 stacks. It not only supports the exclusive authority, but also supports sharing authority. The maximum full control period is 4 seconds and the average control period is 2 seconds. The management interface can provide the number and device model information as well as the occupying information of the connected experiment devices.

4. Program design process

4.1 ADMINISTRATOR PROGRAM DESIGN PROCESS

The system can support the gateway transformation on the basis of the serial device, so as to make a remote access to the controller and also support the group management and control of the equipment's and users. Combine the resources according to the teaching program, and it can provide the exclusive resources and the sharing mode for allocating experiment resources by the way of line. Finally, the system can support the teachers' experiment development, with the experiment time, the mode of equipment network in need and the like. Through the comprehensive control management of access, consisting of the time and queue control, the authorized port switch, routing switch and gateway

control, it can realize the orderly conduct of the whole experiment, providing teachers with the convenient management and the organization, modification, preservation and effectiveness of teaching plan.

The system starts the server and server software. Before the entire system can be used, the database needs to be set according to the conditions of the network mode, experiment devices as well as the experiment courses. Establish device and gateway information needs to create a device group first and then create devices and gateways. The administrator logins to the configuration mode, restores the database, creates a template and then device group, devices, all kinds of users, courses, experiment and experiment time according to the requirements of the experiments. And later the administrator needs to configure the queue, the device group of the queue, cable connection free operations and the supported experiments. Finally, the administrator tests the system. If the test is successful, the database can be saved, or it is needed to be reconfigured [8]. The design process is as Figure 4.

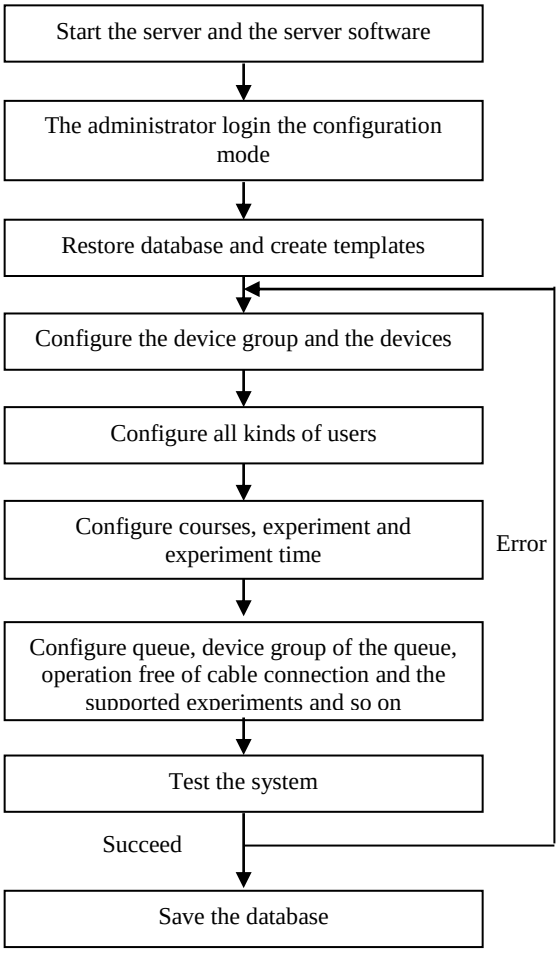

FIGURE 4 Administrator program design process

4.2 TEACHERS PROGRAM DESIGN PROCESS

Teachers can perform all the operations of students, so these operations are not included here. Device automatic identification, one key recovery, power control and other functions are for the switches, routers and others data products. The teacher computer can be any IP of the network segments the of gateway specified "server communication IP". After starting the user end software, the teachers can login the system, set up, restore and modify the teaching programs in accordance with the requirements of the experiments and then check the status of all the devices, queues and users, manage the queues according to the situation of the experiments and do text communications with the students. After the experiment, the data products can be recovered by one key recovery [9].

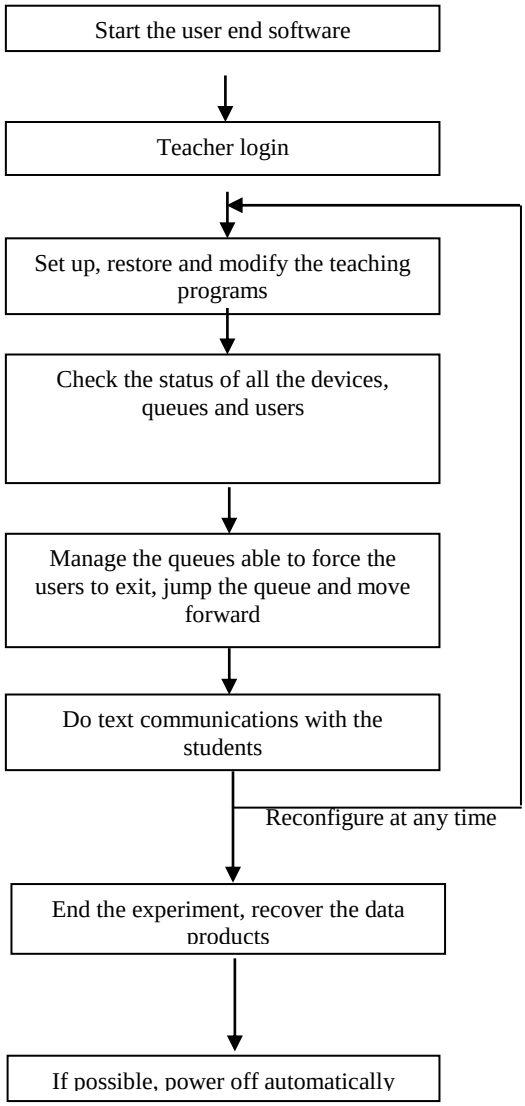

FIGURE 5 Teacher program design process

Support the setting of teaching plan, including setting up all the optional and non-optional courses, experiment and queue to be saved into the file. Therefore, the system

can support the organization, modification, preservation and effectiveness of teaching plan. The text communication can be conducted between teachers and students, so that it is convenient for teachers to help students. Teacher program design process is as Figure 5.

4.3 STUDENTS PROGRAM DESIGN PROCESS

Data network configuration system employs C/S architecture, which can manage all the experimental equipment and provide student with the configuration and testing in a unified platform. The Students program design process is as Figure 6.

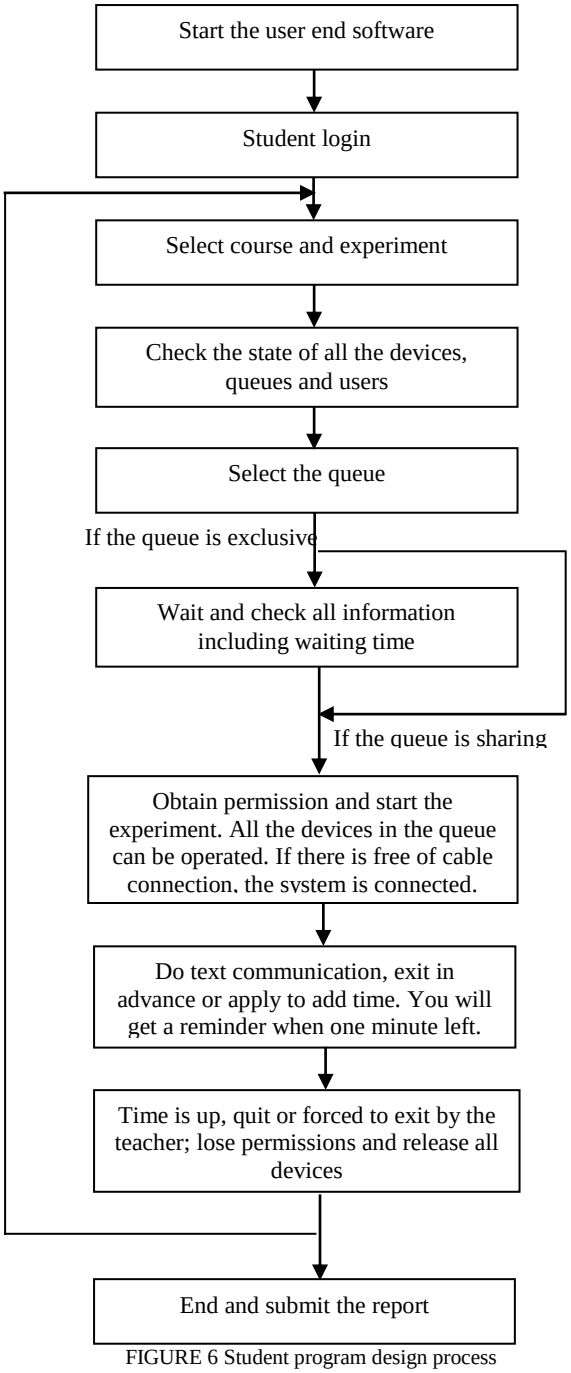

FIGURE 6 Student program design process

The system should support the queue management and operation. Students have the choice to join in the queue or drop out of it while the teachers can manage the queue, such as cutting-in-line, exit, and increase the time of individual students. The system should realize automatic connection among some devices, thus the isolation can be achieved between the device and the internship space. Furthermore, the system's log-in is recorded to trace the equipment failure.

After CCS starts, the students firstly need to try to connect to their IP, the same with the first three bytes of the server. If it requires scanning the server, then send TCP connection to all the possible servers. Then the server will respond to provide basic information. In addition to responding to the asking, the server will do multicast to the users. After selecting a server connection, the user joins a multicast. Waiting for the multicast, if not receive any multicast after two seconds, you will receive an error. Select a test area and write the user name, then it will connect to the server. If the server makes respond and then you enter the system. Otherwise, a starting error message will be displayed [10].

After starting the user end software, the students login the system. They can select the relevant course and experiment and then check the state of all the devices, queues and users. After selecting the experiment, select the queue. If the queue is exclusive, then wait. While waiting, they can check all information including waiting time. After obtaining permission, they can start the experiment. They can do text communication, exit in advance in the experiment process. Submit the experiment report after the experiment.

5 System debugging

Data product debug configuration is generally carried out by means of the console port. The serial port line, available for the configuration and daily protection to the equipment, is a basic cable for the configuration of data product.

Data product is generally attached with a serial port configuration line by random. For ZXR10 product, one end is a DB9 serial interface (with a connection to computer's serial port), and the other end is a RJ45 port (connected to the equipment's console port). The schematic sketch of the serial port configuration line is shown in Figure 7.

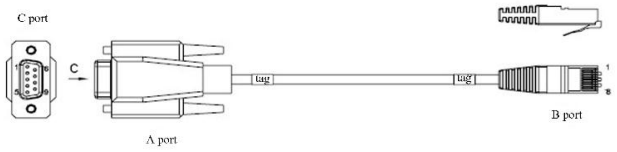

FIGURE 7 Student program design process

It uses the specialized data configuration line, and the connection device of the console port adopts the terminal mode of VT100. After the proper connection of PC and

data product, it can select to connect with TCP/IP or the serial ports such as COM1, COM2 and so on, depending on the connected serial port of the configuration wire. Meantime, it will set the port property of the selected serial port. It can be directly connected to the serial port on the server. While on the user terminal, it can use a serial connection.

Teacher's computer can be any IP of a segment in the "connecting with the server communication IP" specified by the gateway. He/she can run the super terminal by selecting 192.168.1.200 (the specified IP in the sample), 23, and accessing.

6 Conclusions

The most basic principle of the project is to do connection management to the terminals of the network through switches, routers, gateway devices, so as to manage the user authorization. Via Ethernet communication technology and server with C/S structure to manager all the user ends to queue, reserve and so on. These switches and routers can do packet filtering via VLAN technology and ACL technology.

Using a variety of strategies to visit access control, it analyses and filters the users' IP and port as well as the first 80 bytes of the information in order to more accurately control the behaviour of the terminals. This provides opportunity for experiments of multiple campuses and even the entire WAN, which greatly simplifies complexity of the wiring and construction. In communication, it uses broadcast technology and multicast technology, making the whole system respond quickly and able to withstand the impact of large loads. Besides, it uses a distributed server technology, so the user on any network can obtain the information broadcasted by the server of the experimental area.

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