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Web-based data acquisition*

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Abstract: The research work on Web-based long-distance data acquisition (DAQ) is valuable for application to tele-detection machine faults. With an expert system for machine fault detection, faults in a distantly located machine can be diagnosed through the internet. The distant user logs on to the expert system Web page, fills in the requirements, and starts-up the diagnose process. The system then connects to the DAQ server that is installed in the machine, samples data required for diagnoses through the internet, and sends back diagnose results. In such a long-distance system, Web-based DAQ plays an important role by automatic sampling and transferring of data through the internet. We have built an experimental data acquisition system using a National Instruments AT-MIO-16E-10 board running under Ch language environment. In this experimental example, the user can acquire data online. The principle of this experimental method is introduced in this paper. A detailed programming technique is described with an example.

Key words: Data acquisition, Internet, Object-oriented, Long-distance data acquisition system (DAQ)
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INTRODUCTION

With the fast development of the internet technology, users are faced with the requirement of long-distance data acquisition (DAQ) through the internet (Zhou et al., 1999). For instance, if there is experimental equipment already mounted locally, experts or technicians working for away may need to acquire data from this equipment during their researches. Without internet, they have to go to the local source and recorded data and bring the data back for researches, which is sometimes very inconvenient and even impossible. Use of internet, we can make long-distance DAQ on-line simple, easy, and cheap. Web-based DAQ is the understructure of the machine automation. 2001 NSFC (National Natural Science Foundation of China) Projects Guide lists this topic as one of the recommended research areas in machine automation (NSFC, 2000). The general case of Internet-based data acquisition is that the user logon to the data acquisition Web page in any Internet browser. Then the user is asked to select or fill in the DAQ parameters such as sample channel(s), gain(s), sample frequency, scan frequency, total sample amount, etc., according to requirements. After the user checks out, Web-browser will send these messages to the Web-server. The Web-server then codes these messages and sends them to a data acquisition (DAQ) server, to which the data acquisition board is connected. The DAQ server decodes messages, sets up the DAQ board according to parameters and starts the acquisition process. When the process is finished, the DAQ server sends back the sampled data to the Web-server, which then displays the sampled data on screen for browser in chart or data form, or saves it as a file for user. The sketch map of the system is

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shown in Fig.1.

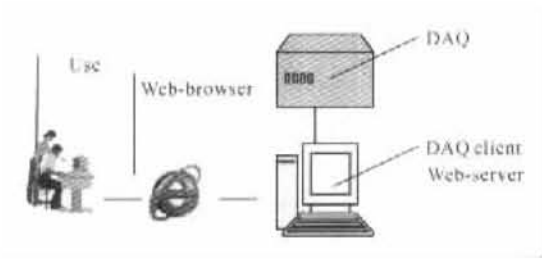

Fig.1 Web-based DAQ sketch map

There are some strong points in this architecture. First at all, it is Web-based. Any user who can reach internet can use it to execute long-distance data acquisition. This technique can be expanded greatly in many areas. For instance, a Web-based expert system can use it directly to tele-diagnose machine faults. Second, it isolates the user from the data acquisition server, where some hardware is installed. This is safe for the equipment, as incorrect hardware setup will lead to error result or even harm the equipment. Isolation of the user from hardware will protect the equipment. Finally, the architecture is friendly to different users with certain level of competence in working with computers. The hardware setup procedure was programmed by an expert in this domain. All general users need to do is to fill up the parameter form, check out the check box in the Web, and write their own application programs. Within industrial production development, such a separation of concerns is crucial for system improvement.

Inside this kind of system, there are several technical issues that need to be solved. The first one is the CGI programming technique. Web-browser uses it to acquire the information that the user checks out and transfers these messages to the Web-server. The acquired results are sent back and displayed in the Web-browser by CGI programming. The next technique used in this system is the Internet programming, or WinSock programming. It builds the connection between the Web-server and the data acquisition server. It is used to send the DAQ command and transfer the sampled data. The last technique used in this area is the suitable DAQ method, which implements the exact data acquisition. The individual techniques mentioned above are all ripe technologies, but their integration together, will give rise to the crucial issue of absence of an integration environment for the software.

The Web-based DAQ system has many requirements. First, the script characteristic of language is most significant in Internet programming. Next, the language should probably be an interpreting language. During the execution of an application through Web, it is inconvenient to re-compile and re-link the code needed. It is strictly required that the task can be executed immediately. Generally the Web-browser, Web-server, and data acquisition server, are located in different place or even different computer platform. It is hard for the user to compile these application programs in different machine. Finally, it should be compatible with normal engineering computing languages. So a great number of existing libraries and engineering toolboxes can be called by the application. In addition, some open-architecture equipment vendors like National Instruments deliver device drivers and application codes written by VB or C. Compatibility with these kinds of language will enhance the utilization ability.

This paper describes the details for realization of data acquisition through the Internet. In our experimentation, a data acquisition board model AT-MIO-16E-10 from National Instruments was used as hardware of the data acquisition system. National Instruments products were chosen because they are popularly used in many industrial automation systems. The National Instruments deliver all of the device drivers and application programs coded by C or C++. The Ch language is used as software integration environment. It is an open architecture integration language environment used for integration of mechatronic systems for agile manufacturing (Cheng, 1995; 1996a), and is an extension and enhancement of the most popular Unix/Windows/C computing environment. As a superset of C interpreter, Ch retains C's low-level features for interface to hardware. Based upon the concept of shell programming, the Ch integration environment is open, modular, and scalable. Functions, commands, and

scripts are the basic building blocks for integration of mechatronic systems. Built-in networking features such as Berkeley sockets and restricted/safe Ch shell provide both flexibility and security for remote operation of mechatronic systems. Ch is designed to be especially suitable for Web-based client/server computing. Ch programs can be used for common gateway interface in the Web-server and as dynamic applets executed through the Web-browser (Cheng, 1996b).

DATA ACQUISITION CLASS STRUCTURE AND OBJECT-ORIENTED PROGRAMMING

Object-oriented programming is getting popular in mechatronic system integration (Mayer, 1991; Han et al, 1998). An "object" is an instance of a concept in the problem domain, and is considered a unit of knowledge concerning any physical or abstract system. In the object-oriented model, the real world is made up of object and messages. An object encapsulates data and provides member functions (or called methods) for accessing data. Each object has a unique name, which other objects use to address it. Objects communicate by sending and receiving messages. Object-oriented programming techniques are usually characterized by encapsulation, modularity, inheritance, and polymorphism. In object-oriented programming, software can be built as components that have standardized application interface. Application program can easily call these components through interface (Sangare et al., 2000). The object-oriented and class features are included in and enhanced the Ch language environment.

In our research practice, all of the device drivers and application programs delivered by Nation Instruments were transferred to a dynamically linked library for Ch calling. We built an AT-MIO E Series based data acquisition class CDaq. Inside this class, all of the internal parameters were defined as private numbers. There were two different kinds of public member functions. One was used for data acquisition system configuration such as sample frequency, scan frequency, trigger method, sample numbers, sample channel (s), channel(s) gains(s), sampling method (continuous or periodic sampling), etc. The other was the sample executing function in charge of data sample and output. Of course, there were some additional functions for error checking and handling. The details of class CDaq is listed in (cie)

CGI AND WINSOCK PROGRAMMING WITHIN WEB-BROWSER, WEB-SERVER, AND DATA ACQUISITION SERVER

The Common Gateway Interface (CGI) is a standard for interfacing external applications with information servers, such as HTTP or Web-servers. A CGI program is executed in real-time, so that it can output dynamic information. For example, let's say that you wanted to "hook up" your database to the World Wide Web, to allow people from all over the world to query it. Basically, you need to create a CGI program that the Web daemon will execute to transmit information to the database engine, and retrieve the results and display them to the client. This is an example of CGI programming. The database example is a simple idea, but most of the time rather difficult to implement. There really is no limit as to what you can hook up to the Web. The only thing you need to remember is that whatever your CGI program does, it should not take too long to process. Otherwise, the user will just be staring at his browser waiting for something to happen. A CGI program can be written in any language that allows it to be executed on the system, such as: C/C++, Fortran, PERL, TCL, Any Unix shell, Visual Basic, AppleScript, etc. It just depends on what you have available on your system. If you use a programming language like C or Fortran, you know that you must compile the program before it will run. If, however, you use one of the scripting languages instead, such as PERL, TCL, or a Unix shell, the script itself only needs to reside in a special directory. Since there is no associated source code, many people prefer to write CGI scripts instead of programs (Li et al., 1999). They are easier to

debug, modify, and maintain than a typical compiled program. Ch is a superset of C interpreter. It is provided with the script language characteristics.

Internet programming, or Socket programming, is another kind of information transfer through Internet. It is used to transfer data between client and server machines. The general process of execution is that the server runs the service program. It allows clients to connect with him through a specified port. When a client requires a connection to the server through this port, and this requirement is acknowledged by the server, a temporary connection is built. Using this connection, the client can send and receive information to and from the server. After having finished the transformation of the information, the server will broke the temporary connection. In our experimental program, we used both CGI and Winsock in one program. Fig. 2 shows the program flow chart.

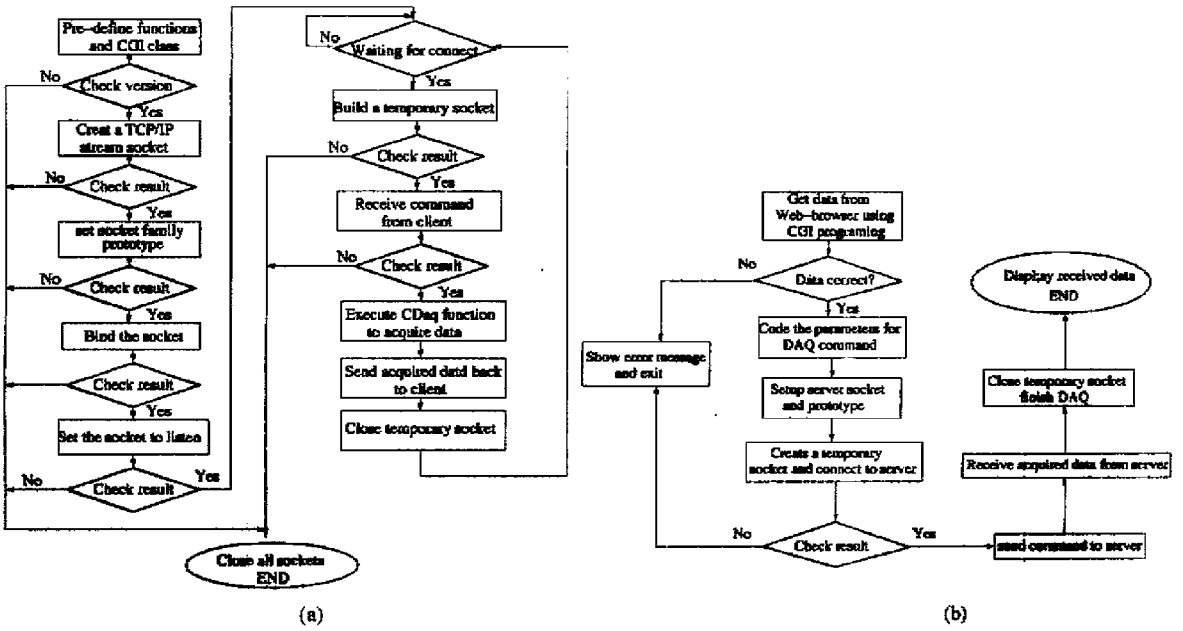

Fig.2 Socket program code flow chart

(a) DAQ server program flow chart; (b) DAQ client program flow chart

EXPERIMENTAL DATA ACQUISITION SYSTEM AND RESULT

We built an experimental Web-based data acquisition system with a Windows OS PC computer and equipped with a National Instruments AT-MIO-16E-10 data acquisition board installed in it functioning as data acquisition server hooked up to the Internet. Another PC computer running under Windows NT was used as Web-server. The experimental program codes and Ch language environment were installed within these two computers. Users can browse the data acquisition Web page, fill in the necessary parameters and execute the data acquisition. The web pages are shown as Fig. 3. In this example, two channels of signals were sampled by the system. The sampling rate of both channels was 400Hz. The scan rate was 1000 Hz. A total of 200 data points were sampled. In our exercise, one channel was connected with a signal generator that produces a continuous sine wave. Another was floating. So it was a random noise signal. The result is shown as Fig 4.

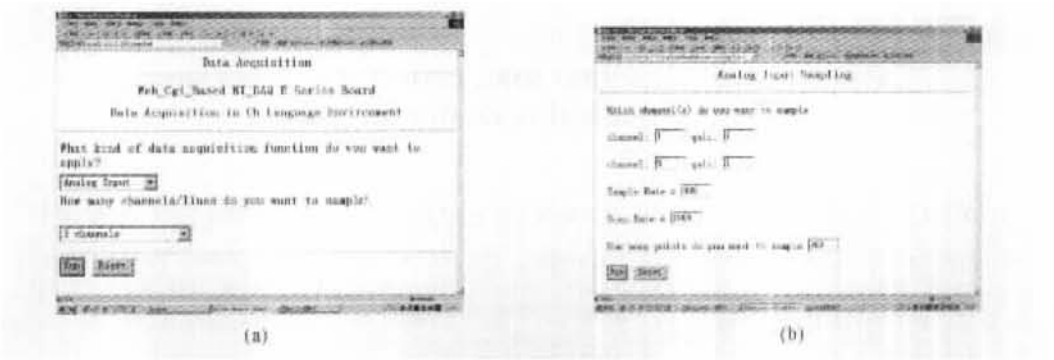

Fig.3 DAQ Web-page
(a) DAQ home page; (b) parameters fill up page

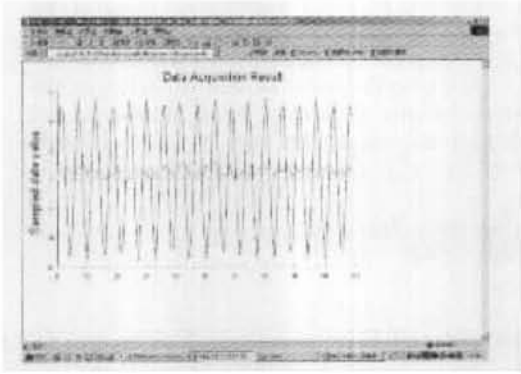

Fig.4 Sample result

CONCLUSIONS

There are many application areas where long-distance data acquisition through Internet is needed. Crucial requirement of this kind of application is a script-like language, which can be used to write CGI and Socket programs, and in meantime can execute general function call and make use of dynamically linked library. Ch is an open architecture integration language environment. It characterizes the script languages. It is an extension and enhancement of the most popular C computing environment, and is suitable for Internet Web-based programming. An example of online data acquisition through Internet using Ch is demonstrated in this paper showing that long-distance online data acquisition through the Internet is available. Users can browse and execute data acquisition through the Web. This method can be used directly in online data acquisition in virtual equipment and can be extended to engineering measures and control through the Internet.

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