Research on Remote Measurement System Based on Computer Network

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Abstract. Rapid development in computer network and automated measurement technologies makes it possible to build a remote measurement system. This paper starts with the requirement of this system. Meanwhile, several different software implementation schemes and network security schemes, which are based on identity authentication and encryption technology, are proposed. In addition, a remote measurement system applying LXI and VPN technologies is implemented and tested. The results indicate that the requirements of both bandwidth and transmission latency can be met easily. The application of this technique is very promising considering the flexibility, cost reduction and other benefits it brings.

Keywords: Computer Network, Automated Measurement, Remote Measurement System, Schemes

1. Introduction
With the development of measurement control technology, more and more measuring instruments can achieve automatic measurement through computer network. Traditional automatic measurement control technology requires that the surveyor and the computer must be located in the measurement field, and the early automatic measurement system also requires all programmable instruments to connect to the same control computer, thus the number of controlled instruments in the measuring system and the spatial range of instrument distribution are greatly limited.

2. Requirements for remote measurement system
The remote measurement control system should consider not only the business functions required by the measurement activities, but also the requirements of monitoring management brought by the operation in the network. Generally speaking, the main functional requirements of such system should include information and functions as follows:

(1) Status information and monitoring functions of remote instrument;
(2) Providing the measuring function of instrument and equipment;
(3) Providing the functions of data analysis and measurement report generation;
(4) Providing the transmission function for measurement reports;
(5) Requirements of safety, handling performance, availability and scalability.
3. Technical solutions of remote measurement system

3.1. Client/Server solution

Client/Server(C/S) is a software architecture commonly used in various large and medium-sized network-computing systems. Under this architecture, computing tasks are logically distributed as the client and service side, which makes it possible to interoperate through network communication technology. The functions of the client side include completing the tasks of interface input, raising processing request to the service side, receiving and displaying the response of the service side. Similarly, the functions of the service side include receiving the client's request, executing the processing logic and returning the processing result to the client side. Measurement and control system of Client/Server architecture is presented in Figure 1.

![Measurement and control system of Client/Server architecture](image)

Figure 1. Measurement and control system of Client/Server architecture

3.2. A scheme based on LXI technology

The previous solutions, which based on Client/Server architecture, deploy the measurement business logic to the control computer in the measurement field, and the measurement result data are also recorded and processed by the computer. In this distributed computing mode, data transmission function is required to transmit measurement data or reports back to the laboratory. If the remote instrument can be connected to the network through the adapter or directly controlled by the computer in the measurement and control laboratory, the tedious network programming or operation setup can be avoided. The advent of LXI technology has made this simple technical solution be possible. Instruments supporting the LXI interface can be directly connected to the LAN and controlled by the measurement and control computer, which is deployed in the same LAN.

There is no need to deploy computers in the measurement field for the remote measurement system realized by LXI technology. For GPIB interface instruments that do not yet support LXI specification, gateway devices can be used to access the LAN, while the devices that already support the LXI specification can be directly connected to the LAN. Eventually, the control computer, which is deployed in the measurement and control laboratory, can realize the control of remote instruments and equipment by transmitting instructions and data through the network.

3.3. Internet access scheme

As the Internet is a public network environment. It is important to ensure the access security of computers and instruments connected to the Internet in the measurement and control laboratory.

Virtual Private Network (VPN) is the technology that uses Internet Network to establish secure Private Network, which has been widely used in enterprise Network and mobile office environment. It is possible to connect the computer networks and personal computers by using the VPN technology, thus we can build a logical enterprise private network. What’s more, VPN technology provides a
variety of identity authentication and transmission encryption mechanisms to ensure the security of these private network channels. VPN technology can be implemented with hardware or software.

4. Remote measurement test system
Several architectures and network plans for remote measurement system are discussed above, as we know, different schemes vary greatly in complexity of implementation, flexibility, price and technical limitations, so after taking all these things into account, it is appropriate to select LXI technology and VPN scheme to implement a remote measurement system based on Internet environment.

The system is designed to calibrate the Agilent 34401A DMM through the Internet in the measurement and control laboratory, similarly, the instrument of Fluke 5720A multifunctional standard source for calibration is also deployed at the measurement site.

As neither the Agilent 34401A nor the Fluke 5720A supports the LXI specification, so we should select the Agilent E5810A LAN /GPIB gateway to connect the two instruments to the LAN at the measurement site. Two Linksys BEFVP41 routers are used to establish the VPN Tunnel between the measurement and control laboratory and the measurement site based on the Internet, as shown in figure 2.

![Diagram of Remote Measurement System](image_url)

**Figure 2.** Remote measurement system based on Internet

5. The experimental results
In the experiment, we select ways of manual, local program control, LAN - based remote control and Internet - based remote control to calibrate, then we can compare data consistency in different ways, and through several Internet calibration test, we can compare the data reversion. During the test, the network bandwidth and transmission delay data are recorded. The experimental results are shown in table 1.
Table 1. Experimental data of remote calibration system

| Standard values (V) | Allowable error limitation (V) | Standard deviation for conformance testing (V) | Standard deviation for repetitive tests (V) |
|---------------------|-------------------------------|-----------------------------------------------|--------------------------------------------|
| Dc voltage (1V)     |                               |                                               |                                            |
| 0.100000            | 1.0E-05                       | 5.8E-07                                       | 6.8E-07                                    |
| 0.500000            | 2.2E-05                       | 1.2E-06                                       | 1.7E-06                                    |
| 0.800000            | 3.1E-05                       | 1.2E-06                                       | 1.0E-06                                    |
| Dc voltage (10V)    |                               |                                               |                                            |
| 1.00000             | 8.0E-05                       | 1.3E-05                                       | 0.0E+00                                    |
| 5.00000             | 2.0E-04                       | 2.4E-05                                       | 1.0E-05                                    |
| 8.00000             | 2.9E-04                       | 3.1E-05                                       | 6.8E-06                                    |
| Ac voltage (1kHz, 1V)|                               |                                               |                                            |
| 0.100000            | 3.6E-04                       | 8.3E-06                                       | 2.0E-06                                    |
| 0.500000            | 6.0E-04                       | 1.1E-05                                       | 2.0E-06                                    |
| 0.800000            | 7.8E-04                       | 1.6E-05                                       | 5.8E-06                                    |
| Ac voltage (1kHz, 10V)|                              |                                               |                                            |
| 1.00000             | 3.6E-03                       | 4.9E-05                                       | 1.7E-05                                    |
| 5.00000             | 6.0E-06                       | 8.2E-05                                       | 4.4E-05                                    |
| 8.00000             | 7.8E-03                       | 5.6E-05                                       | 2.7E-05                                    |
| The peak bandwidth taken up during the transmission (kbps) |       |                                               |                                            |
| Internet            | 44.8                          | 37.6                                          |                                            |
| Internet            | 49.6                          | 43.2                                          |                                            |
| Internet            | 43.2                          | 37.6                                          |                                            |

6. Conclusion
After testing the above remote calibration system, we know that the measured data have good consistency after comparing different calibration methods. The experimental standard deviations of the calibration values are less than 1/5 of the allowable error limited specified in the procedure. What’s more, the bandwidth required for remote calibration of the instrument is very low. The required peak bandwidth is superimposed to about 100kbps in this system. Thus, various mainstream Internet broadband access methods can meet the bandwidth requirements. The transmission delay in the network is less than 300ms, which has no significant effect on the calibration process. In this case, the introduction of computer network into the measurement system can break the limitation of the traditional automatic measurement system in the working area, which may lead to some changes.

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