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Internet Monitoring and Control of Agricultural Storage Facility

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Abstract

To minimize the investment cost of the automation system for agricultural storage houses, the remote monitoring and control methods using Internet were investigated. The local storage facility in a pilot scale (capacity 4.8 m^3) was constructed at outdoor field and installed with a single chip food process controller (SFPC). The SFPC was a stand-alone controller equipped with an RS232C communication device and the measuring modules of the process variables of the food storage house. The storage process variables were equipped with 28 channels of thermometer probes, 2 channels of humidity sensors, and an image sensor. A charge coupled device (CCD) video image sensor was used to capture the images of the working states inside the storage house. The local system, a storage facility, was under the control of a server computer operating under Windows. The data transfer of the process variables of the storage between the SFPC and personal computer (PC) was carried out by RS232C in Windows. A PC under LINUX system was run as a database server using mini-Structured-Query-Language (mSQL). The remote, a supervising computer, under Windows system was connected to Internet. The operating program was composed of 5 programs. The local server control program, Local.exe, was developed for the acquisition and the transport of data, and the control of actuators at the target storage house. Two remote programs, RemoteView.exe and RemoteControl.exe were developed for monitoring and control, respectively. A database program, DataDut.cgi, for the management of the data collected from the storage facility and distribution among the devices was developed. The viewing program, WebView.cgi was developed to monitor the data from the local system through World Wide Web for the remote viewing. The remote automation system using Internet was successfully tested, and its performance was verified at field storage condition with model food loaded.

Key words: food storage, Internet, remote control, monitoring, programming

Introduction

Internet as the World Wide Web is increasingly becoming important in many industries including food and agricultural sectors (Thomas, 1995; Hollingsworth, 1999; Metcalfe, 1999). Even though many web sites are now rapidly emerging as the modern technology in the marketing area of food business, little have been reported in the literatures (Chun, 1998; Kouno *et al.*, 1998). The popularity of Internet in Korea has tremendous impacts on the social structures of the communication networks both in the government and in private sectors. During the last decade, the data transfer rate has steadily increased up to 56 kbps in most districts of Korea. Recently, the technical advances and improvement in the public communication and monitoring structure provide many opportunities for food engineers to study the possibility in Internet applications in food processing areas such as the remote monitoring and control of the food and agricultural factories.

Food processors have to invest around 20% of the total instrumentation cost on the communication facilities for data acquisition and approximated the production lines respectively. In spite of the decreasing communication cost in the public structure, the food industries have not yet turned their attention to the utilization of the public communication tools for their processing lines, main reasons being mostly associated with the security and noise problems. Thus, the food industries have had to construct their own communication system for the factory automation. Banks have been

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successfully expanding their customers access to the bank accounts by introducing security devices and improving data reliability. It suggests that Internet can be applicable to the agricultural storage system in food industry.

The objectives of this paper are to present the hardware architecture needed for the remote monitoring and control method using Internet, and to introduce the development of the operation programs required by the client, the field operator, and the supervising server system in agricultural storage facility.

Materials and Methods

Target system

An agricultural storage facility of pilot scale (4.8 m^3) was built at an outdoor field as the target system to be controlled by a remote supervisor via Internet. A Single Chip Microcontroller Food Process Controller (SFPC) was installed at the local system to carry out the acquisition of storage process variables and activate the actuators of the storage system (Ko and Chun, 2000; Texas Instrument, 1996). The SFPC, a stand alone microcontroller-based controller, provides 10 channels of analog input for the measurements of the storage process variables such as temperature, humidity and light intensity, and also can generate ON/OFF control signals through 10 output channels (Kim and Chun, 1993). It has one RS232C communication port and 5 digits of 7 segments LED display and 16 kbyte EPROM to reside its own operation program written by assembly language (Jun and Chun, 2000). A personal computer, equipped with an overlay board for the image capture under Windows98 operating system, supervised the local system as shown in Fig. 1.

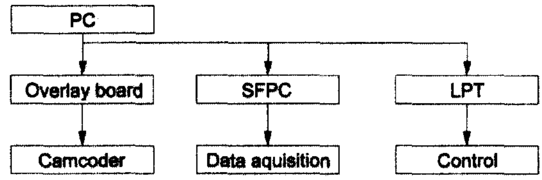

Fig. 1. The hardware architecture of the local system for the management of agricultural storage system.

Remote system

The remote system was composed of a server and client systems. The server system conducted various services such as database, Web, real-time image streaming transfer and real-time remote control. The client system was designed to perform the remote monitoring and control, and to display the still image of the local target system on Web site. For the image transfer to the remote supervisor, Windows98 operating system was used. LINUX operation system was employed for the database server.

Operation programs

For the operation of the server and client systems under Internet environment, five executive programs developed through this study were used to develop the application programs for the remote and local managements of the target system.

Results and Discussion

Construction of the remote Internet control hard-

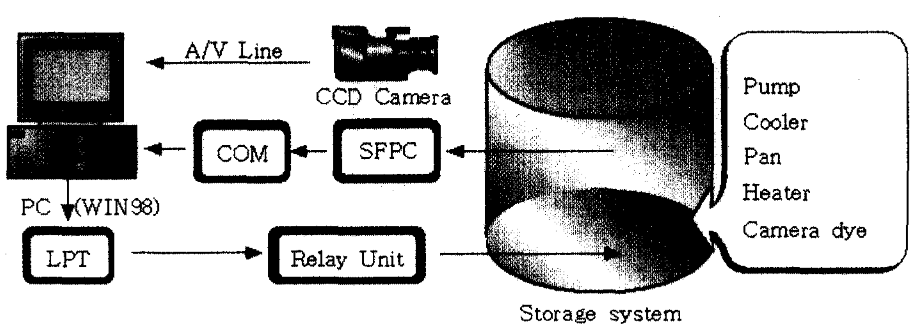

Fig. 2. Hardware composition of the remote Internet control system for agricultural storage facility.

ware for agricultural storage facility

The agricultural storage facility was constructed as illustrated in Fig. 2. The system aimed to capture the images of food commodity under storage and to acquire the storage process variables through 28 channels of thermometer probes (thermister 7 k, Dongkwang Sensor Co., Korea) and 2 channels of humidity probes (SY-HS-200, SamYoung Sensor Co., Korea).

Construction of LINUX server system for the management of database

For the effective management and analysis of the data received from the local system, a server system was developed using a personal computer operating under LINUX. Fig. 3 shows the constructed server system.

Remote data transfer system using Internet

The local target and the database server systems were made accessible by linking then to Internet as shown in Fig. 4.

Construction of the remote monitoring system using Web browser

For an easy viewing using various personal computers with different operation systems, a communication line was installed to accommodate TCP/IP and HTTP. This viewing system was workable only for monitoring of the storage data and images retrieved from database system in the mini-Structured-Query-Language (mSQL) server as shown in Fig. 5.

Construction of the real-time monitoring and con-

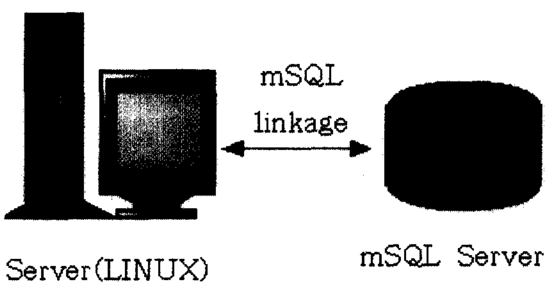

Fig. 3. Hardware composition of LINUX server system for the management of database.

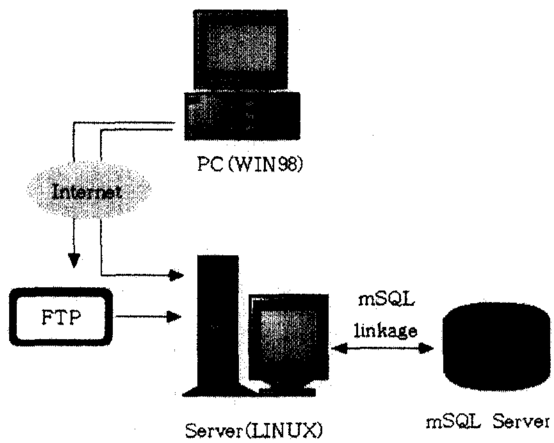

Fig. 4. Construction of the remote data transfer system using Internet.

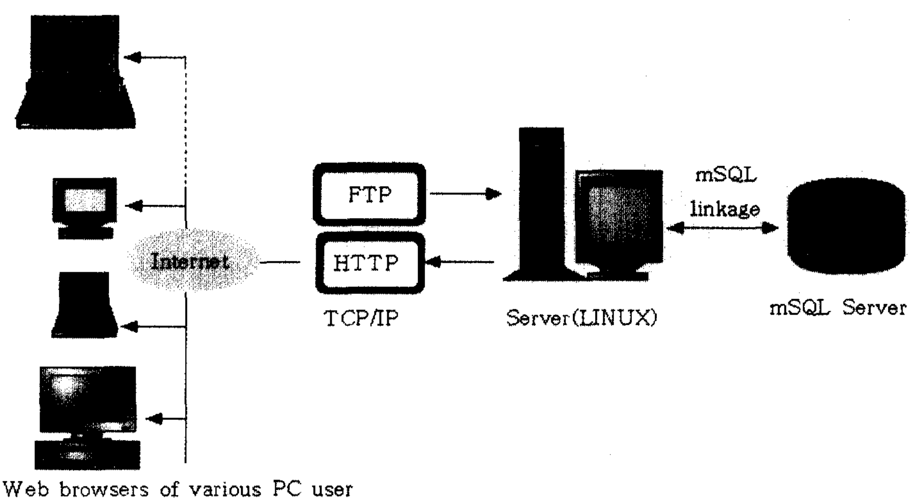

Fig. 5. Remote monitoring system using various Web browsers.

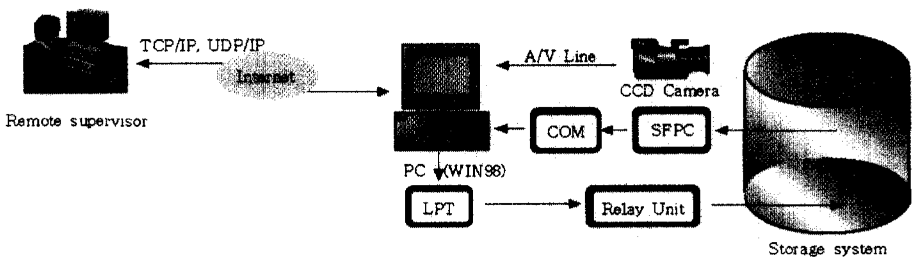

Fig. 6. The real-time monitoring and control system for the supervisor.

Table 1. The operation programs developed for the Internet remote control system

Programs	Specification and functions
Local.exe	Local management program: data acquisition, data transfer and actuator control
RemoteView.exe	Remote monitoring program: real-time streaming image viewer
RemoteControl.exe	Remote control program: real-time access for food storage facility via Internet
DataPut.cgi	Database management program: saving of the process data of the local site at mSQL database
WebView.cgi	Viewing program: monitoring data of the local system through Web browser

trol system for the supervisor

A monitoring and control computer for the real-time monitoring and control of the local target system was provided and linked to Internet as shown in Fig. 6.

The control signal for the automatic control of the local facility was generated from the supervisor and sent through LPT to activate the relay unit for the actuators of the storage house.

Design of the operation software for the Internet remote control system

The design strategy of the operation software was to have one supervisor for overall control of the system and to assign Windows 98 PC of the local site as the principal role in acquiring data from the storage facility and distributing the data to the associated devices. In order to achieve the goal, three executive programs for Windows98 and two common gateway interface (CGI) files for the LINUX server were developed as described in Table 1. The format of the communication data among the system devices was defined according to the TCP/IP protocol.

Development of the local management program

The local management program, Local.exe, was programmed to conduct several functions such as communicating with the SFPC upon requests of data acquisition and control signals for the local target system, the reporting of the processor data to the supervisor, and the connections to the database server.

The program also was composed to announce ON/OFF control logic to the actuators in the agricultural storage facility. The program language was Visual C++, and the size of program was 56 Kbytes as an executive file. Fig. 7 is the overall program flow chart of the local management program which was installed in the local Windows98 PC.

Development of the remote monitoring management program

The remote management program, remoteview.exe, was programmed to carry out the real-time monitoring of the continuous streaming image and the processor data acquired from the local site by executing local.exe. Programming language used was the same as that of local.exe. The size was 35 Kbytes. Fig. 8 shows the communication method between the remote and the local sites. The program allowed only the authorized supervisor's accesses to the system.

Development of the remote control management program

The remote control management program, remotecontrol.exe, was developed to take charge over the control task of the local system on the basis of real-time clock. The programming language used was the same as

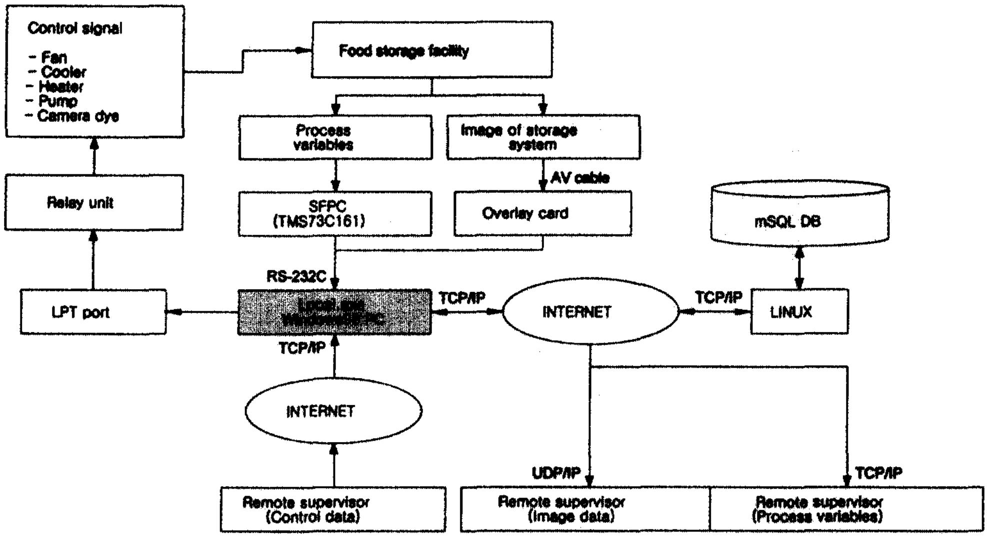

Fig. 7. The overall program chart of the local manage-ment program.

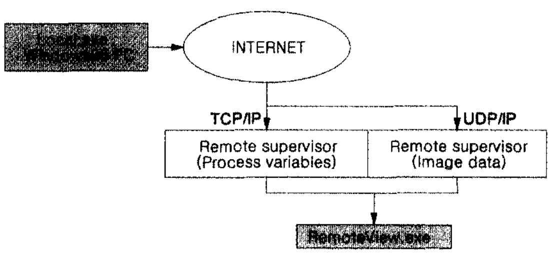

Fig. 8. The communication method between the remote and the local stations.

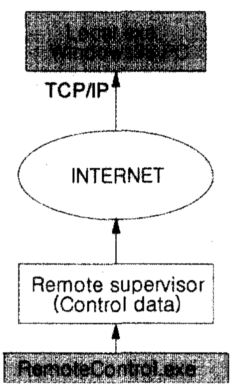

Fig. 9. The control method of the local system from the remote supervisor using Internet.

that of local.exe, and the size of the file was 27 Kbytes. Fig. 9 shows the control method of the local system from the supervising computer in the remote site using Internet. This program also permits only the supervisors to access the system.

Development of the database management program

For the effective management of the data associated with the food storage facility and its environment, a database management program, DataPut.cgi, 3 Kbytes in size was developed and installed in the LINUX server with mSQL database. The database manages only text mode data acquired from the local target. The database table was defined to have 28 fields of integer which were allocated for the measured data: 24 fields for temperature, 2 fields for humidity, 1 field for time, and 1 field for communication port.

For the analysis and processing of the data stored, PERL language and mSQL database programs were employed, respectively. The database can be accessed by the execution of local.exe with the permission of access given by the supervisor.

Web view program

The viewing program in Web site, WebView.cgi, was developed for the remote viewing of the state of the local system including the progress storage of the storing process. The programming tool was the same as that of DataPut.cgi.

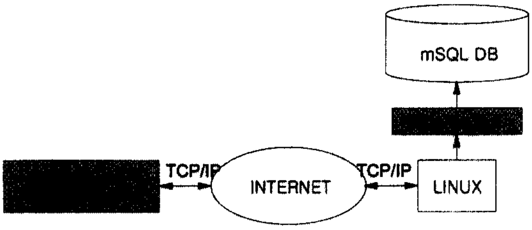

Fig. 10. The flow chart of the database management program.

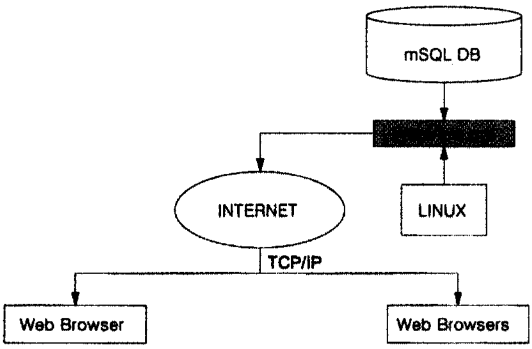

Fig. 11. The flow chart of the Web management program.

Performance of the remote monitoring and control systems

The performance of the hardware and software for the local and the remote systems were successfully conducted. The process data and images obtained from the local target system shown Fig. 12 and 13 illustrates how the system carried out the tasks assigned.

Conclusion

This study was conducted in a pilot scale storage facility and successfully operated for 3 months during the winter of 1999. We could confirm the performance as being very stable and workable in the current public communication structure in Korea. Even though the actual distance between the local and the remote site was 10 m, there is no limitation in distance as long as Internet involved. The supervisor was linked to LAN and switch-board of the public telephone system in Seoul National University, where many users could access. In this environment, the agricultural storage system was secured from the unauthorized access to the supervising system. Even though the immunity against the noise signals from the processing machines was not tested, the feasibility of Internet application for the remote control and monitoring was successfully demonstrated. There was no additional investment cost on the communication system except for a short cable of RS232C

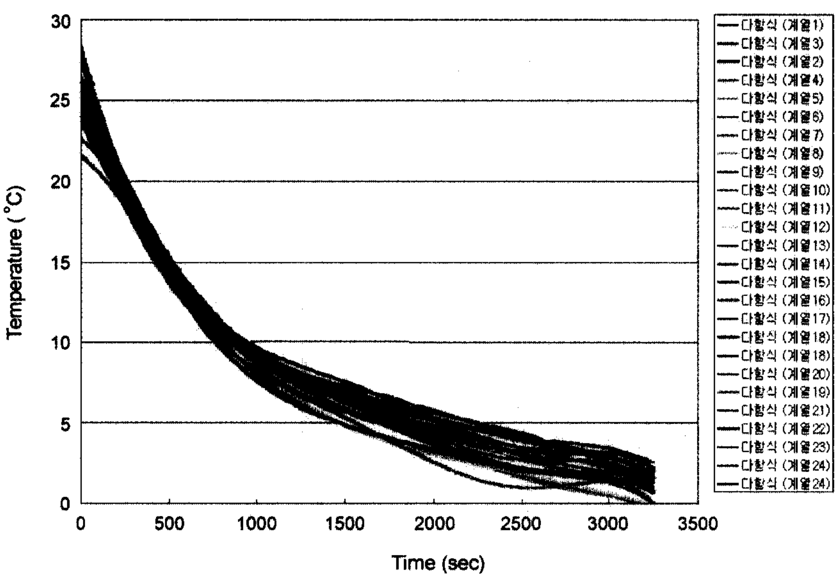

Fig. 12. The monitoring screen displaying the time course changes in temperature at various thermometer probes of the storage house under the remote control using Internet.

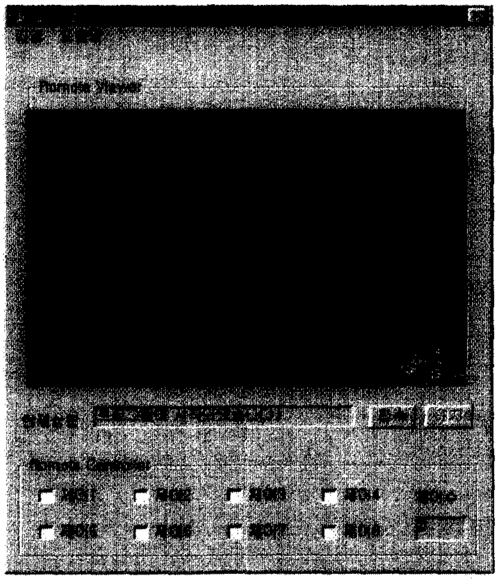

Fig. 13. The picture image transferred from the local site via Internet.

between the local storage facility and the local personal computer.

Acknowledgements

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