A DISTRIBUTED MONITORING SYSTEM UTILIZING CELLULAR PHONE AS GUI

Web-based Application featuring Java technologies

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Abstract: We have designed and implemented a distributed monitoring system. An integrated server of the system is designed to play an intensive role to instruct its subsystems by means of network connectivity. Its subsystems will be organized with, for example, network camera, remote sensors, remote switches and remote-control devices. They can cooperatively work together, obtain out view and internal state of target system, and transfer suitable control signals for that system in order to monitor efficiently. Remote monitoring and remote control are useful for improving system reliability, maintenance and some kinds of security. In order to realize such monitoring and control, Web service with Java technology is available for constructing a distributed monitoring system efficiently. Java programming language is much useful for us to describe smart GUI, system configuration, and network-oriented applications in a short period. Mobile computing devices, especially, wireless portable PC's and/or cellular phones are useful for client users to communicate with monitoring and database server at any place as well as at any time.

1 INTRODUCTION

A distributed monitoring system is developed to realize remote monitoring and control services for system reliability and maintenance. An integrated server is designed to be in the center of our distributed monitoring system and can play a special role to obtain data from distributed sensors and network cameras, cumulate several data as database, extract/select suitable data according to request of data retrieval from clients, and deliver such data into them.

Our server can provide other facilities to do remote control service from clients to scattered control points partially by means of electric power lines and to send urgent messages from server to cellular phones as well as mobile PC's. A prototype of server is implemented on a Linux machine and its software is written in only Java programming language. Software is divided into some modules, which are designed in the way of server-client computing model. Modules for server are written as stand-alone applications of Java, while others for clients are basically implemented as Java applets which are constituted for different kinds of clients, transferred from server to each type of client through HTTP connectivity, and executed on its browser and/or performed by Java virtual machine.

This paper describes general view of our distributed monitoring system including integrated server, its detail services of remote monitoring and remote controlling, and case study for distance experiment prototype.

2 DESIGN OF SYSTEM

Design of system and its performance are to be summarized as follows:

1) Images are taken by network camera, transferred to an integrated server, processed to be resized suitably for each client's display size, stored as

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image database, and retrieved/obtained by remote clients.
2) Remote control services are performed by the following procedures; a request from client arrives to the server, it is deciphered to generate control signal for its according remote control point, its signal is delivered from server to a special-purpose microcomputer-based device, and then hardware logic connected with such a device is switched on or off.
3) Our remote monitoring system provides current information of state data and/or camera image about a noticing target such as factory, office or home, which is separated away from client.
4) Though the above monitoring facilities, users of our system can investigate how their targets work correctly in order to keep their targets under observation.
5) If some troubles happen, our system can send urgent messages to the pre-registered clients with wireless communicating service, and then shut the electric power off automatically by means of its remote control facility, if necessary.

3 SYSTEM CONFIGURATION

Figure 1 shows an overview of distributed monitoring system, which includes some network cameras, a specific control server named Open PLANET server, and "Integrated Server". And moreover system contains some kinds of client machines, which are denoted as "Note PC" and "Cellular Phone" illustrated in the above figure. These servers and client machines are interconnected by means of the internet and partially private network.

3.1 Overview of Prototype

Our integrated server can periodically obtain several kinds of images from network cameras, which are located in LAN, by means of Web service, store them in its internal buffer as database and transfer them according the request of the specific clients of global network. Our server can also provide some remote control services for electrical devices in the internal network in response to the message from global client. Utilization of Web service and Java Applet can facilitate some useful GUI mechanism for users to handle our monitoring system. Overview of service from integrated server is summarized as follows:
1) User of client, at first, accesses the home page of integrated server with web browser.
2) Our Java applet stored in our server is downloaded into the web browser of client and begins to work in it.
3) That applet allows communications between user of client and integrated server.
4) Images are transferred from our server into client and are displayed on the browser, namely, some users can recognize state view of targets on their cellular phones.
5) User's request of control may be performed for specific electrical device on the internals.
6) An emergency message is carried into certain users by means of e-mail system and/or cellular (mobile) phone service, so that pre-registered users can receive the message on ones cellular phone

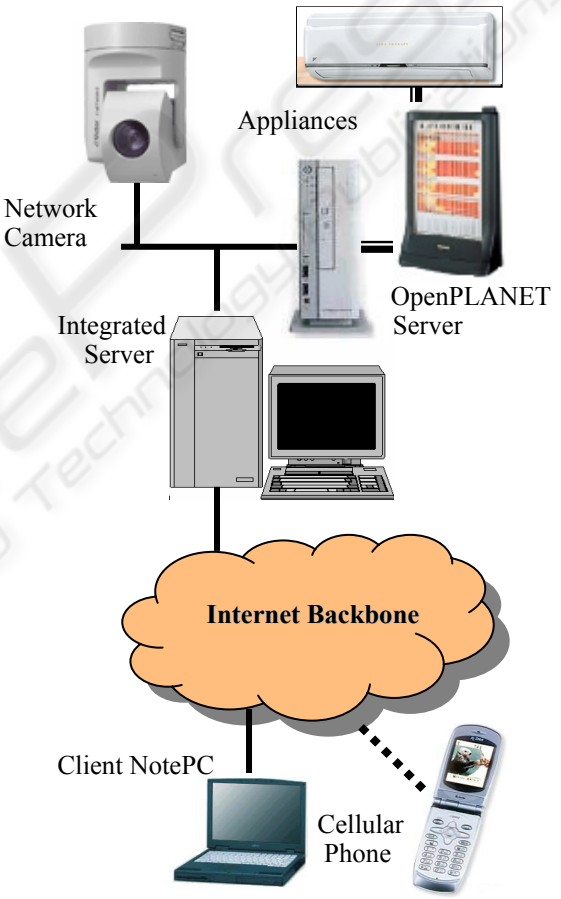

Figure 1: An Overview of Distributed Monitoring System

3.2 Image Transmission Service

In order to realize remote monitoring, it is completely necessary to obtain several kinds of images. Although animated (moving) pictures would be much more effective to piece out the situation than stationary ones, our system can only deal with continuously stationary pictures still now. Integrated

Server requires network camera to transmit JPEG images at a sampling rate, receives such an image, reduces a size of image and accumulates a series of them in the storage. Server also prepares Java Applet on the homepage in side of it for Web service, begins to run the process of http daemon (Apache), waits for clients' access from global network and then delivers such an Applet to the target client. Figure 2 shows a scheme of our remote monitoring procedure.

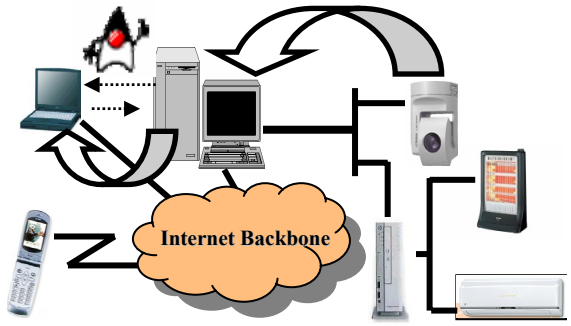

Figure 2: A Scheme of Remote Monitoring Procedure

At the side of client, Java Applet downloaded form our server provides a GUI which communicate server to requests transmitting JPEG image by means of HTTP connection and display received JPEG data on the browser in the mode of stationary image or continuously alternating images like as slide show. In the case of later mode, the applet obtains JPEG data from server in advance, stores and preload in the double-buffering style, and realize quasi-moving picture on the display of PC's browser. JPEG data from the server can be also seen on the LCD of cellular phone. Detail will be described later.

3.3 Remote Control Service

Remote control service seems to be essential for supplementing remote monitoring service and enlarging it into wide application. Various control mechanisms were proposed and this time we employs remote power switching facilities as remote control, which is based upon the Open PLANET technology and has been developed by Shikoku Electric Power Company Ltd. It has some excellent characteristics, one of which is to transmit digital information from node to node through the electric power lines.

The Power Consent Adaptor (PCA) is the special-purpose power outlet based upon the Open PLANET technology, which can turn on or off electric power according to control signal from remote controller via electric line. The Open PLANET server provides remote control facilities to do power switching by means of transmitting control signal for digital information into the PCA.

Our Integrated Server has a connection with such an Open PLANET server, sends and receives socket-based messages to/from such a server, and performs remote control service for electric power switching through the private networking. Communication between our server and an Open PLANET server is carried out based on TCP/IP protocol and software for their communication is realized with Java programming. Java codes can be executed not only on our Integrated Server but also on an Open PLANET server. And moreover almost software of our server has been written with Java programming language.

The merits of employing the Open PLANET technology are summarized as follows:

1) No additional cabling is necessary to realize remote power switching, because control signal can be transmitted via electric power line.

2) No additional remodelling of target device to be controlled is necessary, because the PCA is equipped between such a target device and according conventional power outlet.

Client users can enjoy remote control service from Integrated Server if they request Java Applet download from the server to do power switching. Such an Applet communicates with its server to allow an Open PLANET server to perform the above control mechanism. Figure 3 shows a scheme of our remote controlling procedure.

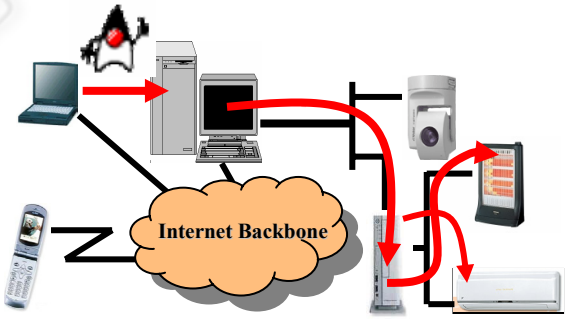

Figure 3: A Scheme of Remote Controlling Procedure

3.4 Message Mailing Service

Users whose e-mail addresses have been entered in our Integrated Server can receive e-mails about some kinds of message from the server, when monitoring system recognizes whether a situation of target system needs sending message, for example, emergency, to client or not.

Our message mailing service can cover two following cases:
1) Normal e-mail transmission service, which includes sending message to such personal computers connected to LAN, and
2) Mobile e-mail transmission service, which deals with cellular phone and PHS (Personal Handy phone System) via global communication network.

In the former case, generally speaking, an e-mail is one of the most usual message transmission methods between computer's users of LAN and the internet. And the message to be sent may contain description of a special URL, which tells users to get information about image, control scheme and Java applet. With such information, clients can access a suitable resource for them to steer the monitoring system efficiently.

On the other hand, clients sometimes leave their seats where they sit down and work with computers. They will carry cellular phones or PHSs with them, however, even at such a situation. In the later case, cellular phones including PHSs provide wide area of e-mail service to clients, so that message from server can be delivered to the target clients no matter where they are. It is very much useful for an emergency message to be sent to clients when monitoring system and clients decide to utilize e-mail service of cellular phones and PHSs. Figure 4 shows a scheme of our message mailing service.

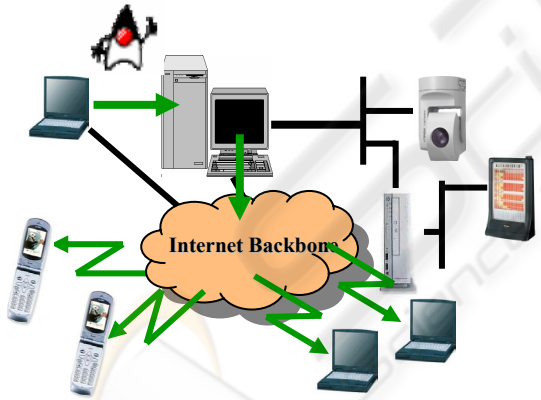

Figure 4: A Scheme of Message Mailing Service

3.5 JPEG Image on Cellular Phone

With Java Applet, clients can browse monitoring quasi-moving image obtained from Network Camera on their browser of PC through Integrated Server. But it has seemed to be more effective and more convenient for clients to browse such images with their cellular phones, because almost people of Japan always carry their cellular phones with them.

Some kind of Java technology allows us to utilize small sizes of Java Applet on specific cellular phones, and then it can be downloaded from a certain Web server into cellular phones and perform a mobile communication based on HTTP connection between them.

Integrated Server has prepared such a Java Applet on its homepage, deliver it into clients' cellular phone according their requests, and communicate it in order to transmit monitoring images and allow cellular phones to browse them. As there are some constraints on the image data size, which one time cellular phones can accept, for both of transmission and display of it, then our Server must reduce data size of JPEG images from network camera into a suitable size for cellular phones and accumulate these images in its storage for request of image delivery from cellular phones.

Figure 5: Monitoring Image on a Cellular Phone

Figure 5 shows a sample view of monitoring image on a cellular phone, which is delivered from Integrated Server. Frankly speaking, it is a view of a display image from CLDC (Connected Limited Device Configuration of J2ME) -based Java application emulator for a certain cellular phone. In order to reduce useless traffic cost between cellular phone and Integrated Server, client of cellular phone

must make sure to push the bottom for obtaining the next image from Integrated Server

4 EVALUATION OF PROTOTYPE

As described in the previous section, our prototype system of Integrated Server can provide several kinds of services such as image transmission service, remote control one, message mailing one and Java applet delivery one, which facilitates browsing JPEG image on the LCD of cellular phone. This section describes the current state and evaluation of our prototype system.

4.1 The Current System of Prototype

Clients of PC, for example, access the homepage of prototype of Integrated Server, download Java applet onto PC's browser and let it perform a series of applications; simultaneously, displaying a series of monitored JPEGs as quasi-moving picture on the browser, providing a control facility for electric power switching by selecting bottoms (On/Off), and sending message to the specific e-mail address by means of internet and cellular phone e-mail services.

With Java applet downloaded from server, Figure 6(a) shows a sample of quasi-moving picture on the up side of browser, where the lump has turned off at first.

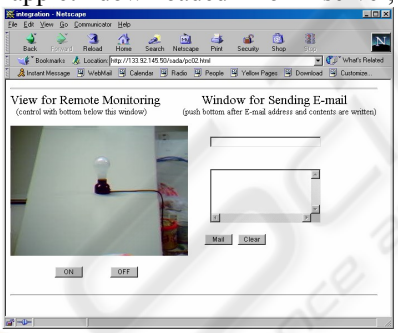

Figure 6(a) Scene before power is controlled

After pushing the left-hand bottom at the left side of browser, the request of client is interpreted by the applet and transmitted to the server through the internet. It is accepted, processed and converted into a message packet to an Open PLANET server in order to switch on the lump. The Open PLANET server generates digital signal according to the message packet, directly control the PCA connected to the lump and make the lump turn on.

When the lump turns on, the picture of it has been taken by network camera, transferred into Integrated Server, and accumulated as JPEG images in its storage. The Java applet downloaded into client has obtained a series of picture data from Integrated Server automatically and display the according JPEG image on the browser, which is shown in Figure 6(b).

By the way, there are two blank text fields at the right side of browser view shown in Figure 6. When an e-mail address and content for mail are described in these text fields respectively, pushing the bottom to send at the left hand below the text field can allow such an e-mail to be transmitted into the according e-mail address. This e-mail service can be provided not only for client with connection of wired LAN and the internet but for client with mobile device such as cellular phone.

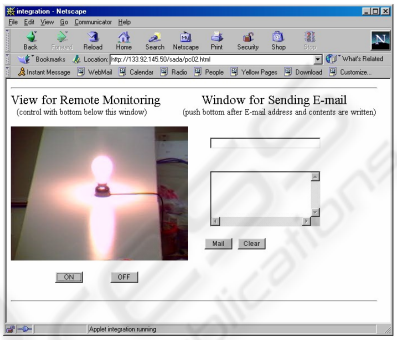

Figure 6(b) Scene after power is controlled

4.2 Evaluation of the Current System

At the present of our prototype system, the following services are available in the distributed monitoring system;

1) Image Transmission Service:

A series of JPEG image file can be periodically taken by network camera, transmitted into Integrated Server, and accumulated with simple image resizing procedure in the storage of that Server. Request to obtain the buffered image in the Server causes transmission of such image into the browser of client PC, process of Java Applet for downloaded images, and display images on the browser in the manner of stationary picture and/or quasi-moving picture.

2) Remote Control Service:

The Open PLANET server can perform remote control for electrical device through electric power supply line. Our monitoring system has incorporated this server into the lower layer of Integrated Server in the private network, which means that system permit no direct access into the Open PLANET server from global network. Integrated Server communicate to ask the Open PLANET server to perform the control service according to the request to control several kinds of electric device and appliance.

This strategy has a week point that control service is heavily dependant on the function of Open PLANET technology as well as a benefit that system is able to block an illegal access for some kinds of power control from global network effectively.

3) Message Mailing Service:

Mailing procedure of our system may cover from wired e-mail service for LAN and the internet to wireless (mobile) packet message transmission based on cellular phone global network. As clients can select their better media which receives a message sent from Integrated Server, mailing service of our system is sufficient for practical usage.

4) Display Image on LCD of Cellular Phone:

This facility is only available in cellular phones of Japan from the specific carrier, namely NTT DoCoMo. Although NTT DoCoMo, for example, is one of the major carrier of Japan, we must do best efforts for our system to be more applicable in order to utilize other kind of cellular phones from other carriers of foreign countries.

Current LCD size of cellular phone seems to be not suitable to display the image for remote monitoring. Of course, cellular phone is very much convenient to be carried with user, so we must expand the facilities of our system such as zooming and scrolling for small image and/or large one.

In the very near future, we must develop Java programs for CLDC+MIDP (Mobile Information Device Profile) -based cellular phone in addition of *i-mode* Java programming application for NTT DoCoMo.

5 CONCLUDING REMARKS

We have described design and tentative implementation of a distributed monitoring prototype system. This prototype has been available to obtain image from network camera, perform power switching for electrical device and appliance and so that it can ensure reliable use of electric and/or mechanical systems. Our monitoring system contains some kinds of servers: Integrated Server is designed to play an intensive role to instruct and integrate its subsystems and sub-servers by means of network connectivity.

In our work, Web-based application style and Java programming are essential keys to allow our system to be much useful to describe several server programs, smart GUI's for PC's and/or mobile phones, and network-oriented applications efficiently. Instead of Integrated Server, many subsystems are organized, for example, network camera, remote sensors, remote switches and remote control devices. They can cooperatively work together to realize distributed monitoring system.

Mobile computing devices, especially, wireless portable PC's and/or cellular phones are useful for client users to communicate with monitoring and database server at any place as well as at any time.

Remote monitoring and remote control are useful for improving system reliability, maintenance and some kinds of security. In order to realize such monitoring and control, is available for constructing a distributed monitoring system.

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