Multi-Channel Housing Monitoring System

Yeong-Yil Yang, Young-Sik Park, Hyun-Jong Lee, Young-Ho Choi, and Jong-Chul Lee

***Abstract*—**In this paper, we propose multi-channel housing monitoring system based on Ethernet and 3G/4G mobile communication for monitoring and controlling the housings installed all over the city. We designed and developed the monitoring program and the embedded system which is installed in the housing. The environment of the housing, such as temperature, humidity and impact can be monitored and the equipment in the housing can be controlled through either Ethernet or 3G/4G mobile communication. When one of communication channels is disconnected, our system communicates through the other communication channel. Sixty embedded systems are installed all over JinJu City and the monitoring program is installed on the server at JinJu City hall. It's working normally.

***Keywords*—**3G/4G, Housing, Monitoring System, Multi-Channel, Smart Phone.

I. Introduction

There are many CCTV(Closed-Circuit Television) cameras installed in the world. There are 550,000 CCTV cameras in Korea in 2014 [1]. CCTV cameras are installed for the crime prevention, the fire prevention etc. The recorded contents form the CCTV camera can be delivered to CCTV monitoring center in real time and it is also stored in storing device in the housing near the CCTV camera. Because CCTV camera for the crime prevention is installed to prevent the crimes, it takes a picture of every person even if they are not involved in the crimes. The recorded contents should be kept securely for the protection of the private life. Therefore it is important to monitor the housings in which recorded contents is included. To monitor the housings, embedded systems installed in the housing should communicate with the monitoring server, i.e. the housing monitoring program. The monitoring program should monitor the temperature, the humidity, the impact, and the lock/unlock state of the housing. If the door of the housing is opened, the embedded system should generates the events to the monitoring program. The system developed for monitoring objects communicates through Ethernet only [2].

The housing can be placed on the summit, the valley and the island where the internet is not reached. When the connection between the server and embedded systems is disconnected, there is no way to monitor the housings. Even if simple initialization of the system, it takes a long time to repair the system because the operator should handle the problem directly by visiting the housing. In Ref. [3], the framework for monitoring and controlling the remote system using smart phone through 3G/4G mobile communication is suggested.

Diversification of communication channels is inevitable trend of the development for monitoring and remote control of the remote systems, home appliances, robot control [4], [5]. As in Ref. [4] and [5], traditional remote control system is mainly focused on multi communication channels between the control center and the user, not between the control center and the remote system.

In this paper, we propose the framework which uses multi communication channels between the monitoring program and the embedded systems. Our system called multi-channel housing monitoring system communicates through Ethernet and 3G/4G mobile communication. When one of communication channels is disconnected, our system communicates through the other communication channel. Also, it's possible to communicate through only one channel, Ethernet or 3G/4G mobile communication.

The framework of multi-channel housing monitoring system will be explained in section II. In section III, the implementation of the proposed system is described. Testing and conclusion are given in Section IV.

II. Framework of Multi-Channel Housing Monitoring System

Multi-channel housing monitoring system consists of two parts, the monitoring program and embedded systems. Fig. 1 shows the dataflow of the housing monitoring system. The monitoring program runs on the computer at the control center, mainly at the control center of the city hall. *H1*, *H2*, ⋯, and *Hn* in Fig. 1 represent the embedded systems which are installed in the housings which contain recording contents and equipment. The monitoring program sends commands to the embedded system, which are represented with the dotted line in Fig. 1. The commands can be classified into two groups. One is the commands for checking the environment of the housing, such as

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the temperature, the humidity and the impact and so on. The other is the commands to control the power of equipment and to lock or unlock the locker of the housing. The embedded system sends the data and the events which are represented with the solid line in Fig. 1. If there is a request from the monitoring program, it sends the data acquired at sensors. Even if there is no request from the monitoring program, it sends the data periodically. If the problem happens to the housing, it generates events to the monitoring program in real time.

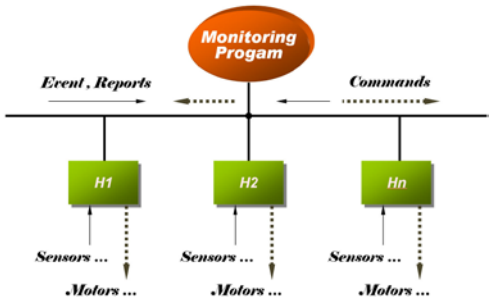

Fig. 1 The dataflow of the housing monitoring system

As shown in Fig. 2, the data between the monitoring program and embedded systems is transmitted through Ethernet and 3G/4G mobile communication. The embedded system has two communication ports, Ethernet port and the OTG(On-The-Go) port. The embedded system can access the internet by connecting LAN(Local Area Network) cable to Ethernet port. Therefore the embedded system can transmit the data to the server which is connected to the internet. The other channel is 3G/4G mobile communication channel. The smart phone in the housing is connected to the embedded system by the OTG cable. The app running on the smart phone communicates with the embedded system through the OTG cable, represented with the solid line between the smart phone and the embedded system in Fig. 2. Also, the app running on the smart phone communicates with the app server through 3G/4G mobile communication, represented with the dotted line between the smart phone and the app server in Fig. 2. The app server transmits the data to the monitoring program running on the server. In addition, the app running on the smart phone provides the functions which the embedded system could be controlled directly by.

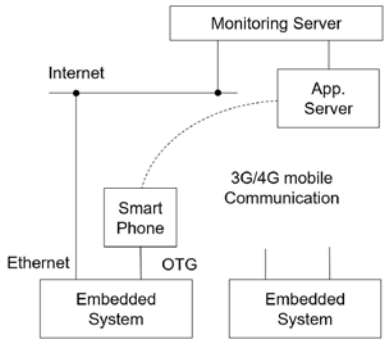

Fig. 2 The overview of multi-channel housing monitoring system

III. Implementation of Multi-Channel Housing Monitoring System

To implement multi-channel housing monitoring system, we designed and developed the monitoring program running on the server, the embedded system, the app running on the smart phone and the app server.

A. Monitoring Program

The monitoring program monitors the housing automatically and provides functions to control the housing. The main functions of the monitoring program are as follows.

- Communicate with embedded systems through either Ethernet or 3G/4G mobile communication.
- Provide monitoring environment of the housings.
- Check the state of the housings periodically and data renewal.
- Handle the events coming from the housing and make alarm on the window of the monitoring program.
- Provide functions to control equipment in the housing, which are to control the power of equipment and to lock or unlock the doors of the housing.

Fig. 3 shows the main window of the monitoring server. The icons which are listed on the upper side of the window provide various functions needed to monitor the housings. The monitoring program provides three kinds of viewing modes, *map view mode*, *list view mode* and *icon view mode*. In *map view mode*, housings are displayed on the map as shown in Fig. 3(a). Fig. 3(b) shows the window of *list view mode*. The housings installed are listed one by one at each row. Fig. 3(c) shows the window of *icon view mode*. Each icon represents the housing, whose information is represented on each icon.

Fig. 3 The main window of the monitoring program

The dialog box shown in Fig. 4 is popped up when the housing displayed on the window is clicked, which shows the information for the selected housing. The operator can monitor and control the selected housing. The dialog box consists of three parts. The location of the housing is displayed on the map at the left part of the dialog box. The central part displays the state of the lockers of doors, the door at the front side and the door at the back side. The locker of the door can be controlled by clicking Lock/Unlock buttons on the dialog box. The right part of the dialog box displays the temperature, the humidity and the impact. The power of all the equipment can be controlled independently by clicking ON/OFF buttons. The events which are generated at the embedded system when the unexpected situation occurs at the housing is displayed on the window in real time.

Fig. 4 The dialog box displaying the information of the selected housing

The monitoring program is developed with Eclipse IDE for Java Developers [6]-[8]. The database is designed with SQLite.

B. Embedded system

The embedded system acquires the data from the sensors such as the temperature sensor and the humidity sensor and so on. The main functions of the embedded system are as follows.

- Communicate with the monitoring program through Ethernet and the smart phone.
- Acquire the data from the sensor and send the acquired data to the monitoring program.
- Turn the fan of the housing on when the inner temperature of the housing is higher than predefined temperature.
- Power equipment up or down according to the commands from the monitoring program.
- Lock or unlock the locker of the doors of the housing according to the commands from the monitoring program.

The embedded system sends alarm messages to the monitoring program if emergency situations occur.

- The temperature in the housing is higher than the limited temperature.
- The door of the housing is opened unexpectedly.

Fig. 5 shows the block diagram of the embedded system. As shown in Fig. 5, it consists of 4 modules.

- *Processing module*: Control the embedded system.
- *Sensor module*: Acquire the data from the sensors such as the temperature sensor, the humidity sensor, the impact sensor and the magnetic sensor to check the door state and the sensors of the locker.
- *Driving Module*: Generate signals to drive the relay to power equipment up or down in the housing and signals to lock or unlock the locker of the doors of the housing.
- *Communication module*: Send and receive data through two communication ports, Ethernet port or the OTG port where the smart phone is connected

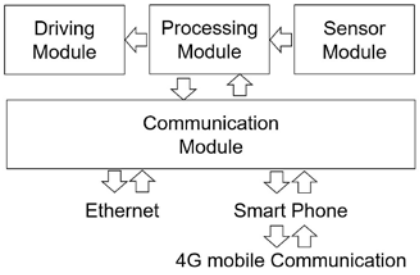

Fig. 5 The block diagram of the embedded system

Fig. 6 shows PCB(Printed Circuit Board) of the developed embedded system.

Atmega128 is used as the CPU of our system. The firmware is developed with AVR Studio.

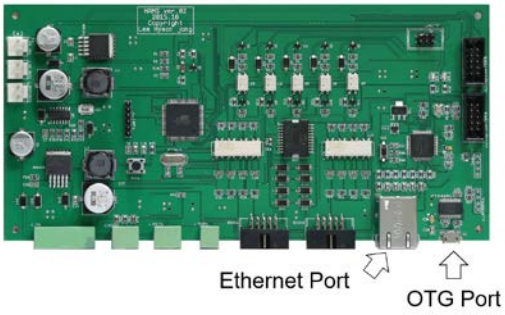

Fig. 6 Developed PCB of the embedded system

C. App running on the smart phone

Fig. 7(a) shows the connection between the embedded system and the smart phone and Fig. 7(b) shows the window of the app running on the smart phone. The main functions of the app running on the smart phone can be classified into two.

- Communication channel between the embedded system and the app server.
- Providing the functions to monitor and set the parameter of the embedded system. The embedded system can be

monitored and controlled through the app on the smart phone. Also the parameter of the embedded system such as IP address can be set through the app on the smart phone.

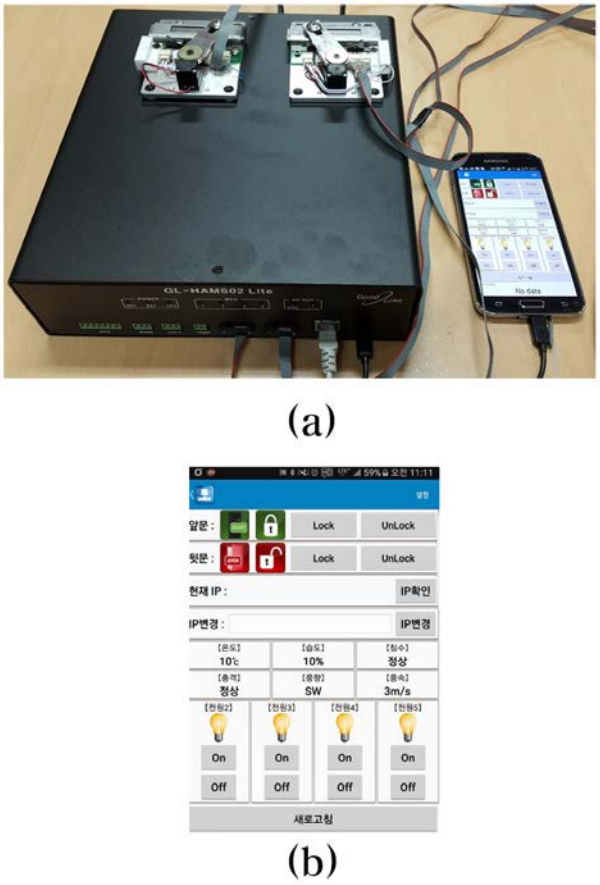

Fig. 7 (a) The connection of the smart phone, and (b) the window of the app running on the smart phone

D. *App Server*

As shown in Fig. 2, the app server communicates with the app running on the smart phone. The app server program runs on the computer which the monitoring program runs.

- Send the commands received from the monitoring program to the smart phone
- Send the data or the events coming from the smart phone to the monitoring program.

IV. Testing Of Monitoring System And Conclusion

Fig. 8 shows the test of implemented multi-channel housing monitoring system when the data is transmitted through Ethernet. In fig. 8, thirty embedded systems and the server computer which the monitoring program runs on are connected to router. We tested the embedded system several days before release.

Fig. 8 Test of multi-channel housing monitoring system

We installed multi-channel housing monitoring system at JinJu City. Sixty embedded systems are installed all over JinJu City and the monitoring program is installed on the server at JinJu City hall last November. It's working normally. About 100 more embedded systems will be installed this year at JinJu City.

We are improving our system to expand the application area in several aspects.

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