Multi-Agent Cloud System for Remote Housing Management

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Abstract: - In this paper, we propose multi-agent cloud system called *HAMS*(*Housing Automatic Management System*) for monitoring and controlling the housings installed all over the city through Ethernet or 3G/LTE mobile communication. We designed and implemented the cloud system to control and monitor the housings. The data in the cloud can be accessed on agents which are client PCs or smart phones. The environment of the housing, such as temperature, humidity and impact can be monitored on agents and the equipment in the housing can be controlled on agents. Our multi-agent cloud system is installed in several cities such as JinJu City, Namhae City and Hapcheon City in Gyeongsang Namdo Province in Korea and so on. It's working well.

Key-Words: - 3G/LTE, Cloud System, Housing, Monitoring System, Smart Phone, CCTV

1 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 and the fire prevention, etc. The recorded contents from the CCTV camera can be delivered to 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 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. In Ref. [2], multi-channel housing monitoring system is proposed, in which the embedded system installed in the housing communicates with the monitoring program at the control center, through Ethernet and 3G/LTE mobile communication. The monitoring program can monitor the temperature, the humidity, the impact, and the lock/unlock state of the door of the housing. Also, if the door of the housing is opened unexpectedly, the embedded system generates alarm signals to the monitoring program. In the previous system [2], the housings can be monitored only at the console of the monitoring server.

CCTV cameras can be managed at different divisions in the city hall according to the purposes of the usage of CCTV cameras such as crime prevention and fire prevention and according to the region where CCTV cameras are installed. It should be possible to monitor the housing at several PCs. When the emergency situation occurs at housings such as the unexpected open of the door of the housing and temperature rise more than the limited value, the alarm signal should be sent to the operator in real time. If housings can be monitored only on the console of the server at the control center, the operator should always watch the console to handle emergency situations immediately. The monitoring program on the smart phone would make it possible to monitor and control the housing at any place and at any time. The diversification of communication channels between the control center and the remote control system is inevitable trend of the development for monitoring and remote control of remote systems, home appliances, robot control [4]-[6].

In this paper, we propose multi-agent cloud system for remote housing management called *HAMS*(*Housing Automatic Management System*). Our system provides cloud environments to monitor

and control housings. In our system, the monitoring program at the control center communicates with the embedded systems in housings. Housings can be monitored and controlled at the client PC and the client smart phone called agents We developed the monitoring program running on the client PC and the app running on the client smart phone, which access the monitoring program at the control center. The monitoring program at the control center and embedded systems communicate through Ethernet and 3G/LTE mobile communication. When one of communication channels between them is disconnected, system communicates through the other communication channel.

The framework of multi-agent cloud system for remote housing management will be explained in section 2. In section 3, the implementation of the proposed system is described. Finally conclusions are given in Section 4.

2 Framework of Multi-Agent Cloud System

Fig. 1 shows the framework of proposed multi-agent cloud system for remote housing management called *HAMS*(*Housing Automatic Management System*). The multi-agent cloud system consists of three parts, embedded systems, monitoring server and agents which are client PCs and client smart phones. The blocks H_1, H_2, ⋯, and H_n in Fig. 1 represent the housings which embedded system is installed. In Fig. 1, the monitoring program runs on the monitoring server which is the computer at the control center. In Fig. 1, the shaded area including the monitoring server and embedded systems are the cloud in our system. There are two kinds of agents, the client PC and the client smart phone. We developed the monitoring program which runs on client PCs and client smart phones. The solid arrow in the cloud in Fig. 1 represents the commands sent to the embedded system and the solid arrow outgoing from agents represents the commands sent to the monitoring server. The commands can be classified into two groups. One is the command group for checking the environments of the housing such as the temperature, the humidity and the impact and so on. The other is the command group for controlling the housing. The dotted arrow in the cloud in Fig. 1 represents events or reports generated from the embedded system and the dotted arrow from monitoring server to agents represents the events or reports sent to agents. The embedded system sends the state of the housing and the data acquired at sensors. If the problem has been detected at the housing, it generates alarm signals to the monitoring server in real time and the monitoring server sends received alarm signals to agents. If a change happens in the states of housings, the monitoring server sends data to agents for updating the display information of agents.

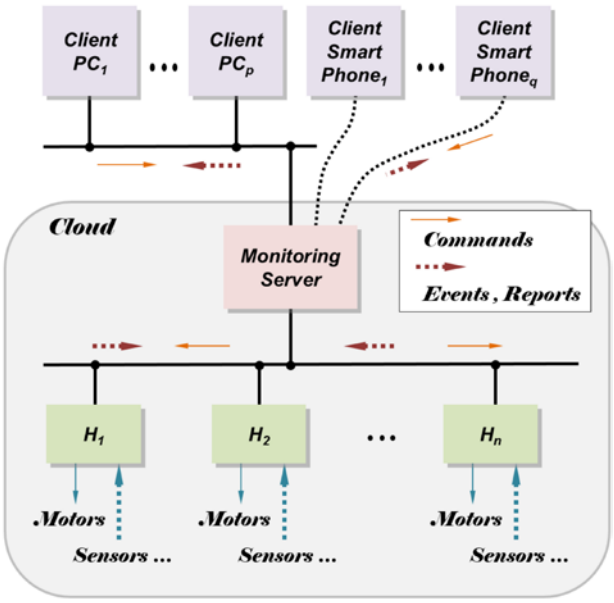


Fig. 1 The framework of multi-agent cloud system of remote housing management.

Fig. 2 shows the dataflow of multi-agent cloud system. The shaded area in Fig. 2 is the cloud in our system. All data of the system, *cloud data*, is stored in the monitoring server. The middleware in Fig. 2 is the gateway in the cloud. There are four communication ports in the middleware. Two ports are used for embedded systems and other two ports are used for agents. *HMP*(*Housing Monitoring Program*) in Fig. 2 is the monitoring program running on the monitoring server in Fig. 1. The monitoring program *HMP* communicates with embedded systems in the housing through Ethernet and 3G/LTE mobile communication. The embedded system has two different communication ports, Ethernet port and the OTG(On-The-Go) port. The embedded system can be accessed through the internet by connecting LAN(Local Area Network) cable to Ethernet port of the embedded system. Therefore the embedded system can transmit the data to the monitoring program *HMP* through the middleware in Fig. 2. The other port is 3G/LTE mobile communication port. The smart phone in the cloud in Fig. 2 is placed in the housing and connected to the embedded system by the OTG cable which is represented with the dotted line in the

cloud in Fig. 2. The app running on the smart phone in the cloud communicates with the embedded system through the OTG cable and communicates with the middleware through 3G/LTE mobile communication. The app server running in the middleware transmits the data to the monitoring program *HMP*.

The monitoring program *HMP* communicates with agents through Ethernet and 3G/LTE mobile communication. The client PC is connected to Ethernet and the monitoring program *CHMP*(*Client Housing Monitoring Program*) running on the client PC can access *cloud data* through the middleware in the cloud in Fig. 2. Also, the app called *AHMP*(*App Housing Monitoring Program*) running on the client smart phone communicates with middleware through 3G/LTE mobile communication which is represented with the dotted line between the smart phone and the middleware in Fig. 2.

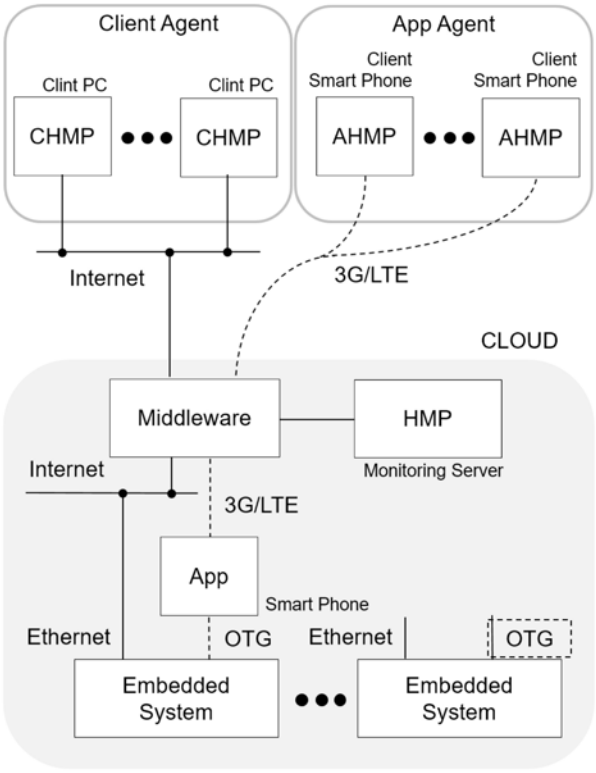


Fig. 2 The dataflow of multi-agent cloud system

3 Implementation of Multi-Agent Housing Management System

To implement multi-agent cloud system for remote housing management, we implemented the middleware which is the gateway to the monitoring programs *HMP*, *CHMP*, *AHMP* and solutions for communication with the embedded system developed in Ref. [2].

3.1 Middleware

Fig. 3 shows the detailed block diagram of the middleware. As shown in Fig. 3, there are four communication ports to access the monitoring program. The main functions of the middleware are as follows.

- Send received messages from embedded systems or agents to the monitoring program *HMP*.
- Send received messages from the monitoring program *HMP* to embedded systems or agents.

There is no direct communication between embedded systems and agents in the middleware.

We will describe the details for the implementation on the functions for agents, i.e. the functions related with the cloud. As shown in Fig. 3, the middleware consists of three blocks, the message queue, the security module and the app server module. The message queue stores the messages received from embedded systems and agents. The app server module sends messages to smart phone or receives messages from the smart phone. If the operator logs in the system at agent, the unique socket for that agent is generated. The data for account is transferred through that socket.

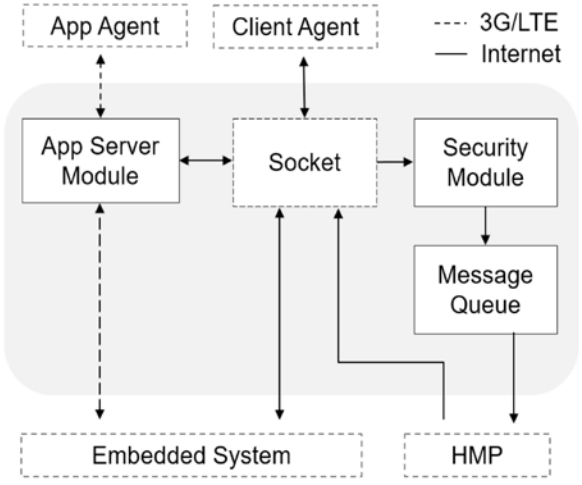


Fig. 3 The detailed block diagram of the middleware

If the massage is received from agents, the middleware checks the received message whether it's from authorized agent account. To verify the authorized account, the middleware checks *login id* and *password* and *identification number* which are included in the message. MAC address of the client PC and USIM number or IEMI of the smart phone are used as *identification number*. If the message is

unauthorized account, the middleware sends the error message to the agent. For messages from the authorized account, the middleware insert the received message to the message queue. The messages in the message queue are sent the message to the monitoring program *HMP*.

If there is a change in the state of the housing, the display of the agents which show the information of that housing should be updated. The middleware distributes the message to sockets if the message for data renewal on agents is received from the monitoring program *HMP*.

3.2 Monitoring Program on Server

The main functions of the monitoring program are as follows.

- Register/Unregister the client PC and the smart phone in the agent group of the cloud system.
- Store the data of the cloud system.
- Check environments of the housing, i.e. temperature, lock/unlock state of the lockers, ON/OFF state of the power supplied to equipment periodically.
- Send the message to the middleware to renew the data displayed on agents, if a change in environments of housings happens.
- Handle events coming from the housing and send alarm message to agents.

If there is a request from the agent to change the state of housings, the monitoring program *HMP* sends the command to the embedded system. And then, the monitoring program *HMP* send the message to update the data to be displayed on agents after receiving the result from the embedded system.

3.3 Monitoring Program on Client PC

The monitoring programs, *HMP* and *CHMP* have the same user interface as shown in Fig. 4. The function for registering/unregistering agents is active at the monitoring server only.

The monitoring program *CHMP* runs at the registered client PC and can be logged in as system administrator account or the user account. In the system administrator account, following functions become active.

- Create/Delete the user account.
- Register/Unregister the housing to the specific accounts. The housing can be registered to several accounts.

As described in Ref. [2], 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. In *icon view mode*, each icon represents the housing. Fig 4 shows the window of *list view mode* where housings are listed one by one. The housing colored with green represents the embedded system connected with the smart phone. The other embedded systems are connected with Ethernet.

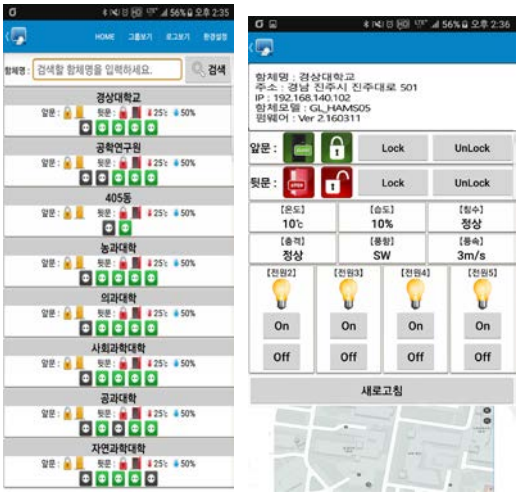
Fig. 4 The main window in *list view mode*

When the housing on the window is clicked, the dialog box is popped up. The dialog box displays the information stored in monitoring server for the selected housing such as the location of the housing, the state of the lockers of doors, the temperature, impact and the ON/OFF state of the power supplied to equipment. The power of equipment and the state of lockers can be controlled independently by clicking ON/OFF buttons. When the unexpected situation occurs at the housing, the alarm message is displayed on the window in real time.

The monitoring programs, *HMP* and *CHMP* are developed with Eclipse IDE for Java Developers [6]-[8]. The database is designed with SQL Lite.

3.4 Monitoring Program on Smart Phone

The monitoring program *AHMP* which is the app on the smart phone runs at the registered client smart phone. In the monitoring program *AHMP*, the operator can log in as the user account only. Fig. 5 shows the windows of the monitoring program *AHMP*. Fig. 5(a) shows the list of housing in the selected group. If one of housings in Fig. 5(a) is selected, the monitoring program *AHMP* displays the information stored in monitoring server for the selected housing as shown in Fig. 5(b). The monitoring program *AHMP* shows the same information with the monitoring program *CHMP*. The power of equipment and the state of lockers can be controlled independently by touching ON/OFF buttons on the screen. When the unexpected situation occurs at the housing, the alarm message is displayed in real time.



(a) (b)

Fig. 5 (a) List of housings, and (b) the state of the housing

4. Conclusion

We proposed multi-agent cloud system called *HAMS*(*Housing Automatic Management System*) for monitoring and controlling the housings installed all over the city through Ethernet or 3G/LTE mobile communication. The housing can be monitored on the client PC and the smart phone, which make it possible to handle the emergency situations in houisng immediately.

Our multi-agent cloud system is installed in several cities such as JinJu City, Namhae City and Hapcheon City of Gyeongsang Namdo Province in Korea as so on. Our system has been installed from last year and about 100 embedded systems are installed at each city.

We are developing the monitoring system for other application areas, especially the area for monitoring the marine product.

Acknowledgement

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References:

[1] Statistics, "Installation and operation of CCTV under public institution in Korea," *Documents from Statistics, Korea*, 2015.

[2] Yeong -Yil Yang, Young-Sik Park, Hyun-Jong Lee, Young-Ho Choi, and Jong-Chul Lee, "Multi-Channel Housing Monitoring System," *NAUN Int'l Journal of Computers and Communication*, Vol 10, 2016.

[3] D. H. Kim, Y. S. Park, S. G. Kwon, and Y. Y. Yang, "Implementation of Surveillance and Combat Robot Using Smart Phone," *Journal of Institute of Electronics Engineers of Korea*, vol. SC-48, No. 5, pp. 462–467, Sept. 2011.

[4] Kaiguo Li, Zhiliang Kang, Wuweu Ding, and Shen Mao, "Design of Appliance Control System Based on TCP/IP Protocol," *Journal of Measurement and Control Technology*, vol. 30, No. 7, pp. 41–45, 2011.

[5] Wenbing Wan, Xuerui Li, and Yonghua Shi, "Design and Research of Smart Switch Control System Based on Zig," *Journal of Embedded System*, vol. 32, No. 3, pp. 57–79, 2010.

[6] Tengfei Ahang, Qinxiao Li, and Funin Ma, "Remote Control System of Smart Appliances Based on Wireless Sensor Networks," *25th Chinese Control and Decision Conference* (*CICC*), pp. 3704–3709, 2013.

[7] Kenneth L. Calvert and Michael J. Donahoo, TCP/IP Sockets in Java, Second Edition: Practical Guide for Programmers 2nd Edition, 2008.

[8] Fiach Reid, Network Programming in .NET: C# & Visual Basic .NET 1st Edition, 2004.

[9] Johannes Eickhold, Serial Communication in Java with Rasberry Pi and RXTX, 2012.