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An Integrated Emergency Call System based on Public Switched Telephone Network for Elevators

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Abstract

Today, most of elevators have an emergency call facility for emergency situations. However, if the network installed in the elevator is also out of power, it cannot be used for the elevator remote monitoring and management. So, we develop an integrated and unified emergency call system, which can transmit not only telephone call but also data signals using PSTN(Public Switched Telephone Network) in order to remote monitoring and management of elevators, even though a power outage occurs. The proposed integrated emergency call system to process multiple data such as voice and operational information is a multi-channel board system which is composed of an emergency phone signal processing module and an operational information processing module in the control box of elevator. In addition, the RMS(remote management server) systems based on the Web consist of a dial-up server and a remote monitoring server where manages the elevator's operating information, status records, and operational faults received via the proposed integrated and unified emergency call system in real time. So even if there's a catastrophic emergency, the proposed RMS systems shall ensure and maintain the safety of passengers inside the elevator. Also, remote control of the elevator by this system should be more efficient and secure.

In near future, all elevator emergency call system need to support multifunctional capabilities to transmit operational data as well as phone calls for the safety of passengers. In addition, for safer elevators, it is necessary to improve them more efficiently by combining them with high-tech technologies such as the Internet of Things and artificial intelligence.

Key words: *Elevator, Integrated Emergency Call, Public Switched Telephone Network, Remote Management*

1. INTRODUCTION

Most of elevators require a combination of integrated safety technologies and various information technology services such as passenger ride measurement and transportation, disaster prevention and crime prevention[1-3]. In particular, the existing elevators have at least an emergency call facility in order to respond

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to emergency events[4-6]. In the case of Korea, it was obligatory to install an emergency call facility in the elevator after a major power outage in September 2011. Even if the emergency call facility is basically out of power, it is composed of PSTN(Public Switched Telephone Network) so that it can make a phone call with the outside with only a minimum of itself power. Generally, the elevator remote management collects and processes the status of elevator operation, information and obstacles through the wired or wireless network installed in the elevator[7-9]. But, if the network installed in the elevator is also out of power, it cannot be used for the elevator remote management.

Therefore we design and implement an integrated and unified emergency call system where can transmit not only telephone but also data signals using PSTN for remote management of elevators, even though a power outage occurs. By using PSTN for the emergency call system, there is no need to install a separate wired or wireless network in order to transmit data such as operating or driving information of elevator and it is free from power failure.

The proposed integrated and unified emergency call system to process multiple data such as voice and operation data is multi-channel board system which is composed of an emergency phone signal processing module and an operational information processing module in the control box of elevator. The operation information processing module transmits the data to the remote management server by using FSK (Frequency-Shift Keying) of PSTN. In addition, the server systems consist of a dial-up server and a remote monitoring server where manages the elevator's operating information, status records, and faults received via the proposed integrated and unified emergency call system in real time[4].

If an emergency situation occurs due to any events such as earthquake, fire, a sudden power outage, the emergency call system shall ensure and maintain the safety of passengers inside the elevator. Also, remote control of the elevator by this system should be more efficient and secure. Therefore, the proposed system is an economical and efficient system that can process phone and data signals in multiple ways even in the power failure situation which is a disadvantage of wired and wireless network[4,9].

In the near future, all elevator emergency call systems need to support multifunctional capabilities to transmit operational data as well as phone calls for the safety of passengers in response to the interruption of electricity.

The paper begins with a review of background, then goes on to describe an architecture of the proposed system, before providing results from an early user study, followed by a discussion and conclusion.

2. BACKGROUND

If an elevator breaks down in any events such as disaster, blackout while in operation, passengers inside the elevator can directly request help from the manager using the emergency call facility. The emergency call facility is designed to operate at least all times with its own power even in the event of a power outage occurs. However, most low-end emergency call facilities are low-cost interphones, which have poor call quality due to noise[1-3,7].

The remote management system, on the other hand, is a system that remotely monitors the operation state of elevators for maintenance, but only sends and collects operational information to the server via a separate network line. However, remote management is not possible when power is lost on elevators installed over a wired or wireless network. Moreover, the owners will have to pay for the network charges and the cost of installing the auxiliary network based on the establishment of the Internet communication environment necessary for elevator operation[4,9].

Since this integration of the emergency call network and the data communication network into PSTN for emergency call is highly economical and efficient, we propose and implement the integrated emergency call system

3. AN ARCHITECTURE OF THE INTEGRATED EMERGENCY CALL SYSTEM

In this chapter, we propose a PSTN-based integrated emergency call system that enables integrated processing of data and telephone signals for the remote management of elevators. Unlike systems developed by conventional technology, the PSTN-based elevator remote management system can remotely manage elevators using the proposed emergency call system without the need for a wired or wireless network in the event of a power outage.

The overall system structure shows the PSTN-based elevator remote management system using the integrated energy call system as shown in Figure 1, and a description of the key technologies is as follows.

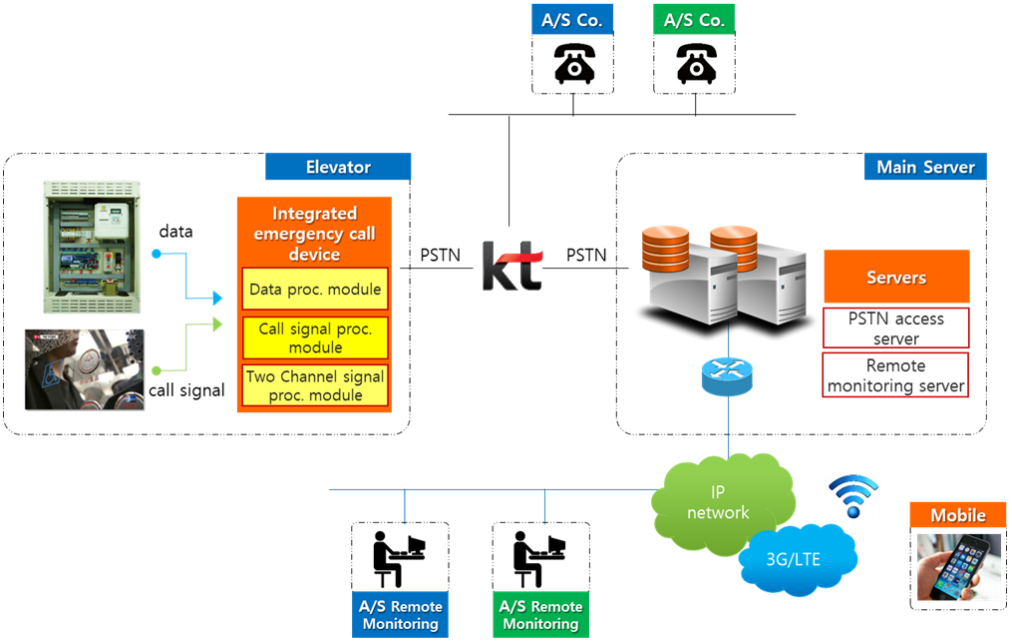

Figure 1. The structure of a PSTN-based elevator remote management system

3.1 A design of the integrated emergency call unit

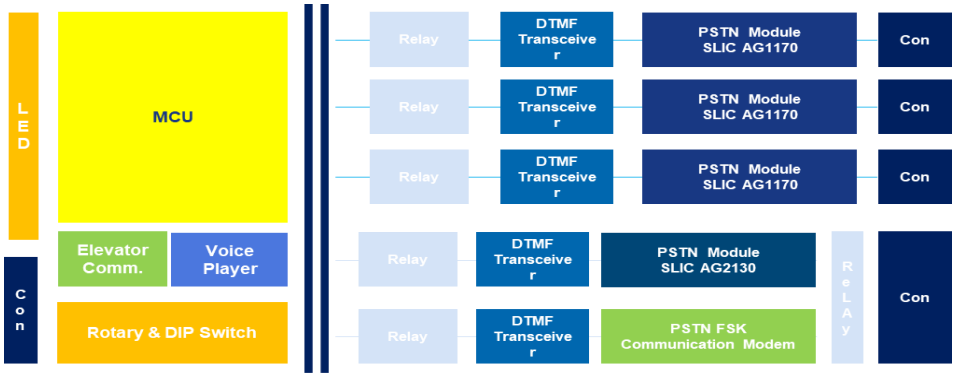

Figure 2. A block diagram of the integrated emergency call unit

The integrated emergency call unit support simultaneous processing of data and telephone call signals. The block diagram in Figure 2 shows the design of an integrated data and telephone signal processing module for

emergency call systems installed in elevators. It can send and receive data or telephone signals from RMS(Remote Management Server), PSTN-based servers, and emergency call processing technology.

- Multi-tasking technology for porting FreeRTOS with sending/receiving data from RMS/ PSTN-based servers/ Emergency call processing technology

3.2 A design of the PSTN-based data collecting and processing unit

Figure 3 shows the design of the module's block diagram for collecting and communicating elevator operating information from the emergency call unit to the main server through PSTN.

- Collecting the elevator operational information transmitted from the emergency call unit by PSTN and delivering it to the server.

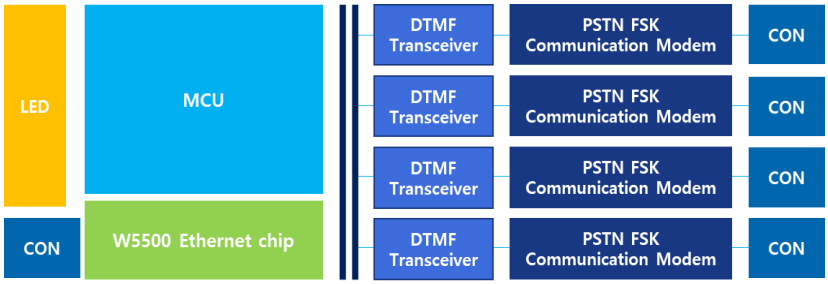

Figure 3. A block diagram of the PSTN-based data collecting and processing unit

3.3 A data processing mechanism

Elevator operation data can be communicated by UDP communication from the PSTN access server to the main server, but the transfer from the main server to the PSTN access server cannot be delivered immediately because IP of the private area will exist. To do this, the server must continue to open the virtual ports of NAT(Network Address Translation) using UDP Hole Punching. This can reduce the overload on subsequent increases in packets.

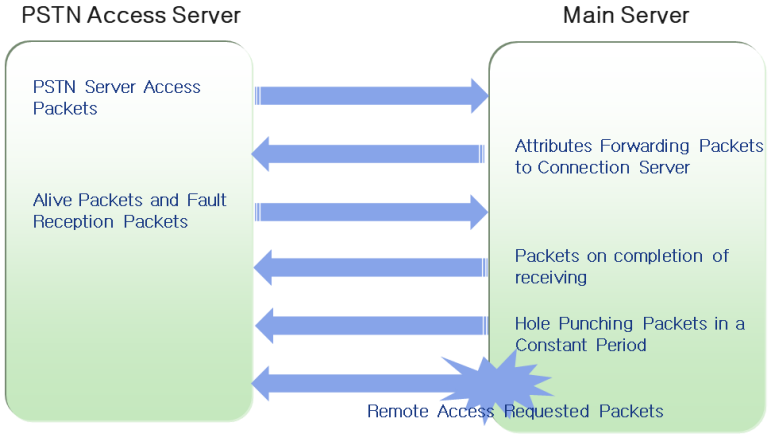

Figure 4. A sequence diagram for UDP packets

Figure 4 shows a sequence diagram of UDP packets after UDP/TCP's integrated protocol is designed for the protocol for communication between the PSTN access server and the main server. The PSTN access server regularly reports the information to ‘AliveCheck’ on main server, storing Ids and elevator lists for sites that have been entered once over the telephone network. The main server always opens its virtual port

by using Hole Punching on the possibility that the position of the PSTN access server is hidden behind NAT.

3.4. An integrated processing mechanism for the phone call and data communication

Figure 5 shows a sequence of connecting to the TCP server for user needs using a common protocol and transmitting data to users in real time. The UDP server constantly searches for new connections and requests TCP access through hole punching when a user requests it. The PSTN access server connects the phone at the on-site to indicate that the current connection is from the server, not from a regular phone, and the emergency call unit begins to pass the current elevator information to the PSTN access server.

The communication protocol between the emergency call unit and the PSTN access server uses the same protocol between the PSTN access device and the main server. Therefore, if an elevator fails at the site, it connects to the PSTN access server and sends information. Once the dial-up connection is complete, the PSTN access server connects to the TCP server to deliver real-time information about the elevators, and when ordered by the main server to transmit the current status information of the elevators at the site, dial the phone number of the emergency call unit to maintain the connection. The priority of all sequences is prioritized by the actual voice telephone.

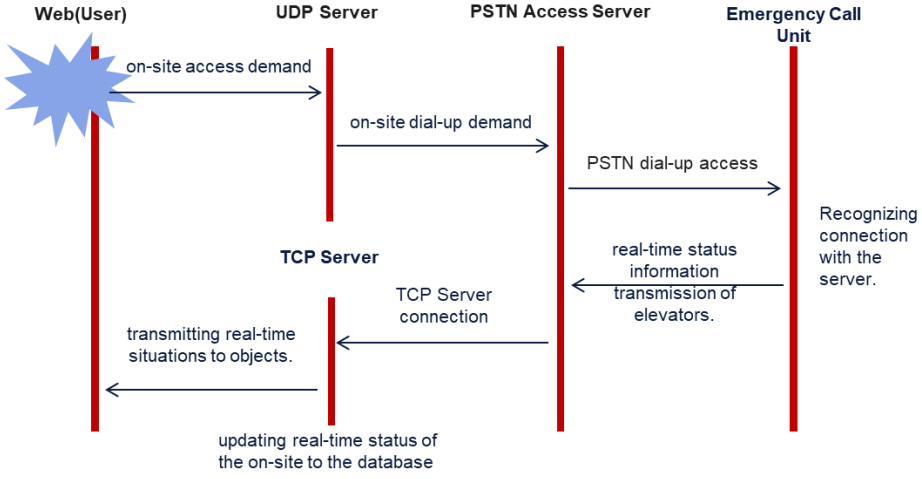

Figure 5. A sequence diagram for processing the integrated call and data communication

4. IMPLEMENTATION

The proposed emergency call system consists of two hardware, the integrated emergency call unit and the PSTN-based data collection and processing unit designed in the chapter 3. It also consists of each firmware of two units and the system-wide RMS. The following are the results of implementing each designed unit.

4.1. Implementation of the emergency call unit

MCU(Main Control Unit) of the emergency call unit compares STM with ATmega, so STM was more suitable when programming was derived in complex forms because of the larger size of the SRAM. PSTN chipsets also applied the product of SILVER TEL because there should be no voltage drop problems when connecting multiple units in parallel. DTMF(Dual Tone Multi Frequency) chipsets should be communications as well as normal DTMF functions, and should also be able to transmit in addition to receiving DTMF. So the DTMF chipset is CMX865A, which is capable of all transmission and reception to BELL20X, V2X and DTMF, and can also be handled by external interrupts. The internal call device of the

elevator should be at least two channels. In other words, since it should be possible to send and receive calls from the machine room to the pit, instead of developing the telephone between the machine room and the pit, we modified to ring the bell again using hook-on. FSK for communication with PSTN access server communicates with BELL20X under DTMF chipset support. Figure 9 shows the proposed emergency call unit created through the work of the artwork.

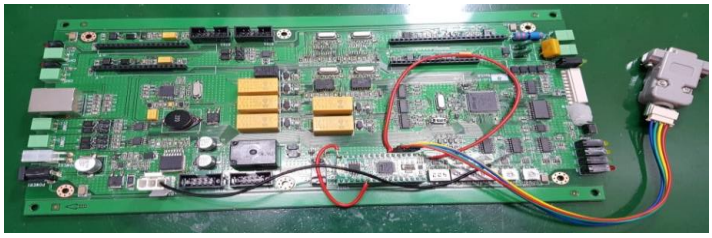

Figure 6. A PCB of the emergency call unit

4.2. Implementation of the PSTN-based data collection and processing unit

The proposed PSTN-based data collection and processing unit was made using STM chipset series as MCU and made two RS485 chips so that they can be converted to RS422. W5500 as an Ethernet chip is supported at 100bps and offered at least four sockets. SN65HVD23 as a CAN transceiver also selected for signal input. Powerless inputs/outputs were received through the sub-PCB, which was developed with multiple connections in each series. Additionally, we added an external ROM for the black box function. Figure 10 shows the proposed PSTN-based data collection and processing unit through the work of the artwork.

Figure 7. A PCB of the PSTN-based data collection and processing unit

4.3 Implementation of phone calls and data communication

A combination of DTMF signal modules and PSTN signal modules was subsequently tested for CID(Calling Identity Delivery) telephone performance to verify that the telephone functionality was functioning properly. In the event of a failure of the elevator at the site, communication between the emergency call unit and the PSTN access server uses FSK BELL203 1200bps. After sending the information, the phone connection was terminated.

The PSTN access server maintains the connection by calling the phone number of the emergency call unit when the main server is ordered to send information on the current status of the elevator at the site. At this time, the network protocol between the PSTN access server and the main server implemented UDP/TCP as the W5500 chipset. To support variable network packets, the length limit of data sent and received was limited to no more than 256 bytes. The top priority of all signal sequences has been set to actual voice calls.

4.4. The Web-based RMS

To control and manage the emergency call system designed in Chapter 3, the Web-based RMS was developed in three elevators as shown in Figure 8. The Web-based RMS stores and manages data received in real time through the emergency call system installed in each elevator in an external database, and performs real-time operational state and operational records, fault records and statistics based on the Web.

Figure 8. The Web-based RMS in 3 elevators

The following Figure 9 shows some captured screen to be inserted into the database for raw data of operating information sent in real time for each elevator.

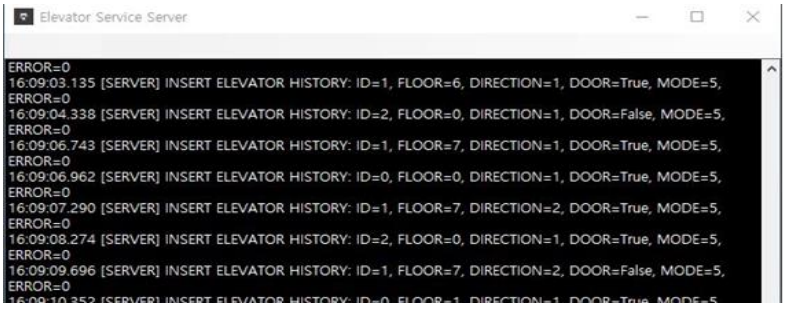

Figure 9. A screen to store operating information

The top menu of Figure 8 provides information on the current status, operating information and operating history of each elevator. Figure 10 shows the overall error rate and the number of errors per day, week and month by compiling all error conditions as well as the operational records of all elevators.

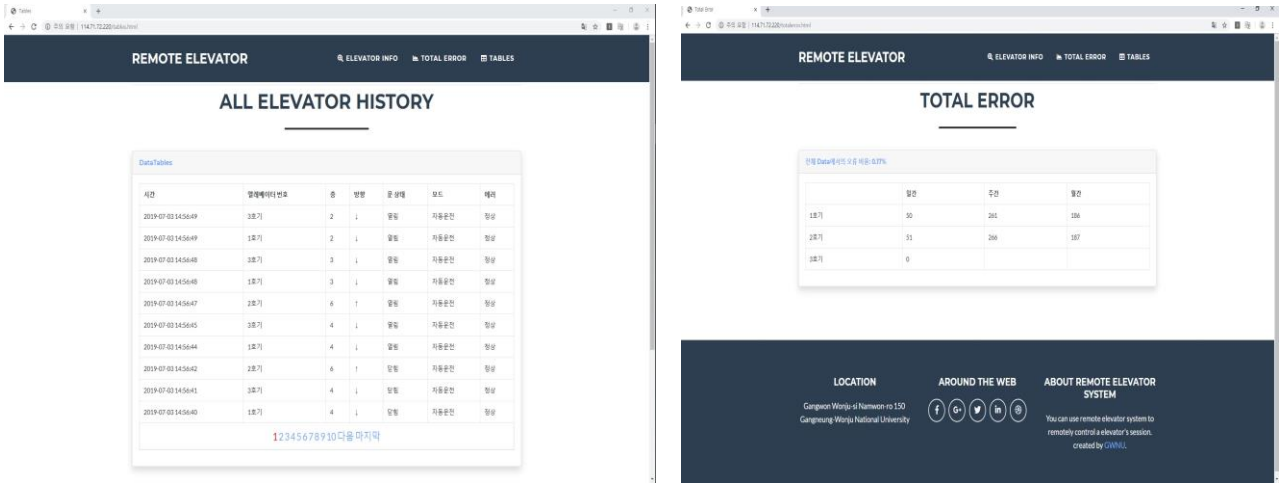

Figure 10. Operational records and status information for all elevators

Figure 11 shows a list of elevators currently under management, and when a manager click on each picture, he can get detailed information, error status information, and operational records on the current elevator.

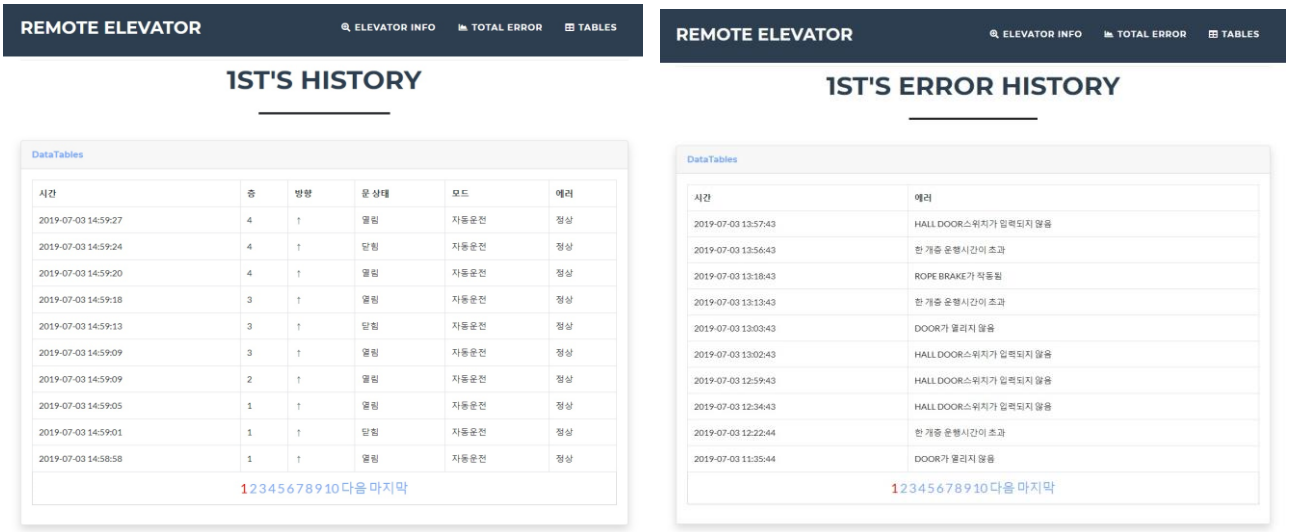

Figure 11. Status, information and operation records of the current elevator

5. CONCLUSION

In this paper, we proposed an integrated emergency call system incorporating data and telephone signals for PSTN-based elevator remote management. The existing elevators could not be managed remotely if a power failure caused the wired or wireless network to be shut down.

However, the proposed PSTN-based integrated emergency call system can remotely manage the elevator by sending data signals as well as phone calls to the emergency call unit, even if a power outage occurs. The proposed emergency call system consists of two hardware, the integrated emergency call unit and the PSTN-based data collection and processing unit. They also consist of each firmware of two units and the system-wide RMS.

In addition, the proposed RMS systems based on the Web consist of a dial-up server and a remote monitoring server where manages the elevator's operating information, status records, and operational faults

received via the proposed integrated and unified emergency call system in real time. So even if there are any disaster or emergency, the proposed RMS systems shall ensure and maintain the safety of passengers inside the elevator. Therefore, the proposed system improves the safety of elevator passengers in any emergency situations caused by an earthquake or fire, and so force.

In the future, we expect more convenient and safer elevator products by applying technologies that combines advanced information technology services such as the Internet of Things[10].

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