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A Study on the Elevator Safety Management Method Using Remote Monitoring System

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Abstract.

Background/Objectives: Recently, the installation and use of elevators in many countries such as Korea is increasing. Technical and institutional arrangements are needed to ensure safe use of elevators. Each country has an increasing number of public management entities, such as supplying rental housing for housing stability. They are having difficulty in managing elevators because they are provided with elevators from various companies. In addition, SMEs in the elevator industry cannot easily have a platform that monitors elevators in real time. Therefore, it is intended to present an integrated elevator remote management platform that can be utilized by public management entities and small and medium-sized enterprises.

Methods/Statistical analysis: This study introduces research on elevator maintenance, elevator failure analysis, and remote management systems. In addition, it will be introducing the standard of signaling system for integrated management of elevators of SMEs with different signaling systems.

Findings: In this study, a remote-control integrated model for elevator safety management was presented through standardization of various elevator protocols, development of a rational information transmission system, data collection, and remote-control methods. In addition, in connection with the integrated remote-control model, the elevator management entity shows a way to more safely-manage elevators for various elevator products of SMEs.

Improvements/Applications: However, it is necessary to standardize the failure data presented by each company. And since the foundation for data accumulation has been laid, continuous research is needed to incorporate the functions that elevators control themselves by using machine learning techniques based on this

Keywords: Elevator, Safety, Elevator Integration Module, Elevator Maintenance, Safety Management.

1. INTRODUCTION

According to the information announced on the website of the “National Elevator Information Center” of the Ministry of Public Administration and Security in Korea, the total number of elevators installed as of December 2020 is about 750,000 units. In addition, the number of new elevators installed over the past five years is about 40,000 units, which is the third largest in the world after China and India. The installation and use of elevators is also increasing in many countries other than Korea. In addition, each country has an increasing number of public management entities, such as supplying rental housing for housing stability. They are provided with elevators from various companies. An elevator is a vertical means of transportation that is used every day, and its service life is usually 15 to 21 years. However, depending on maintenance, it may be used for more than 30 years. Technical and institutional arrangements are required to safely use elevators. The Korean Elevator Safety Management Act stipulates that regular and occasional inspections are mandatory. The elevator management entity shall undergo safety inspections such as regular inspections, occasional inspections, and detailed safety inspections within every period for elevators installed by law. In addition, the results should be self-examined once a month and stored in the “Comprehensive Elevator Safety Information Network” managed by the state. In addition, the elevator management entity shall also serve as a safety manager after receiving elevator safety management training for elevator safety management or appoint an elevator safety manager for persons who have completed elevator safety management training. Elevator safety managers are obliged to prepare regulations on the operation and management of lifts, manage and supervise maintenance companies, notify elevator failures, and operate lifts for quick rescue if passengers are trapped in lifts. Due to the recent revision of the law, the definition of the remote management function has been defined as a legal regulation with the introduction of the smart management technique. Smart management techniques are two major axes, real-time monitoring and remote control. It is a technology that can check the status of the elevator in real time and control it remotely within the possible range when a problem occurs. In order to implement such a management system, data communication technology and technology for collecting and storing information are required. In addition, the development of an application that allows each user to monitor in real time must be accompanied. Currently, elevator control panels are equipped with systems that can extract and transmit a variety of information. Until now, for elevator monitoring, on-site management has been carried out in the form of mainly using the elevator monitoring panel installed in the management room. For information transmission to the monitoring panel, serial communication such as RS-485 and CAN communication are mainly used. Global elevator companies are already providing services that can detect elevator failures through remote monitoring. However, services are provided only for newly installed elevators, and even if a new elevator is installed, remote monitoring services may not be received. In addition, SMEs in the elevator industry cannot easily have a platform that monitors elevators in real time. In the case of public rental housing complexes, it is difficult to manage because elevator products from various companies are used. In addition, communication protocols configured for each elevator control panel are all different, and in some cases, the protocol may not be disclosed. In this study, through standardization of various elevator protocols, development of a rational information delivery system, data collection and remote-control methods, the purpose of this study is to present a platform for remote integrated elevator management that can be utilized by public management entities and SMEs.

2. MATERIALS AND METHODS

Today, elevator-related research is not limited to the design and development of parts, but various related systems, evacuation guidance in case of fire, and marine elevators are being conducted. This chapter introduces a study that presents an integrated operation model of a remote management platform, elevator safety field, remote management system, and safety equipment in elevators.

2.1. ELEVATOR MAINTENANCE AND FAILURE CASE STUDY

For the maintenance of the elevator, a study was conducted to find the correlation with the elevator parts by analyzing the failure cases of the elevator. Based on the contents of the maintenance log, the case of failure during operation of the elevator was analyzed to determine whether the cause of the malfunction was related to the quality of the elevator power. In this study, the cause of the failure and malfunction written in the maintenance log cannot be determined as a failure due to power quality, but it was investigated that the problem was solved by power reset in many cases [1]. In addition, in a 2014 study by Nak-Hoon Kim and others, a failure classification system was designed for elevator models of two manufacturers, and cross-analysis was conducted to confirm the independence of each manufacturer [2]. Based on this, it can be used as a basis for determining a maintenance policy. As the spread of smartphones spreads, research on using smartphones for elevator safety inspection and self- examination was conducted [3]. Since there are various sensors in a smartphone, it is an application that diagnoses the vibration and noise of elevators by using them, and it shows that the efficiency of inspection work can be improved.

2.2. A STUDY ON THE INTEGRATED ELEVATOR SAFETY SYSTEM MODEL

In 1995, Park Jong-Heon et al's "Elevator Remote Monitoring and Diagnosis System" analyzed the outline, structure and function of the elevator remote monitoring system, and described the direction of development. The structure and technology of the remote monitoring system at that time are still in use [4]. CCTV and emergency call devices installed in elevators are individually controlled. In order to control these two elevators together, Yon-gun Kim et al. presented a framework integrated with a remote-control service based on Android [5]. This study shows that the emergency call device and CCTV can be linked with the remote service framework. In another paper by the author, a framework for integrated operation of various elevators is proposed based on the previous research [6]. This study focuses on the framework structure and has a limitation in that the standardization method of data of heterogeneous elevators is not explained. In addition, there was also a study that proposed a system for collecting and analyzing factors that can occur from natural phenomena and mechanical errors caused by mechanical complexity of the elevator system by applying data mining techniques [7]. This study focused on the design of the system using data mining and presented data analysis items. In addition, a data mining system for elevator safety management was modeled. However, it is regrettable that no examples of derivation of the relationship between the presented analysis items have been raised, and the verification of the analysis items data is insufficient. Recently, a lot of researches incorporating AI technologies such as machine learning are being conducted, and in the elevator field, they are being used to optimize the control of elevators [8][9]. Yun-gyeom Kim and others compared and analyzed the development of elevator maintenance technology of major elevator manufacturers and considered the system elements and functional requirements of the remote monitoring and control system. In Kim's thesis, related patents were analyzed using analysis techniques such as Cites Per Publicity (CPP), PII (Public Impact Index), Technology Index (TS), PFS (Patent Family Size), and IP History. Through this, they attempted to present a direction for the development of elevator remote monitoring technology [10]. Yun-gyeom Kim's research provides guidelines for the overall technical requirements for remote management systems. Small and medium-sized enterprises (SMEs) need a standardized signaling system for their platform for integration because their elevator control signals are different. The Korea Information and Communication Technology Association defined the configuration, protocol, and monitoring data for IoT gateways for remote monitoring of elevators and published them as standards [11]-[13]. In this standard, a protocol for remote elevator monitoring was proposed under the name ELMP-485, which is based on RS-485 serial communication. It provides guidelines and standards for building remote monitoring of elevators incorporating IoT. Table 1. shows the message structure of ELMP-485 communication presented by Korea Information and Communication Technology Association.

Table 1: Message Structure of ELMP-485(Based on RS-485 Protocol)

Start Flag (SF-0x7E)	Destination Address (DA)	Message Type (Type)	Data length (Len)	Data (DATA)	Cyclic Redundancy Check (CRC)	End Flag (EF-0x7E)
1 byte	1 byte	1 byte	2 byte	n byte	2 byte	1 byte

3. RESULTS AND DISCUSSION

There are a variety of elevator products sold by global elevator companies and SMEs. In addition, interfaces such as communication methods and communication data between elevators are different for each manufacturer. In order to integrate the elevators of many SMEs, an interface that can integrate elevator control signal data from each manufacturer is required. This interface should convert the data of the elevator controller and the sensor to check the state of the elevator into the data used in the RMS module. The types of data generated by elevators are largely classified into status information (general elevator operation status), real-time event information (events defined by manufacturers), and diagnostic data (diagnosis result data). In the proposed system, in order to standardize the elevator data of various manufacturers transmitted using the ELMP-485 signal system, it is converted into a standardized JSON message expressing a pair of key and value. The code value of each elevator and the status value of the elevator form a pair of keys and values and are transmitted to the system.

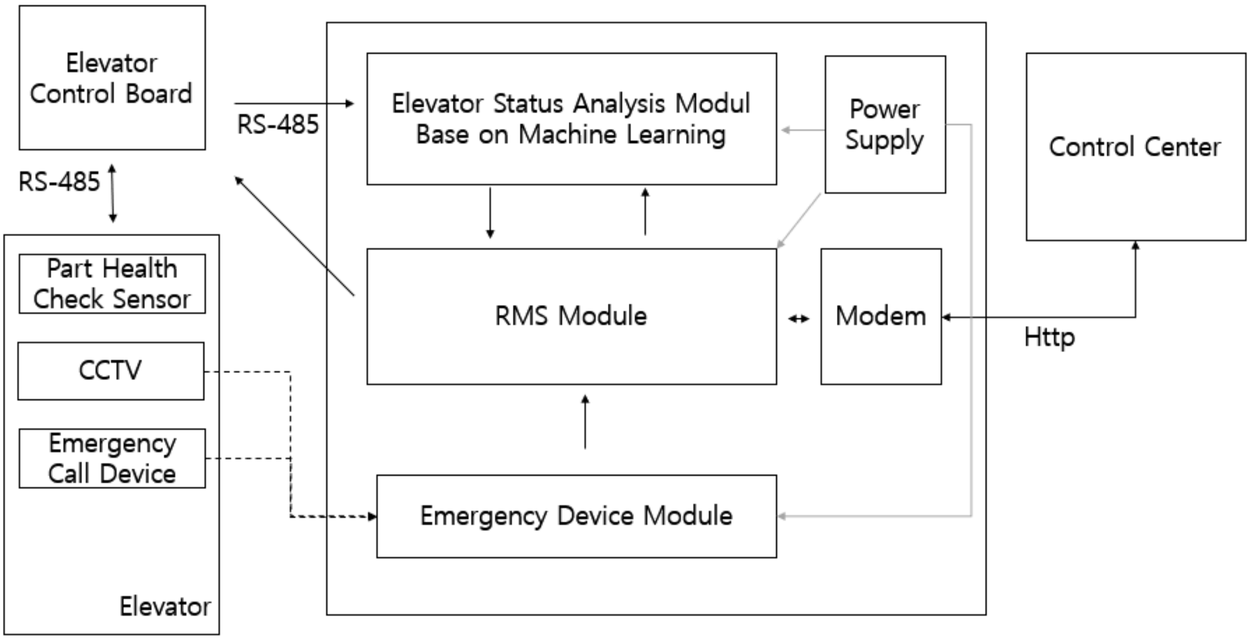

Figure 1. Generic Integrated Model of Remote Elevator Safety Management based on Analysis Data

Figure 1 shows the composition of the integrated elevator remote safety management model based on data analysis. The status information, parts information, etc. generated in the elevator are communicated with the control panel through a standard protocol. When elevator information is transmitted to ESAM (Elevator Status Analysis Modul) in the message structure defined in the standard protocol in the elevator control panel, the ESAM analyzes the elevator failure and emergency situations using the data. The analyzed data can be remotely monitored by the elevator management subject by the RMS Module. In addition, emergency signals detected through the Emergency Device Module can be monitored in order to promptly respond to a passenger's rescue request using the elevator's emergency call device. Figure 2 is an analysis-based elevator remote integrated safety management model expressed in BPMN. Looking at Figure 2, the elevator management entity can check the data transmitted through the RMS Module, determine the elevator status, and take measures such as requesting repair in case of a failure. The analysis-based elevator remote integrated safety management model combines edge computing technology and cloud server functions. It is possible to increase the stability of data processing by utilizing edge computing technology to process elevator information data generated in real time. By building it as a cloud server, it has the effect of reducing the cost of building and operating the server directly, and you can focus on the remote elevator safety management service without worrying about the scalability and setting of the server.

Figure 3 is a BMPN that shows the elevator safety management plan of the elevator management entity. When an emergency-situation occurs in an elevator, a passenger sends a remote rescue request, and the elevator management entity recognizes and responds to the situation through a remote monitoring system. The elevator management entity takes measures for the rescue of passengers, judges the data analyzed by RMS, and requests elevator maintenance and inspection that suits the situation such as a breakdown. As shown in Figure 2, data is transmitted and analyzed even in normal times, so it is possible to prepare for parts replacement by judging the status of elevators and parts.

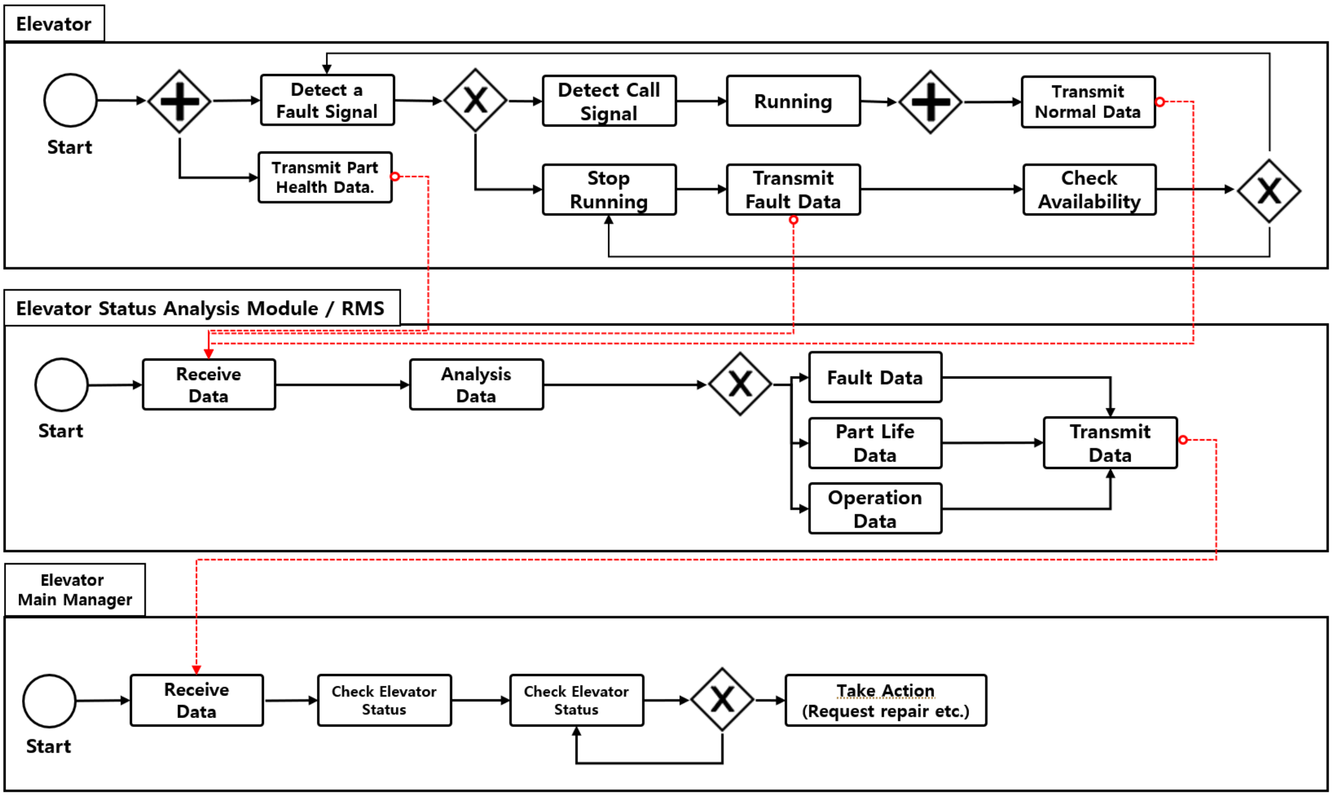

Figure 2. Business Process Modeling of Generic Integrated Model of Remote Elevator Safety Management

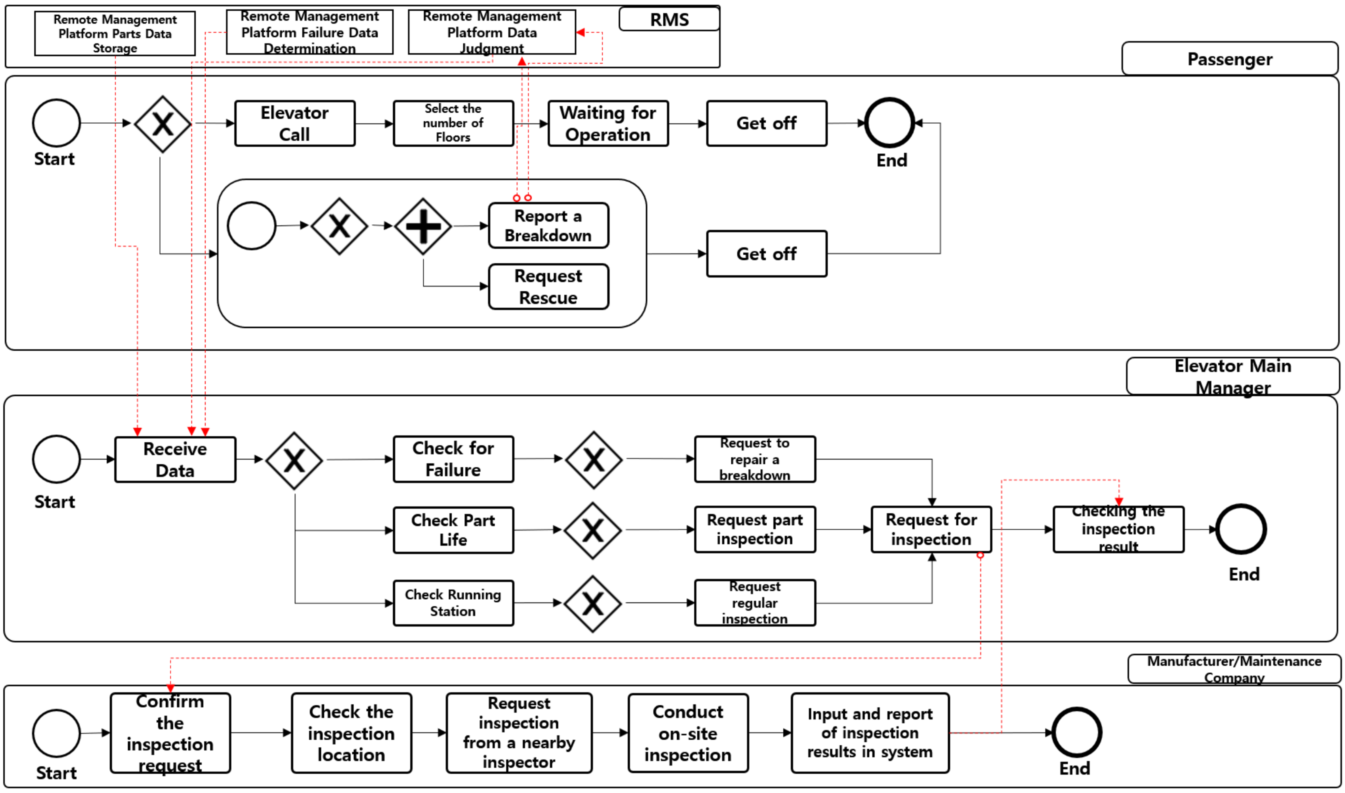

Figure 3. Business Process Modeling of Elevator Safety Integrated Management Method for Elevator Manager

4. CONCLUSION

The installation and use of elevators is increasing not only in Korea but also in many countries around the world. Technical and institutional devices are needed to safely use elevators. In this study, we propose an elevator safety remote integration model that can cope with various elevators of small and medium-sized enterprises so that the elevator management entity can manage it more safely and accurately. In addition, a method for the elevator manager to remotely manage the safety of the elevator was also proposed. In the remote integrated management model, the control signal system of elevators is different for each manufacturer, so a standard protocol is used to integrate them. By receiving the elevator signal system for each manufacturer as elevator status and behavior data, it is possible to respond to elevator failure and condition monitoring of various elevator manufacturers. In addition, this model was used to suggest a way for the elevator management entity to perform a safer and more accurate elevator inspection. Figure 4 is a system configuration diagram of the integrated elevator management platform for collecting and controlling information provided from various control panels provided by various companies. A cloud server was used to avoid heavy storage devices, and edge computing technology was applied to the function of receiving information transmitted from the elevator control panel to the management room and transmitting the data to the cloud platform. Edge computing has the advantage of being able to communicate with more than 40 users, and the control means in the management room is alive even if the cloud server is down, so it was introduced in the realization of the elevator remote integrated management platform. Figure 5 shows an overview of the elevator remote safety management plan of the elevator management subject using the cloud-based elevator remote control integrated model. The elevator transmits fault/normal signal data to the edge server, and the edge server transmits the received data to the cloud server to analyze the data. Analyze the data by using the data on the elevator status. Data analyzed in real time on the cloud server can be transmitted to administrators. The analyzed data can be checked by the elevator management entity to respond to each situation, such as requesting the manufacturer or maintenance company for elevator failure, part life check, and regular elevator inspection. Through this study, by introducing remote management using a cloud platform in the elevator industry, we laid the foundation to lead the evolution of technologies using various IoT and predictive preservation technologies for elevators. In addition, by introducing edge computing technology, it laid the foundation to implement the integrated management of elevators that are widespread in a wide variety and geographically. This technology is considered to be suitable for use in public enterprises or competent authorities in charge of housing stability and large-scale rental business to establish a safe elevator use environment. In addition, it is expected to play an important role in system linkage of smart cities, and it is expected that it will be able to contribute to the overall elevator industry by providing open APIs so that SMEs can utilize this platform. However, it is necessary to standardize the failure data presented by each company. In addition, since the foundation for data accumulation has been established, continuous research is needed to incorporate the functions that elevators control themselves by using machine learning techniques based on this.

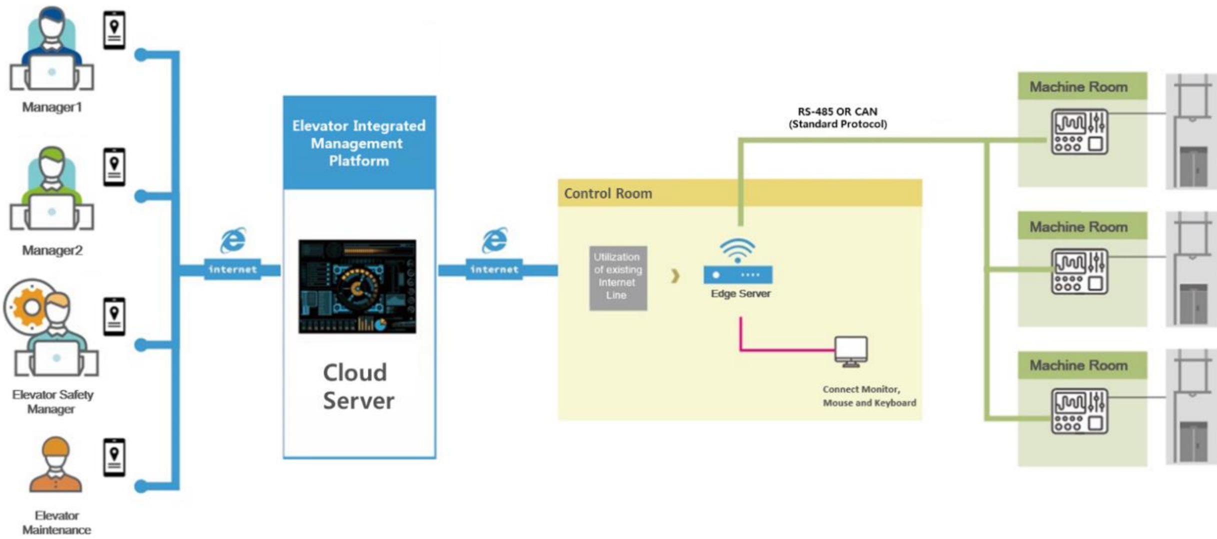

Figure 4. Elevator Integrated Management System Diagram

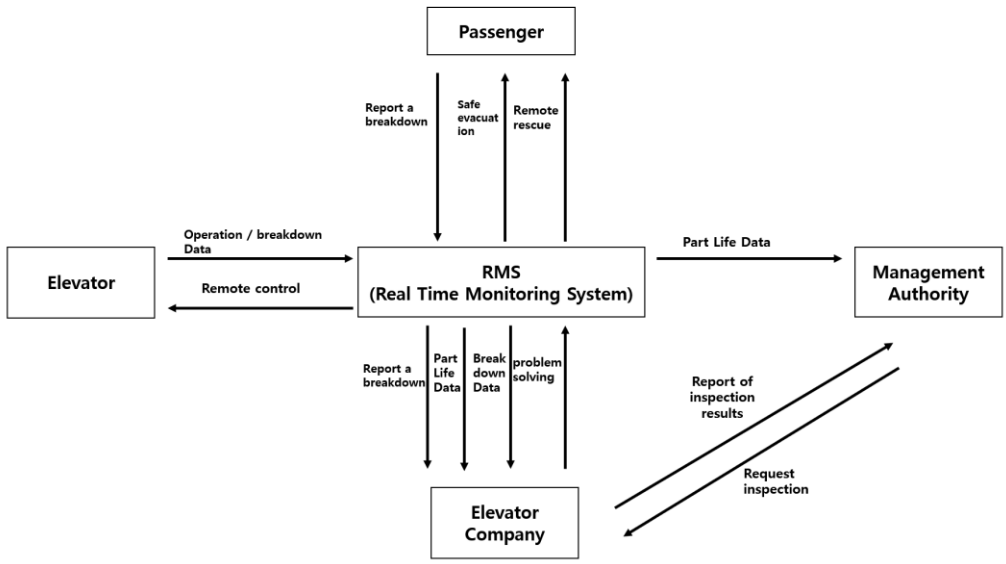

Figure 5. Overview of Elevator Safety Management Method Using the Integrated Machine Learning-Based Elevator Remote Control Model

5. ACKNOWLEDGMENT

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