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Design of IoT Platform Based Smart Disaster Prevention Systems

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Abstract

This paper is aimed to propose SmartSDP, which is an IoT based disaster prevention type platform intended for installation and operation of a smart sterilization central control system. Core technologies for this platform are ‘disaster sign detection and analyses’, ‘damage prediction and forecast models’, and ‘disaster information delivery system’ and a summary of differentiations from other disaster prevention technologies is introduced. In addition, existing study fields and their limitations were briefly examined to improve the conditions and SmartSDP (A Platform for Sanitation), which is a disaster prevention platform for prior improvement of air quality in hospitals and clinics that can be commonly encountered around us, was studied.

Keywords: IoT, Datamining, SensorNetwork,

INTRODUCTION

Over the last several years, disease-related accidents occurred in South Korea have greeted serious situations as systematic limitations have been revealed. As the forms of disasters and safety accidents have become complicated, diversified, and difficult to predict, other forms of management measures than recovery- based responses have become necessary. Therefore, recently, such management measures have been evolving into the form of prediction and monitoring of and preemptive responses to disasters. Among various studies, the most representative technologies are as follows [1].

- Disaster sign detection and analysis using data analysis and sensing
- Damage prediction and forecast models applied with complicated algorithms
- Delivery systems that can deliver the analyzed results accurately at the right time to the right place

However, since actual disasters cannot be responded with a single system, various technologies should be complexly constructed. Technologies that enable the foregoing include the Internet of Things(IoT) the construction of platforms that provide basic frameworks connect technologies with each other. In this paper, we implement disaster prevention system using element technology based on IoT technology, and implement disaster prevention type platform for integration and extension of disaster prevention technology, data, and system. Combining the foregoing, in this study, an IoT technology based system that can prevent disasters using element technologies will be implemented while implementing a disaster prevention type platform for integration and expansion of disaster prevention technologies, data, and systems.

The proposed disaster prevention type platform is intended for installation and operation of central control type sterilization systems usable at small and medium sized hospitals and clinics and its architecture has been made by first implementing modules that can detect and forecast disasters and deliver disaster information, implementing sensing, wireless communication, and central control modules that would be placed on the foregoing modules, and integrating the modules to implement the IoT platform. Related technologies that must be combined to implement this platform are the following technologies or algorithms.

RELATED WORKS

Since the range of IoT technologies is so wide, dealing with all fields of IoT technologies is impracticable. Since collecting information on air pollution, etc. using sensors is the beginning of system operation, in this paper, related works on sensing technologies, wire/wireless communication technologies, network infrastructure technologies, and service interface technologies are examined

IoT technology study (sensing technology)

Sensor is a generic term of information devices that measure physical / chemical / biological information from the targets of measurement and convert the information into signals readable by the observer or the system. Sensors are devices that act on the first step of recognizing and producing information on things. Diverse sensors have been developed depending on the targets and methods of sensing, implementing technologies, and the fields of application [2].

Table 1. Sensor classification

Sensor type	Kinds of sensors
Targets of sensing	Physical sensors (force, temperature, electromagnetic, and optical sensors) Chemical sensors (gas, ion, and water quality sensors) Bio sensors (blood sugar, protein, and DNA sensors, cell chips, etc.)
Sensing mode	Resistor type sensors, capacitive sensors, optical sensors, magnetic sensors, etc.
Degree of integration	Simple sensors, electronic sensors, digital sensors, intelligent sensors
Implementing technology	Semiconductor sensors, MEMS(microelectromechanical systems) sensors, nano sensors, convergence sensors, etc.

In particular, smart sensors (intelligent sensors) refer to those sensors made by combining logic/ judgment / communication functions into existing sensors to implement advanced functions such as data processing, automatic correction, self-diagnosis and decision making, high precision, high convenience, and high added value. [3] [4]

Sensors cannot operate alone and require devices to process sensing results. With the development of sensor devices and sensor network technologies, devices (smart device, IoT device) have been greatly developed recently. Convergence technologies made by combining sensing technologies and devices are as follows. [5] [6] [7]

Wire/wireless communication and network infra technologies

Wireless device(sensor) network technologies include the IEEE802.15.4 standards for Wireless Personal Area Network(WPAN) transmission for information exchange and interlocking with diverse devices, ZigBee standards for application of the IEEE802.15.4 standards to industries, and 6LoWPAN and RoLL technologies of IETF for grafting of IP technology on device(sensor) networks. These technologies are the wire/wireless network technologies addressed in the IoT[8][9]. In this study, to implement a central control type sterilization and disinfection system, communications between the sterilizers installed in individual buildings and rooms and the center were implemented with Wi-Fi communications.

Service interface technology

IoT service interfaces refer to the parts that play the role of interlocking humans, things, and service, which are the major three components of the IoT, with application services that performs certain functions. Their concept is not that of network interfaces but they play the roles of interfaces (storage, processing, conversion, etc.) to perform services such as information sensing, processing/extraction/treatment, storage, judgment, situation perception, recognition, security/privacy protection, certification/permission, discovery, object standardization, ontology based semantics, open sensor API, virtualization, positioning, process management, open platform technology, middleware technology, data mining technology, web service technology, and social networks[10].

IoT platform technology

IoT platforms refer to those semantic information-based IoT service platforms that provide personalized or system customized real-time sensing information services so that users can easily use desired sensing information at anytime, anywhere regardless of time and space.

An IoT platform consists of planet platform for registering and retrieving IoT devices, a mashup platform that collects data from IoT devices and provides mashup services based on the collected data, a store platform that provides diverse IoT app/ web applications, and a device platform that is connected to diverse things to generate and collect data.

SMART STERILIZATION AND DISASTER PREVENTION PLATFORM (SMARTSDP)

In this chapter, the related studies introduced in chapter 2 will be analyzed to study SmartSDP, which is a disaster prevention platform, using various algorithms examined in the related studies in order to study and present a platform where central control type smart sterilization systems can be operated.

Indoor air pollution control system (SmartSDP) introduction

Table 2. Sensor data processing system

Query language /System	Application field	Input field	Basic operator	Supported Windows		User operator availability
				Variety	Basic element / Processing method	
Aquery	Stock quotes. Network traffic analysis	Sorted relations	Relational, 'each', order-depen dent (first, next, etc.)	Fixed, landmark, sliding	Time and Count /Not discussed	Via "each" operator
Aurora	Sensor data	Streams only	group-by. resample, drop, map, window sort	Fixed, landmark, sliding	Time and count /streaming	Via map operator
CQL/ STREAM	All-purpose	Streams and relations	Relational. relation-to-stream sample	Currently only sliding	Time and count /streaming	allowed
StreaQuel/ TelegraphCQ	Sensor data	Streams and relations	relational	All type	Time and count /streaming or periodic	Allowed
Tribeca	Network traffic analysis	Single input stream	group-by union aggregates	Fixed. landmark, sliding	Time and count /streaming	Allows custom aggregates

Table 2 shows the results of analysis of existing representative sensor data processing systems and their query languages [12]. However, since most of them are for outdoor use, indoor sensor network based cases are very rare. Therefore, these systems are not sufficient to predict disasters in advance and respond to the disasters.

Structure of the disaster prevention platform (SmartSDP)

The structure of the indoor/outdoor in-situ sensor network based disaster prevention platform and the sensor data processing process utilizing spatial information are introduced. The structure of the indoor sensor based small disaster prevention system for situation information modeling and processing is as shown in Figure 1.

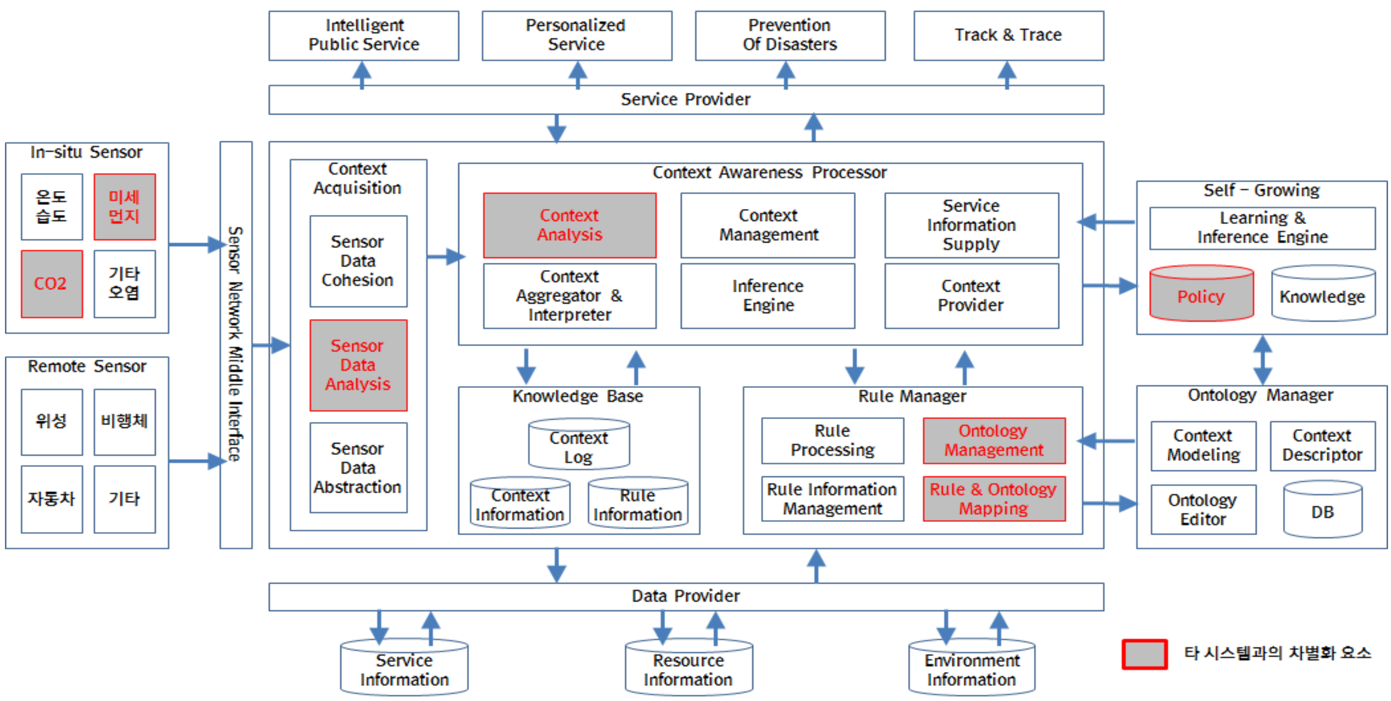

Figure 1. Structure of indoor air quality monitoring platform

Major algorithms of the disaster prevention platform(SmartSDP)

SmartSDP comprises algorithms many functions for data exchanges with the central control system that operates on it and disaster prevention. Among them, the algorithm that detects the diffusion of air pollutants is the core. In this system, a Gaussian algorithm model (CALPUFF) was implemented and applied.

System (SmartSDP) design

System design and implementation thereafter can be divided into a hardware part and a software factor for consideration. The hardware part is for the development of embedded systems divided into power supply, air quality measurement sensors, Wi-Fi communication modules and the software part is for development of web applications such as embedded hardware interlocking and central control of the system.

Figure 2 is a rule that defines data transmission and reception between embedded hardware and software applications. The information transmitted to the central control system includes a total of two kinds of information; the conditions of the purifiers in individual floors and rooms in the hospital or clinic received in real time and the waiting states of individual rooms.

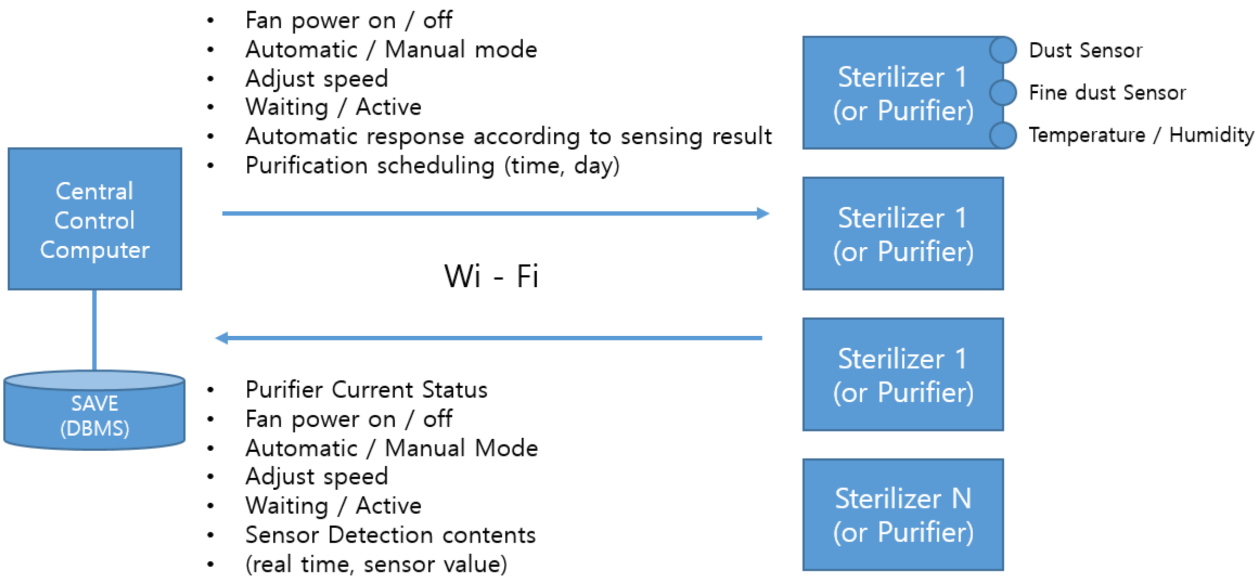

Figure 2. Data transmission and reception between embedded hardware and software applications

The central control sterilization system implemented in this study is a system that operates on a platform and the following prerequisites should be satisfied in component design.

- Expandable modules should be developed so that the modules can be utilized when other linked devices are developed later
- Java based design to make even details functions into components thereby ensuring excellent reprocessibility and expandability
- Electronic government (e-Gov) framework based development to introduce newest technologies
- Development and project management according to information engineering methodologies

Major technologies applied to the development of applications can be classified as shown in Table 3

Table 3. Major technologies applied to the development of applications

Major technologies	Details
Client screen control	Development of intuitive UI for device control, implemented using HTML5, JQuery, movements and arrangement ensuring independence between components were implemented
Interlocking with HW devices	Device information sensor data collection, remote control transmission/receiving module, mobile and homepage information sharing
Utilization of Java Utility	g-Government Framework 3.5.x or higher, JDK 1.8x or higher, WAS : Tomcat 6E, Eclipse : support e-gov, MySQL : 5.7x or higher

SYSTEM (SMARTSDP) IMPLEMENTATION AND EXPERIMENT

In this chapter, to demonstrate the excellent performance of the proposed system, indicators such as data transmission/receiving, data maintenance, and response speeds are presented. Based on the results of this experiment, the evaluation and conclusion of the proposed system were derived.

Overview of the system (SmartSDP)

The purpose of this study is to provide optimum hospital environments at all times by implementing an IoT based smart system in which data from air pollution measuring sensors attached to sterilizers are sent from the platform to the central control center and sterilizers and purifiers are operated as automatically(manually) scheduled based on the results.

The air quality is served in real-time through a function to push the air condition in hospitals or clinics to the homepage or kiosk. A block diagram of the system for the foregoing is as shown in Figure 3.

Implementation of major functions of the system (SmartSDP)

System requirements include the requirement for data processing in the direction going from the devices (HW, SW) to the central control program, the requirement for data processing in the direction going from the central control module to the devices (HW, SW), and a function linked to the outside, which is the requirement for information transmission to the hospital home page to provide information on the condition of air in sickrooms in the hospital or clinic in real-time.

The modules comprise air pollution measurement sensor modules, data transmission / reception Wi-Fi communication modules, central control modules, and program modules.

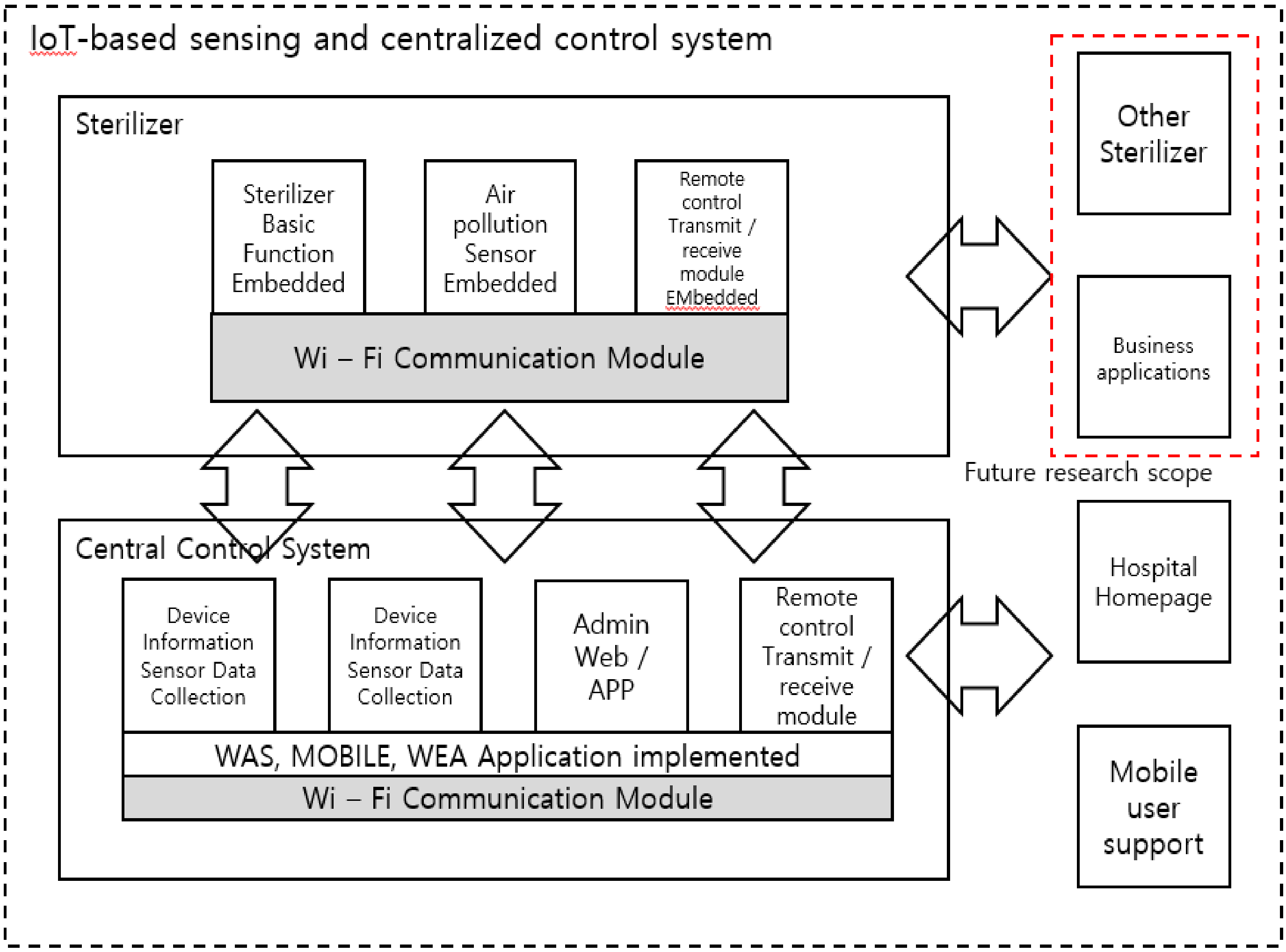

Figure 3. Block diagram of the SmartSDP based sterilization and disinfection central control system

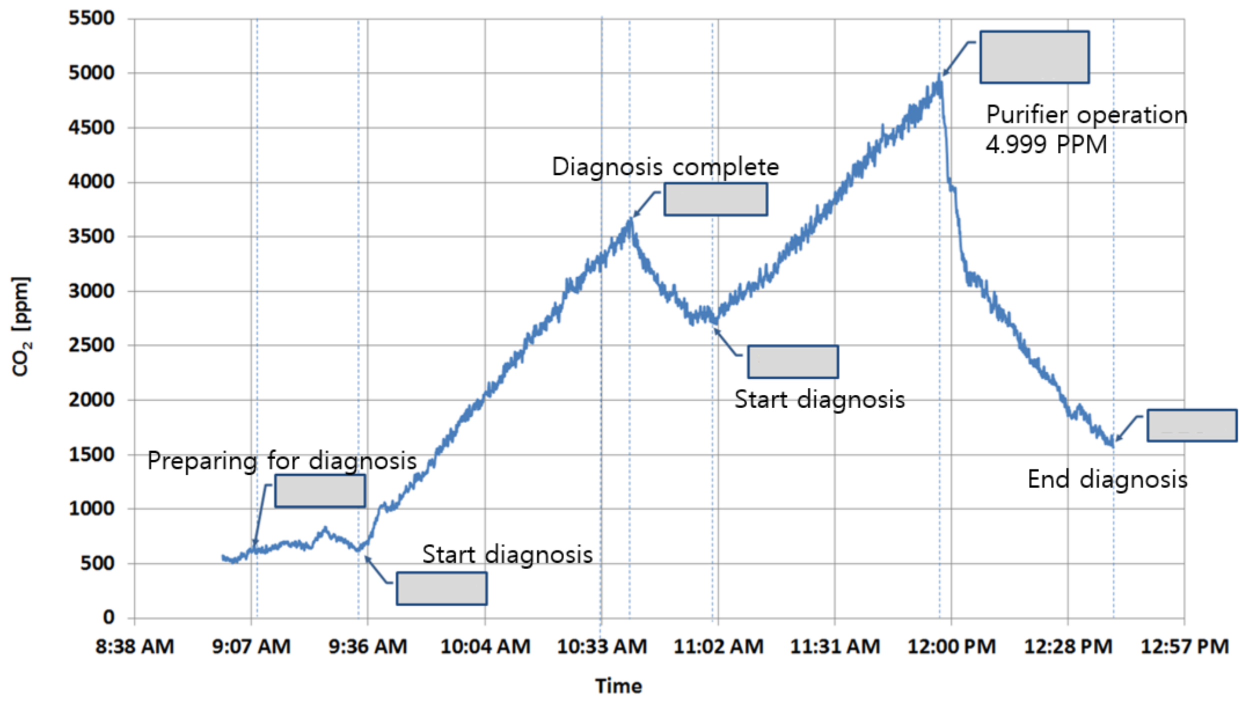

Figure 4. Sickroom CO2 variation measurement graph

(room #301, building A of Y clinic located in Geomdan, Incheon)

System (SmartSDP) experiment and evaluation

The system was actually experimented and the results were measured to evaluate the degrees of improvement. As for the experimental environments, sensor modules and central control servers were installed in individual sickrooms of four certain hospitals and clinics. The experimental environmental condition was general sickrooms in a size of 900×710×260(width×length×height). A preparation period of 20 minutes was given for accuracy. Thereafter, indoor air pollutants were measured in each room and the mean, minimum, and maximum values were calculated.

The experimental results are as follows.

The experiment was carried out for two weeks in four sickrooms used by many people and data were stably transmitted periodically per 6 seconds. Indoor air quality measuring tests were carried out for two indoor air pollutants and temperature/ humidity items and the following conclusions were obtained. As shown in Figure 4, the average CO2 concentration is higher than the average concentration specified by the Ministry of Environment. In addition, the measured values of CO 2 variations in the general sickroom of the hospital was 537ppm, which was lower than the average concentration specified by the Ministry of Health before the rounds in the morning when there were not so many people but the concentration of CO2 steadily increased overtime after the beginning of treatment. The CO 2 concentration increased up to the limit could be reduced as the central control system judged the condition and operated ventilators. As shown in the graph, the CO2 concentration rapidly decreased after the ventilation.

The performance evaluation of this proposed system should satisfy the indicators as shown in Table 4. According to the results of the experiment, the system satisfied the performance in all aspects.

Table 4. System evaluation through goal achievement rates

Major performance indicators	Unit	Final goal of the development	Objective measuring method	
			Number of samples	Test standard
1. Rate of reduction of air pollutants	%	50% or higher	4	Self-test
2. Rate of maintenance of optimum air quality	Level	5 or lower	4	Self-test
3. Network transmission rate	sec	Within 5 sec	4	Self-test

CONCLUSION

Recent disaster types are predominantly infection disasters by humans such as the spread of diseases and infectious diseases rather than disasters caused by natural disasters. To overcome the limitations of the current system, this study investigated SmartSDP (A Platform for Sanitation), a disaster prevention platform for prior improvement of air quality in hospitals and clinics, which were frequently encountered around us and results better than those of previous studies were obtained. The SmartSDP and the sterilization systems installed on the SmartSDP were entirely implemented experimented using firsthand implemented applications and the systems could improve indoor pollution levels when they were installed in hospitals and clinics. Although the current Smart SDP is specialized in small and medium sized hospitals and clinics, studies will be continued hereafter to develop the SmartSDP into a special air pollution disaster prevention platform by expanding it and improving its functions.

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