International Journal of Engineering & Technology, 8 (1.4) (2019) 424-436

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A Study on the Dynamic Situation Response Scenario for Constructing ICT Convergence Disaster Response System

Chul-Gyoo Lee[1], Sang-Ho Moon[2]*, and Young-Jung Yu[3]

[1]*Public Risk Management Center, Busan University of Foreign Studies, Busan 46234, Republic of Korea*
[2] *Division of Computer Software, Busan University of Foreign Studies, Busan 46234, Republic of Korea*
[3] *Division of Computer Software, Busan University of Foreign Studies, Busan 46234, Republic of Korea*
**Corresponding author E-mail: shmoon87@bufs.ac.kr*

Abstract

Recently, natural disasters due to changes in the natural environment such as climate change have appeared in various forms. In addition, due to the development of architectural technology, the construction of super high-rise buildings as well as the enlargement and complexation of buildings are rapidly taking place. Also, with the rapid increase in the population of the city due to industrialization, buildings are becoming larger and more complex. These natural and technological changes increase the possibility of a complex type of disaster—either natural or social type of disaster, or a combination of both These changes strongly require the paradigm shift of response systems, including the prediction, preparation, response, and recovery phases of disasters. If social disasters such as fires occur in high-rise or large-scale buildings, not only large-scale casualties but also social losses could be expected to occur. Therefore, in the event of a major disaster such as earthquake, typhoon or tsunami, it is necessary to utilize response scenarios that can cope with various changes appropriately in disaster situations. In order to change the paradigm of the disaster response system, the proponents of this study identified the necessary functions and requirements for the transition to a dynamic situation response system. To do this, a case study was conducted on the disaster response system of super high-rise buildings and accident cases. These functions and requirements were aimed to be implemented in disaster response systems based on dynamic situation response scenarios. The system also included real-time information gathering, analysis, decision and action planning through the use of ICT technology. The scenarios were analyzed by task according to the specific situation corresponding to time, and then a strategy was designed to be applied to computerization, automation and intelligence. To verify dynamic situational response scenarios, the proponents confirmed the feasibility of the study by designing a database of the disaster response system which implements the scenario.

Keywords: *Dynamic Disaster Response based Real-time Information, Disaster Response System, Dynamic Situation Response Scenario, ICT Convergence Disaster Response, Super High-rise Building*

1. Introduction

The development of ICT technology, also called the fourth industrial revolution, has caused many changes in society making it more complex and diverse. For this reason, it is also necessary to make changes in the perspective of people and things relating to the rapidly developing technology.

With the rapid increase in the population of the city due to industrialization, buildings are becoming larger and more complex [1][2][3]. Also, as the size of the buildings grows, there are many floating populations besides the existing residential area. If social disasters such as fires occur in high-rise or large-scale buildings, not only large-scale casualties but also social losses could be expected to occur. Therefore, in the event of a major disaster, it is necessary to utilize response scenarios that can cope with various changes appropriately in disaster situations.

Since tbe types of disasters would be diversified according to changes in nature, society, and technology, there are many situations that cannot be imagined when a disaster occurs. Howeever, the methods and systems for responding to disasters have not changed much from the previous system. Despite the availability of the latest technology and equipment, and related laws, they are not properly utilized in actual disaster situations. In this study, the proponents proposed a dynamic disaster response system to accept and utilize these environmental changes. In addition, dynamic situation response scenarios were suggested in order to establish implementation plans for the disaster response system. These scenarios play an important role in implementing disaster response systems that can be tailored to the various disaster types and circumstances.

To do this, first, the necessary functions of the dynamic disaster response system were presented based on the actual conditions of the super high-rise buildings which are increasing rapidly in recent years. In detail, the problems of the current disaster response system were analyzed through case studies, and necessary technologies and functions for solving these problems were identified.

Then, in order to design a disaster response system using the identified essential technologies and functions, dynamic response scenarios corresponding to real-time situation change were constructed. In detail, the scenarios were composed of real-time-based information gathering, analysis, decision and action plans with the use of ICT technologies. Also, these scenarios were applied with location identification techniques for evacuation and rescue, and mobile technologies for dynamic situation propagation.

Dynamic situation response scenarios proposed in this paper were based on real time, and constructed for the application of super high-rise buildings. However, these scenarios can be used not only in super high-rise buildings but also in places where people are concentrated and have limited evacuation routes, such as large ships, underground facilities, and multi-use facilities. Also, these could be applied to disaster types and disaster sites that are difficult to suppress and rescue.

Researches have been conducted on large-scale disasters such as fires. There was a study that implemented an escape route search algorithm in the event of fire or terrorist attacks [4], and a study that proposed an evacuation guidance algorithm using mesh routing in high-rise buildings [5]. Also, there were researches related to a real-time evacuation guidance system using a variable induction device in case of an underground space fire [6], and a study that suggests an evacuation simulation system that can be used in actual disaster situations [7]. One of the most represented international studies was focused on the investigation of terrorism in the US World Trade Center [8]. In this study, 30 items were proposed in relation to the protection of fire in super high-rise buildings.

This paper was organized as follows. Section 2 discusses essential functions of a dynamic disaster response system. In Section 3, the disaster cases of super high-rise buildings and the existing researches were analyzed to identify the necessary improvements for the dynamic disaster response system. In Section 4, a dynamic situation response scenario with 8 tasks from the initial response to the end of the fire situation was configured. Section 5 concludes this paper and proposes further research.

2. Essential Functions of Dynamic Disaster Response System

2.1. Existing System of Super High-rise Buildings

Based on the analysis of actual conditions and systems in super high-rise buildings, the essential functions of the dynamic disaster response system were identified. While the super high-rise buildings serve as city landmarks, and play an important role in forming a vertical city through the development of architectural technologies, the vertical evacuation needs to be changed from the existing horizontal evacuation. It is also necessary to solve the problem of confusion and safety that may occur during evacuation.

In general, physical and technical characteristics of super high-rise buildings cause various problems in disaster management. To solve these problems, the super high-rise buildings have been operating a comprehensive disaster prevention center for integrated disaster management including safety management such as firefighting, electricity, and gas. Computer systems, basic facilities and equipment monitoring systems were installed and operated in the disaster prevention center of super high-rise buildings. However, the linkage between these facilities and the existing system such as disaster prevention system was not working properly, which causes difficulties in information sharing and disaster response in the event of a disaster. Therefore, in order to properly perform comprehensive disaster prevention for super high-rise buildings, it is necessary to implement a dynamic disaster response system based on real-time information by linking and interoperating with disaster prevention systems and various facilities.

Evacuation in high-rise buildings becomes inefficient when residents have to encounter many difficulties in identifying evacuation situations. To solve this problem, location identification techniques can be used to guide residents to evacuate to routes leading to stairs and emergency exits that were less crowded. Also, CCTV image analysis algorithms can be applied to reflect the evacuation route by collecting evacuation area information through visual distance detection [10][13].

2.2. Essential Functions

In order to implement a dynamic disaster response system, five functions must be basically satisfied: situational dynamic response scenarios, additional fire surveillance, evacuation guidance according to the situation, mobile information sharing, and identification of resident's location.

2.2.1. Situational Dynamic Response Scenarios

As the society becomes complicated, recently, the type of disaster and the type of buildings were diversified. Also, in order to secure the golden time for lifesaving, it was becoming more and more important to respond quickly and accurately. However, since the existing disaster response manual was made in a uniform and regular form, it was difficult to apply in various disaster situations. Manuals prepared for uniform situations are difficult to operate in a disaster situation. To solve this problem therefore, it is necessary to collect real-time information for each situation, and to make a customized on-site disaster response based on the collected information. To do this, it is necessary to configure elaborately dynamic disaster response scenarios.

2.2.2. Additional Fire Surveillance

Conventional automatic fire detection equipment or sprinklers work when a certain temperature was reached. Therefore, when these equipments activate, it means that fire damages was already incurred. In order to reduce fire damage, it is essential to detect fire early, and additional fire detection methods will be needed in addition to existing equipment such as sprinkler. With the development of intelligent sensor and intelligent CCTV, temperature change or fire image can be checked in real time, and these information can be effectively used for detection of signs of fire and quick response to the fire. Therefore, it is vital to incorporate additional fire detection functions into the current disaster response system.

2.2.3. Evacuation Guidance according to the Situation

When a fire occurs in a super high-rise building, a large number of people evacuate at once and a bottleneck occurs in the emergency stairs. This bottleneck may lead to delayed evacuation to the floor on fire and the adjacent floors, which may need to be evacuated first. Also, it is necessary to change the evacuation route according to the fire propagation and the smoke propagation. A situational evacuation guidance system automatically identifies non-evacuation and hazardous areas after collecting temperature, smoke, and visibility information in real time. Then, the system can collect resident location information in order to provide an optimal evacuation route and assist rescue activities.

2.2.4. Mobile Information Sharing

For efficient response when a fire occurs, information sharing must be supported for accurate and prompt decision making. In urgent situations such as fire, information sharing plays an important role in making decisions for evacuation, rescue and suppression. In order to share information in real time, dynamic disaster response systems could utilize mobile technology. Using mobile technology, it is possible to transmit and share information in real time to residents, firefighters, and related organizations, thereby responding efficiently to disasters.

2.2.5. Identification of Resident's Location

In super high-rise buildings, generally, the number of residents in each floor is too large especially in the case of department stores, hotels, and other residential high-rise buildings, hence it is more difficult to identify the actual number and locations of residents. When a fire occurs in these areas, failure in identifying the number of residents could lead to failure in rescuing. Even if firefighters were the ones carrying out a rescue operation, locating people in a large space would still be challenging,

Identification of resident's location can provide safe evacuation routes by avoiding unavailable or dangerous areas while the identification of firefighter's location can assist firefighters in their rescue and fire suppression activities and can identify routes that do not conflict with evacuation routes. Location identification technology is a key function for dynamic disaster response systems by allowing evacuation and rescue operations to be performed in real time. Location identification technology using beacons and mobile devices can provide information for finding intelligent evacuation route [11][12].

3. Improvements for Dynamic Disaster Response System

3.1. Derivation of Improvements

In addition to the functions required for the dynamic disaster response system described in the previous chapter, improvements that can solve the problems of super high-rise buildings should be considered in order to build an appropriate system. In this paper, the disaster cases of super high-rise buildings and the existing research reports were analyzed in order to identify the necessary improvements for the dynamic disaster response system [14]. The following table shows the improvements discovered through existing disaster analysis. These improvements need to be applied when implementing dynamic disaster response systems.

Table 1: Improvements discovered through existing disaster analysis

building information processing(structural change)	building information processing(interior and exterior material)	building information processing(fire partition)
use of flame retardant panel	replace with flame retardant outer panel	use of flammable materials and minimize internal materials
use of composite aluminium panels	fire door control technology	database of fire doors and fire extinguishing equipment
construction of emergency situation propagation system	emergency propagation (broadcasting)	management system for emergency contacts
installation of fire extinguishing equipment	information processing for fire extinguishing equipment	construction of integrated firefighting system
minimizing exterior decoration	preparing for unexpected situations due to external shock	processing technology for risk information
Installation of intelligent fire alarm	improvement for intelligent system	information processing of fire extinguishing valve and electric pump
improvement for fire system	fire safety regulations	technology for fire detection and smoke detection
implementing disaster prevention system for construction work	detection technology for alarm operation	detection technology for air outlet
use of fire-resistant concrete	installation of emergency evacuation route	design of a large accident manual
emergency situation propagation technology	computerized emergency response	monitoring technology for emergency stair
distribution of emergency power supplies	acquisition and guidance of new evacuation route	improvement of firefighting facility installation standard
technology for vertical propagation prediction	sprinkler operation detection technology	aluminium panel replacement
technology for automatic firefighting equipment	technology for automatic fire alarm	detection technology for automatic door operation
fire detection technology in vulnerable area	communication network redundancy and decentralization	information processing for evacuation stair
Information processing for fire and smoke detection	construction of fire alarm and evacuation system	detection technology for fire receiver operation
computerized instruction manual	use of flammable building materials	use of flame retardant interior material
manual computerization technology	sharing insulation material information	information processing for fire partition
emergency stairs door control (open and closed)	emergency broadcasting system	emergency situation propagation technology
firefighting training simulation	information processing for firefighting facility	detection technology for firefighting water operation
detection technology for elevator operation in case of fire	construction of a system to respond to unanticipated emergencies	Installation of sprinkler between 30cm from outside wall
detection technology for ventilation facility operation	detection technology for ventilation equipment operation	installation of integrated disaster prevention system
installation of a number of escape routes	computerized evacuation manual	installation of human detection sensor in elevator
complex disaster detection and response manual	bombing emergency scenario	earthquake early warning

Basically, in order to apply the improvements, solutions should be presented in various aspects such as architectural design, legal regulation, and strengthening of training. Among these improvements, the proponents had selected improvements that can be solved using ICT technology and can be directly applied to the disaster scene. These improvements should be reflected in building a dynamic disaster response system while converging with ICT technologies. The following table shows the Delphi survey results through expert groups on these improvements.

Table 2: Delphi survey results of improvements for dynamic disaster response system (Avr = average, SD = standard derivation, Me = median, Mo = mode, CD = convergence degree, AD = agreement degree, CVR =content validity ratio)

	Avr	SD	Me	Mo	CD	AD	CVR
response scenario automation	4.75	0	5	5	0	1	8
sensor based algorithm	4.06	0	5	5	0.12	0.95	7.5
fire door operation detection	4.55	0	5	5	0.5	0.8	7.5
fire equipment data processing	4.5	0.5	5	5	0.5	0.8	7
smoke control operation detection	4.45	1	5	5	0.62	0.75	6.5
resident location identification	4.35	0	5	5	0.5	0.8	7
mobile display for propagation	4.35	0.57	5	5	0.5	0.8	7
emergency response operation detection	4.3	0.5	4.5	5	0.5	0.77	7
fire water operation detection	4.3	1	5	5	0.62	0.75	6.5
real-time detection around the building	4.1	0.5	4.5	5	1	0.55	6

3.2. System Development Method reflecting Improvement

In order to implement improvements mentioned above in the system, it is essential to utilize the necessary technologies such as dynamic situation response scenario, IOT (Internet of Things) sensor technology, mobile situation propagation technology, location identification technology, system interworking technology and so on. In detail, after interfacing with fire-fighting facilities, building management system and information communication system, information collection and analysis were performed in real time based on IOT sensor technology, mobile technology, and location identification technology. These technologies provide information that can be tailored to complex and diverse disaster situations.

The information collected in real time enables more customized configuration of scenarios to respond to appropriately, and was applied to the algorithm for automated decision that are appropriate for the disaster situation. That is, a dynamic disaster response system using ICT technology can operate dynamic situation response scenarios based on real-time information. This system enables dynamic situation response scenarios to operate efficiently in the disaster situation. This differs from the existing system which uses the response based on the stored information because it uses the response based on the dynamic situation response scenario.

The following figure shows the configuration structure of the integrated disaster prevention system implemented by reflecting the above-mentioned improvements and was based on dynamic disaster response scenarios. For this purpose, this system was efficiently operated by combining IOT sensor technology, mobile technology, and location identification technology.

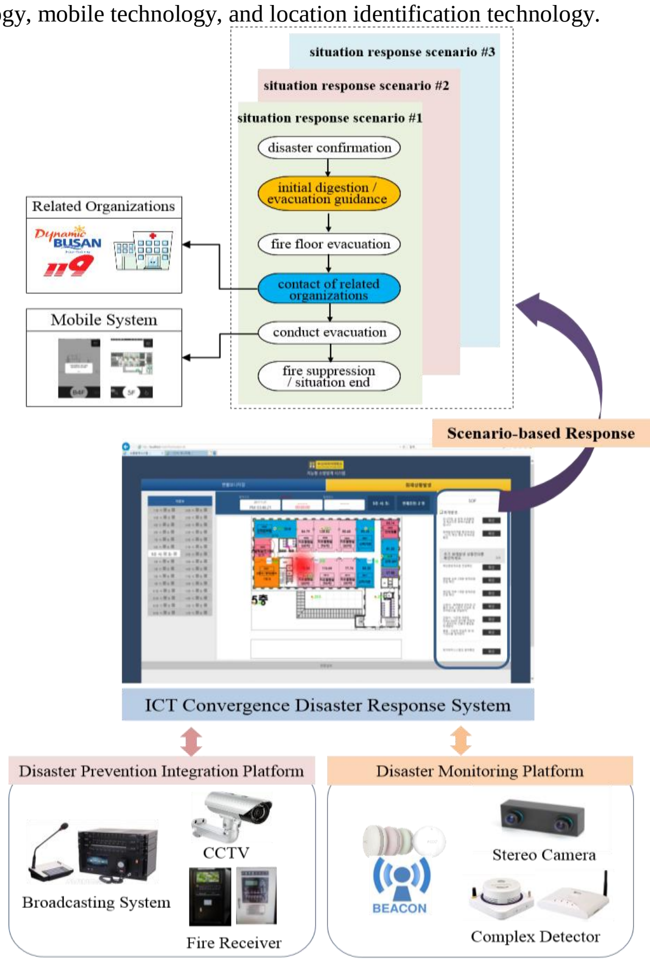


Fig. 1: Configuration of the ICT convergence disaster response system

4. Dynamic Situation Response Scenario

4.1. Configuring Scenario based on Real-time Information

ICT technology provides a basis for collecting, analyzing and deciding real-time information. As various sensor technologies were developed, it is possible to respond based on real-time information according to the disaster situation. In order to analyze, judge and make decisions using the collected information, dynamic scenario response scenarios must be configured according to the workflow. In this paper, a dynamic situation response scenario was constructed with 8 tasks from the initial response to the end of the fire situation. Each task should be performed after associating with specific actions and the corresponding responses.

4.1.1. Response Scenario for Task 1

In general, initial response is the most important for safe evacuation and rescue in a fire situation. Since various situations and variables can exist, the initial response should concentrate a lot of judgment and action. In the initial response, fixed and unified manuals at disaster sites can cause problems, therefore, it is necessary to configure the initial response scenario step by step according to the situation. Then, it should be specified to respond appropriately to the situation in the field.

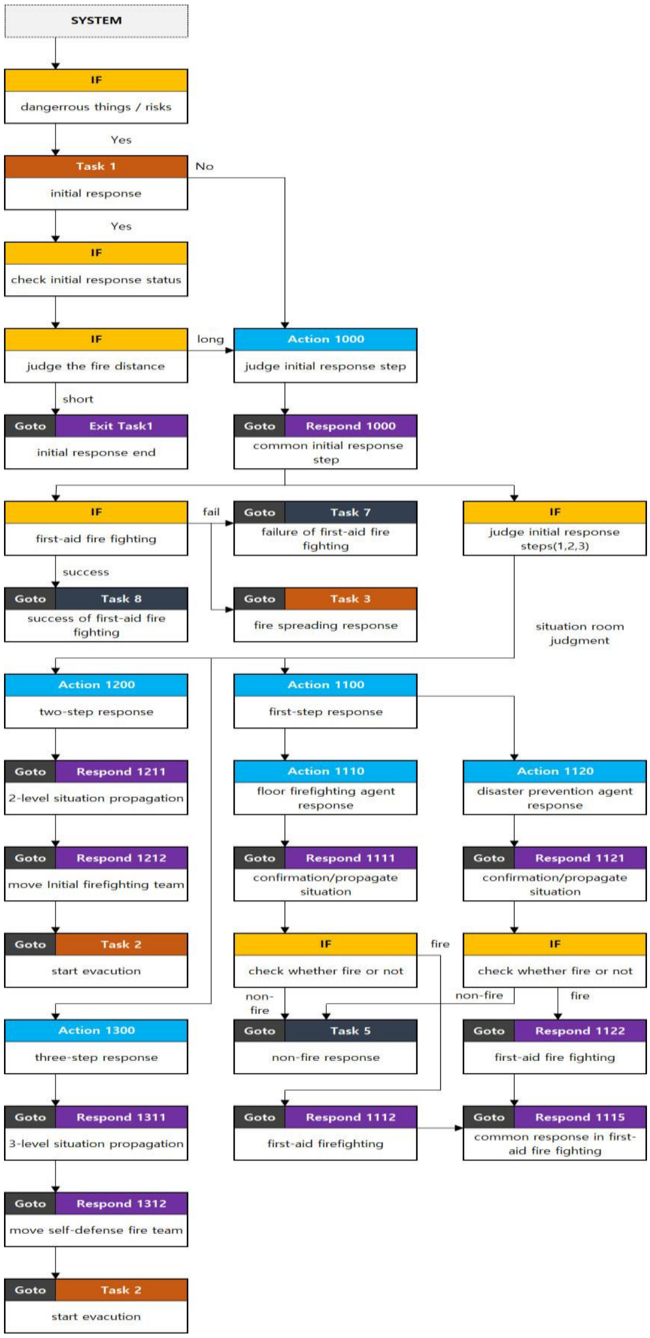


Fig. 2: Dynamic situation response scenario for Task 1

Based on the information collected in real time, the system determines the initial response step and then performs the corresponding method according to the step. If a fire is identified at the initial response stage, steps 1 and 2 will assess the capability of initial extinguishing, and step 3 will determine if the initial fire extinguishing is effective. In the initial response scenario, it should be assessed using information collected from CCTV, sensors, fire detectors, and etc. in real time. The dynamic response scenario for task 1 is shown in Figure 2, and consists of six actions and ten responses.

4.1.2. Response Scenario for Task 2

In the second and third steps for the initial response, evacuation should be started at the same time when the fire is confirmed. In order to begin evacuation, the type of disaster must be judged based on the information collected first. Then, it spreads mission and evacuation route to residents and firefighters according to disaster type. The following figure shows the dynamic situation scenario for task 2 consisting of two actions and four responses.

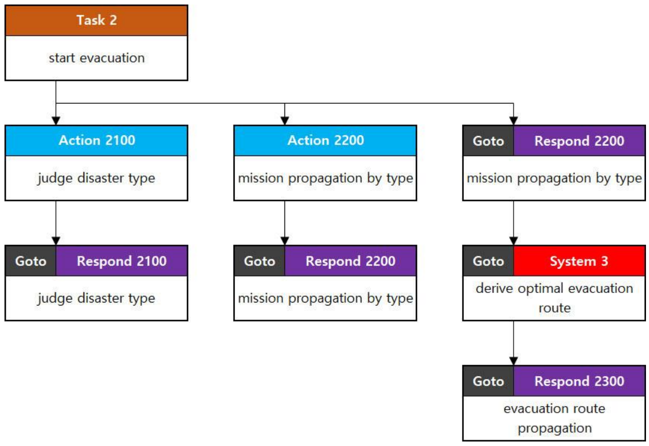


Fig. 3: Dynamic situation response scenario for Task 2

4.1.3. Response Scenario for Task 3

When initial fire extinguishment fails, Task 3 performs work that can respond to the fire spread. In order to respond to the spread of the fire, it is necessary to automatically identify the non-resident zone and the dangerous zone through temperature changes, visible distance, and smoke concentration information collected from various equipment. After predicting the fire propagation and the smoke propagation based on the place characteristics of the fire occurrence area, the optimal evacuation route should be provided in real time for residents. The dynamic response scenario for task 3 is shown in the following figure, and consists of four actions and three responses.

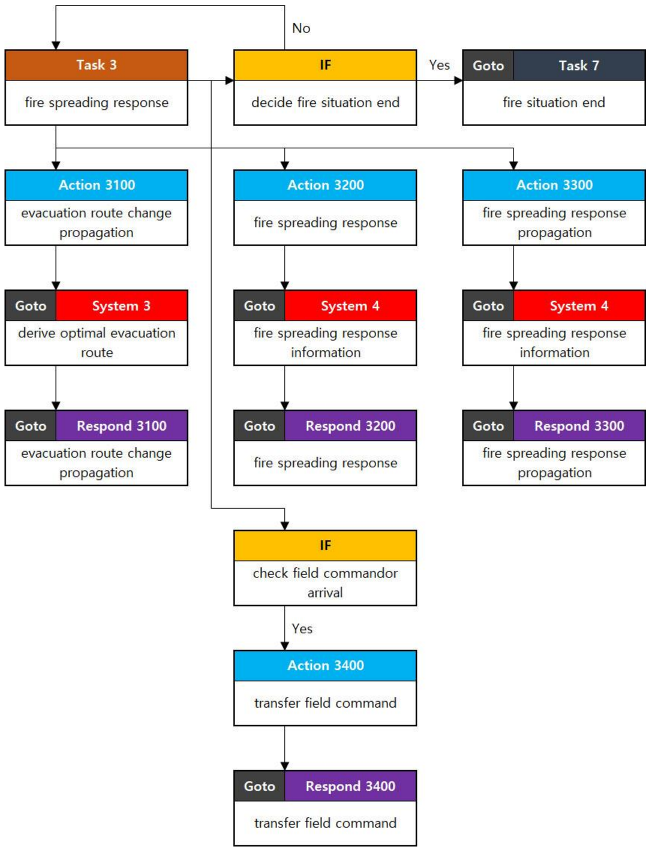


Fig. 4: Dynamic situation response scenario for Task 3

4.1.4. Response Scenario for Task 4

Task 4 should perform actions related to emergency rescue when an emergency situation arises. To do this, the most important thing is to identify the location of the resident. Through location identification, it is necessary to identify the residents who need to be rescued from the inhabitable or hazardous areas. In addition, the location information of the rescuer is transmitted to the firefighter and information on the entry route is provided.
The dynamic response scenario for task 4 is shown in the following figure, and consists of three actions and two responses. Also, in this scenario, it is necessary to link with the disaster response system in order to efficiently respond to the disaster prevention. Through the linkage of the disaster response system, the emergency response information and the emergency evacuation route information were retrieved and utilized in the scenario.

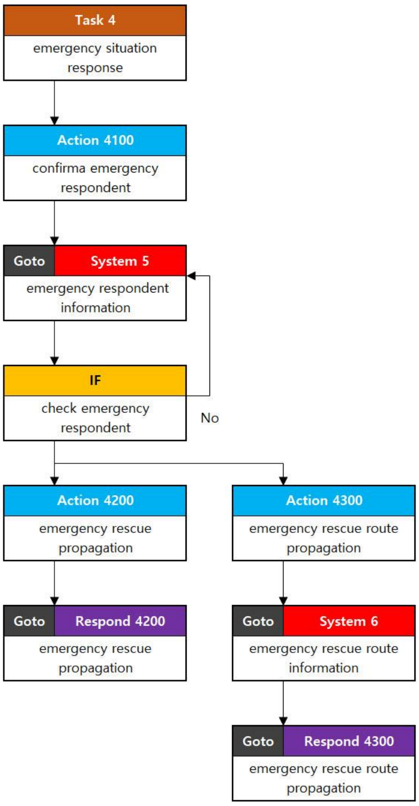


Fig. 5: Dynamic situation response scenario for Task 4

4.1.5. Response Scenario for Task 5

Even if a fire was reported, it often happens that it is not actually a fire situation. In the initial response phase, task 5 is to terminate the situation if it is not a fire situation. The dynamic response scenario for task 5 is shown in the following figure, and consists of one action and one response.

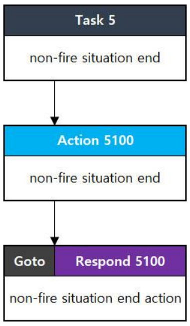


Fig. 6: Dynamic situation response scenario for Task 5

4.1.6. Response Scenario for Task 6

In the initial response phase, task 6 consists of activities to be performed when the fire was extinguished successfully. The following figure shows the dynamic situation scenario for task 6 consisting of two actions and two responses.

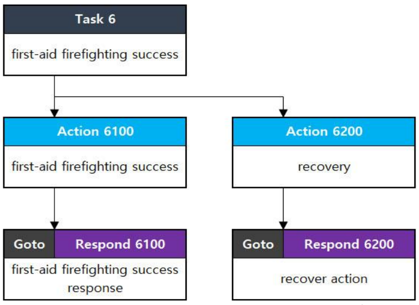


Fig. 7: Dynamic situation response scenario for Task 6

4.1.7. Response Scenario for Task 7

In the initial response phase, task 7 consists of activities to be performed in case of fire extinguishing failure. The dynamic response scenario for task 7 is shown in the following figure, and consists of two actions and two responses.

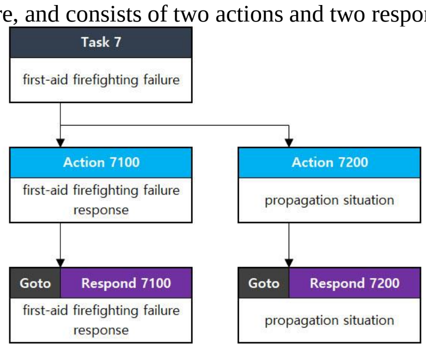


Fig. 8: Dynamic situation response scenario for Task 7

4.1.8. Response Scenario for Task 8

In the initial response phase, task 8 consists of activities to be performed when the fire situation is over. The following figure shows the dynamic situation scenario for task 8 consisting of two actions and two responses.

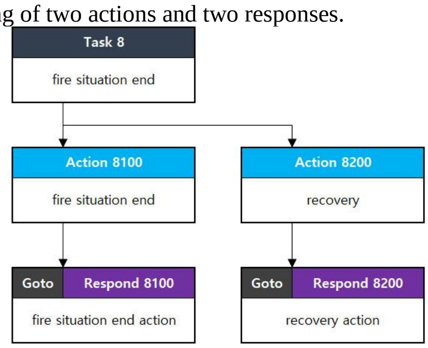


Fig. 9: Dynamic situation response scenario for Task 8

4.1.9. Response Scenario for System

The dynamic situation response scenarios of the tasks described in the previous section consist of actions that must be performed by field disaster personnel when a fire occurs. In order to efficiently configure dynamic disaster response scenarios, there were some parts that need to be automatically performed by disaster response systems other than field personnel. The following figure shows the processes that must be performed to support dynamic disaster response scenarios in various subsystems of a disaster response system.

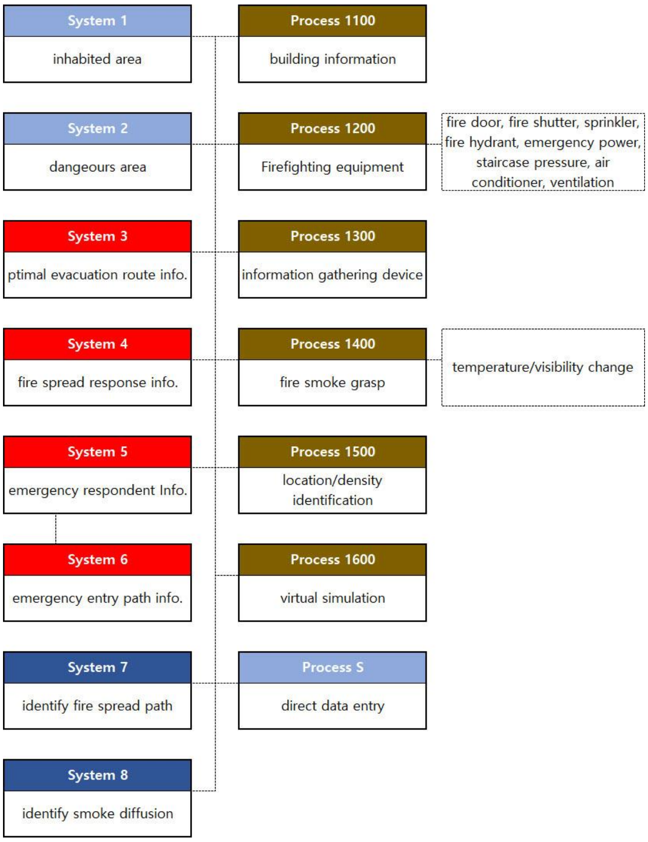


Fig. 10: Dynamic situation response scenario for system

4.2. Database Design for Dynamic Situation Response Scenario

The dynamic response scenario described above must be implemented in dynamic disaster prevention system operated on real-time information. Based on the information collected through IOT sensors and equipment, dynamic response scenarios were constructed so that the system can automatically identify non-evacuation zones, derive the optimal evacuation route, respond to fire spread, and make decisions on emergency rescue.

Dynamic situation response scenarios are tasks to support the technology needed to build a dynamic disaster response system, interworking with other systems, automated algorithms, and decision making based on situations. The following figure shows the database design for implementing dynamic situation response scenarios in the system.

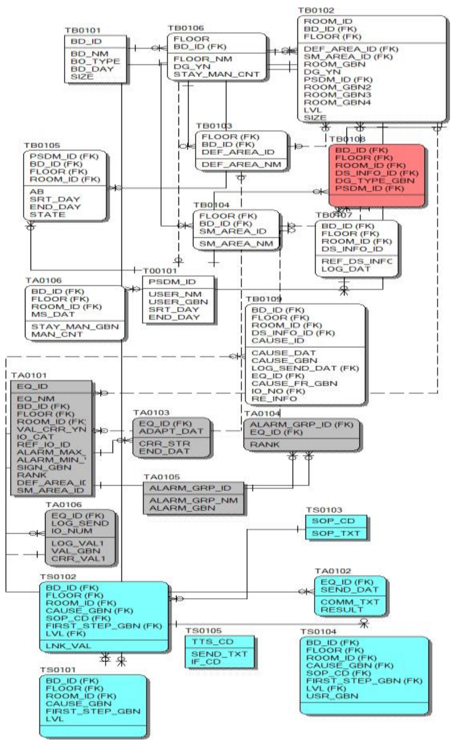


Fig. 11: Database design for dynamic situation response scenario

5. Required Technology for Implementing Dynamic Situation Response Scenarios

In order to implement dynamic situation response scenarios into the disaster response system, necessary technologies such as location identification and mobile situation propagation are required. In this chapter, the major required technologies were described for realizing dynamic situation response scenarios.

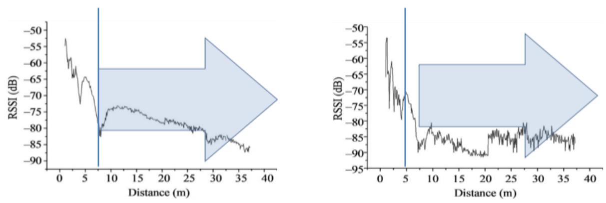
5.1. Location Identification Technology

An important factor in realizing dynamic situation response scenarios in the event of a fire is to locate the residents. In this study, a location identification technology that applies on beacons and mobile was used to locate occupants in the building. In order to determine the position of the occupant, the indoor space is divided into cells of a certain size, and the position is determined by using the signal strength, signal pattern, signal delay, etc. received from the occupant's mobile device. At this time, it is important to determine the appropriate cell size by analyzing the correlation between the number of beacons and the accuracy of placement and position identification. It is also necessary to install a beacon in the escape stair or at the entrance of the evacuation area as well as indoors in order to monitor the status of the evacuated personnel. Therefore, beacons can be used to identify the number of people inside the building and the number of people that were evacuated. In addition, information obtained through the beacon can be transmitted to the firefighter in real time, thereby helping the rescue operation. The following figure shows the beacon signal test results for location identification.

signal strenth (dbm)	distance
-51 dbm	1m
-59 dbm	2m
-61 dbm	3m
-70 dbm	4m
-75 dbm or more	5m or more

result of signal measurement (average)

- use the principle that the distance of the beacon is inversely proportional to the signal strength
- Mobile apps keep track of beacon signal strength in the background
- determine the beacon position on the strong side of the signal through the signal intensity sampling for a short time



- Since the RSSI differs in measurement value depending on the measurement or the sensitivity of the measuring and the direction of the measuring device, a value of -80 dbm or more is not taken.

Fig. 12: Signal test results for location identification

5.2. Mobile Technology

Mobile is becoming a universal means of communication in modern society, so mobile technology could play a very important role in rescue operation during disasters. Almost everyone in a building nowadays has a smartphone and is carrying it like part of their body. In a fire incident, it is essential to inform residents and firefighters of the real-time information related to the fire situation in order to evacuate effectively. To do this, in this paper, two separate types of mobile apps were developed for residents and firefighters.

Resident's apps and firefighter's apps work effectively with escalation by providing real-time fire information in conjunction with the integrated disaster management systemInformation on resident location, fire propagation, smoke spread, and non-resident areas are transmitted in real time to the firefighter app. On the other hand, the resident's app guides the residents in an optimal evacuation route in real time. The following figure shows the execution screen of the mobile app for firefighters while automatically updated in real time with the integrated disaster response system.

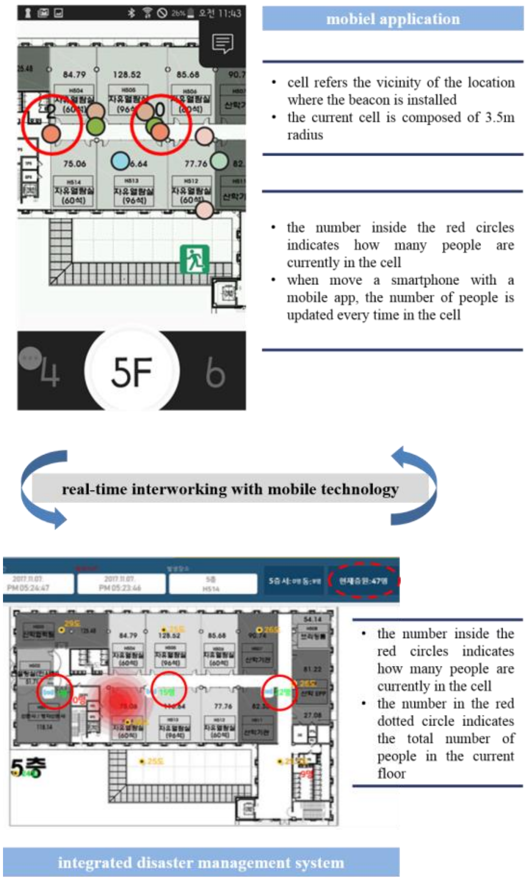


Fig. 13: Execution screen of the mobile application

5.3. CCTV Image Processing Technology

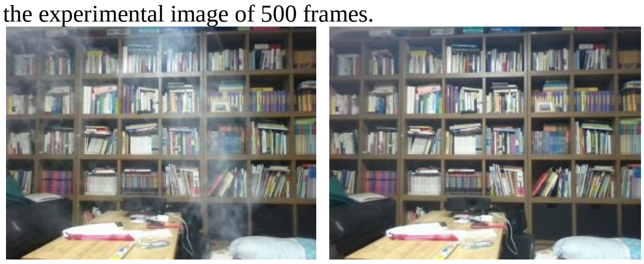
In general, CCTV (closed-circuit television) is used as a device to monitor the current situation. CCTV is already a common monitoring device, and it is essential to link with existing CCTV in order to effectively realize the dynamic disaster scenario. When a disaster such as a fire occurs in a super high-rise building, securing an evacuation route is importance for dynamic disaster response.

For this purpose, it is necessary to detect the smoke through the image received from the surveillance camera installed in the building. In detail, the image collected from the CCTV installed in each passage is analyzed in order to assess whether the visibility due to the smoke changes. That is, it is necessary to analyze the visibility due to the fire smoke using CCTV image analysis technology.

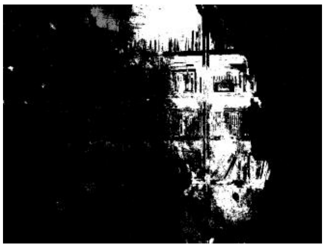
There have been studies to detect smoke automatically from video. Fujiwara and Terada proposed a method of automatically detecting smoke from images using fractal coding [15]. Since the shapes and the densities of smoke vary instantaneously, however, there is a limit to stable smoke detection by these methods. Kopilovic et al. detected smoke using a method of calculating motion irregularities [16]. In a similar way, Yu et al. analyzed statistically the motion of the smoke area [17][18]. In order to analyze the behavior of the smoke area, they used the visual flow estimation method proposed by Lucas and Kanade [19]. However, the visual flow method has a disadvantage of guaranteeing reliability in a noisy environment. Toreyin et al. detected smoke using wavelet transforms after separating foreground and background [20]. Rafiee and Tavakoli separated the background and the foreground, and calculated smoke area candidates using color in the foreground. Finally, they detected smoke using wavelets [21]. Stadler and Ike proposed a method to detect smoke based on the TVL1 visual flow estimation method proposed by Perez et al. [22] [23].

A technology for detecting smoke and measuring visibility was developed by analyzing CCTV images through previous research [10]. This CCTV image processing technology can be useful for realizing dynamic disaster situation scenarios. In detail, it is possible to automatically determine whether or not the area is unavailable by measuring visibility by smoke when evacuation routes are derived.

It is important to measure visibility based on smoke in order to determine non-resident areas. In order to measure this visibility, our image processing technology does not extract smoke directly from the CCTV image, but extracts the background image from the image containing the smoke. Specifically, the background image is extracted from the smoke image by using the Gaussian distribution for calculating the probability of the background pixels. The following figure shows the smoke image, the background image, and the foreground mask image extracted from the experimental image of 500 frames.



(a) smoke image (b) background image



(c) foreground mask image

Fig. 14: Experimental image for image processing

The basic idea of our image processing technology is that the visibility due to smoke is proportional to the feature loss of the background image. That is, the intensity of features in the background image is weaker as the density of smoke in CCTV images increases. The visibility can then be calculated due to the density of smoke by comparing and analyzing the intensity of the features existing in the smoke image in the same area as the intensity of the feature existing in the background image. The following figure shows the visibility measurement results calculated using our image processing algorithm at 500, 850, and 1000 frames of the experimental image.

(a) 500 frame (b) 850 frame

(c) 1000 frame

Fig. 15: Visibility measurement result of the experimental image

6. Conclusion

With the development of ICT technology, information can be collected, analyzed and judged in real time. In this paper, a dynamic situation response scenario was configured that can respond appropriately to the situation in real. The scenarios were analyzed by task according to the specific situation corresponding to time, and then a strategy was designed to be applied to computerization, automation and intelligence. To verify dynamic situational response scenarios, the feasibility was confirmed by designing a database of the disaster response system which implements the scenario. This scenario should play an important role in establishing a tailored response method for disaster situation.

In order to properly operate the proposed scenarios in the field, it is necessary to study verification techniques for information that induces misjudgment. For example, firefighters must perform rescue operations in hazardous situations when they collect location information that a resident is in non-residence areas. If the information is incorrect, it could lead to endangering the firefighters. Therefore, it is necessary to conduct a future research on the technique of verifying the accuracy of collected information.

Acknowledgement

This research was supported by the Field-oriented Support of Fire Fighting Technology Research and Development Program funded by the Ministry of Public Safety and Security (“MPSS-Fire Safety-2016-85 “).

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