Implementation of an Integrated Disaster Information Cloud System for Disaster Control

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Abstract

We construct and evaluate an integrated disaster information cloud system at the time of mega disaster. The integrated disaster information cloud system comprises the disaster information input function, disaster information output function, disaster information transmit function, department management function, and past disaster management function. In this article, we described the disaster information input function and the disaster information transmit function. The disaster information input function realizes easily retrieving disaster information by digitizing disaster information received from each relevant administrative organs and residents. And the disaster information transmit function transmits disaster information necessary for residents to dedicated applications. We conducted a questionnaire survey of 23 local government staffs to evaluate an integrated disaster information cloud system.

Keywords: Disaster Information Cloud System, Disaster Information Registration Function, Disaster Information Transmit Function, Evaluation Grid Method

1 Introduction

Japan is prone to mega disaster such as the Mount Ontake Eruption (September 27, 2014), the Kanto-Tohoku Rainfall Disaster (September 9-11, 2015), and the Kumamoto Earthquake (April 14, 2016). Therefore, technological development for "Disaster Prevention and Reduction" is one of the most important research subjects for safety and security of people. Currently, various systems for disaster prevention and reduction are being developed. However, there is no system covering all the work of the emergency response headquarters (disaster information collecting, sharing, transmitting, etc.). The Japanese government is reviewing disaster countermeasures legislation with lessons learned from mega disasters [11, 1]. Reinforcement of local disaster prevention by self-help, mutual assistance, and public assistance is currently the most important issue. In our previous research, we constructed the disaster information exchanging system [16, 17, 6, 5]. The disaster information exchanging system realized the function to exchange real-time disaster information reported by residents and information reported from disaster-relevant administrative organs. And, this system realized the function to share electronic disaster information. However, these previous systems can not customize functions according to the characteristics of local governments since these system is constructed in consideration of overall optimization through hearing survey of local governments.

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The rest of the article is organized in the followings way. Subject extraction of the emergency response headquarters by evaluation grid method and related work are described in section 2 and section 3. In section 4, we described objective of our system. In section 5, we present the system structure of integrated disaster information cloud system. In section 6, we present the integrated disaster information cloud system. In section 7, we evaluates the integrated disaster information cloud system.

2 Subject Extraction of the Emergency Response Headquarters by Evaluation Grid Method

In this research, we structurally revealed the needs of emergency response headquarters using evaluation grid method. Evaluation grid method is a semi-structured interview survey method aimed at structurally visualizing user's needs based on the concept of cognitive psychology[14]. In this research, we used the evaluation grid method support tool "E-Gird" developed by Onoue et al. [18, 12]. E-Grid is a web application that supports interview and analysis of evaluation grid method. Figure 1 shows the results of structurally extracting the needs of the emergency response headquarters using E-Grid. As a result of structurally extracting the needs of the emergency response headquarters at the time of mega disaster, three major needs became clear.

As the first need, it became clear that the emergency response headquarters needs to unified management of disaster information by importance level and prevent the leakage of disaster response from the following evaluation items.
(1) Unified management of all damage situation
(2) Status confirmation of disaster response
(3) Leak prevention of disaster response
(4) Unified management by importance level

As the second need, it became clear that the emergency response headquarters needs to share disaster information in real time and collaborate with each relevant administrative organs from the following evaluation items.
(1) Real time confirmation of the damage site situation
(2) Acquire real-time disaster information from each department
(3) Unified management of information received from residents
(4) Establishment of a system through emergency response drill
(5) Real-time collaboration with each relevant administrative organs

As the third need, it became clear that the emergency response headquarters needs to share disaster information as decision materials of disaster response from the following evaluation items.
(1) Request to support the Self-Defense Forces, firefighting, police
(2) Plan for relief supplies
(3) Real-time grasp of the number of dead and injured people
(4) Real-time grasp of lifeline information
(5) Registering various hub information on Web-GIS

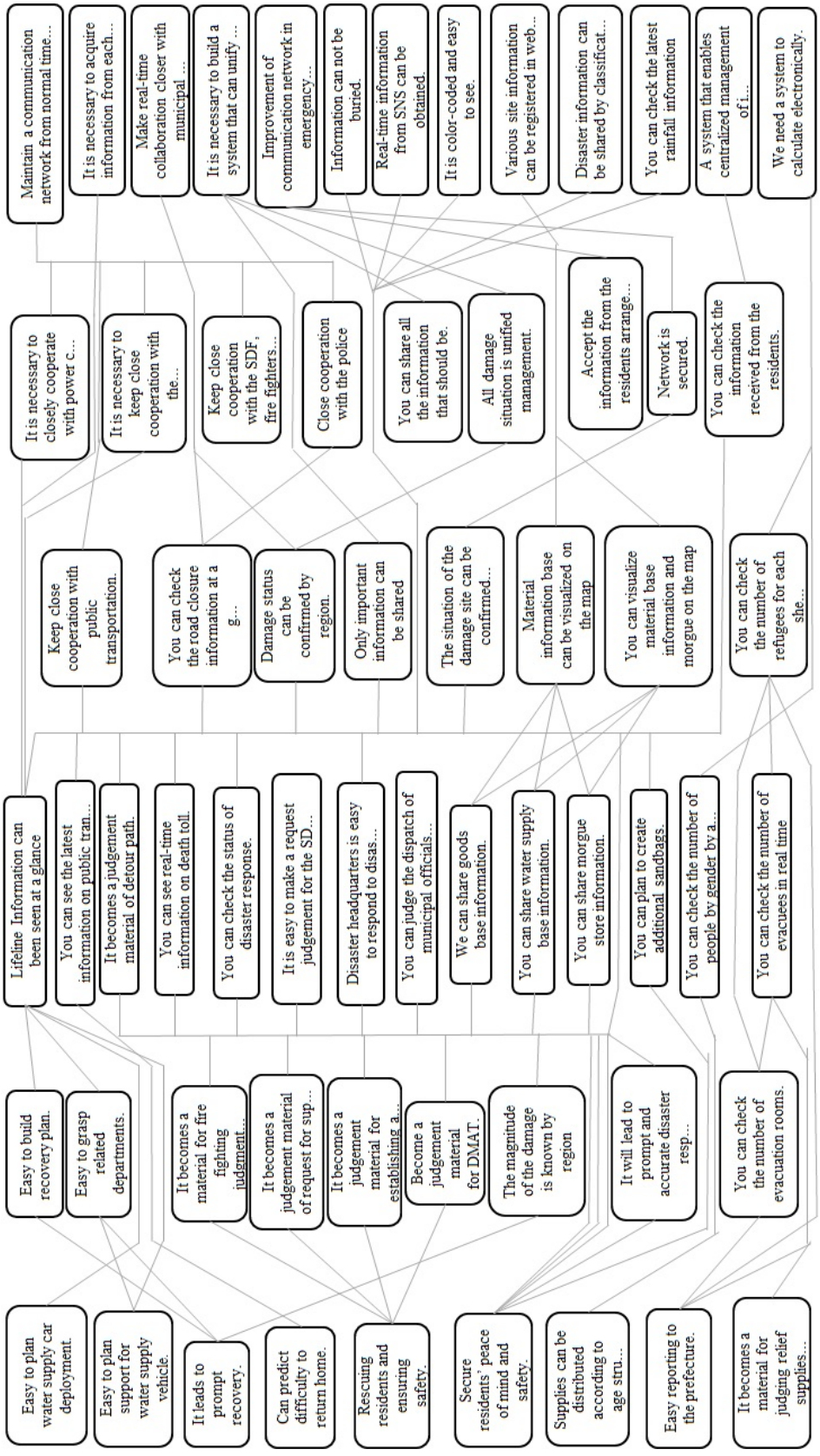

Figure 1: Subject Extraction of the Emergency Response Headquarters by E-Grid

3 Related Work

In [13], Sanada et al. developed a disaster information system based on a present business model analysis. This system categorized disaster information as inspection progress, facility damage, emergency restoration, support request, traffic regulation, and others. In addition, this system used an electronic map utilizing the electronic national land of Geographical Survey Institute. However, this disaster information system can not customize the function according to the characteristics of the user.

In [15], Suzuki developed the disaster response management system that supports local governments with disaster responses. This system realized the function of sharing the prefecture's instruction, compliance situation, damage report, evacuation centre information and so on. Moreover, this system realized functions that can judge the importance according to the content, and can automatically report aggregate information to the prefecture and the country. In [4], Ise et al. developed a disaster information utilization system for municipalities. This system realized the function to easily reconstruct system workflow and information design. However, both system can not provide the emergency response headquarters with the optimum functions according to the characteristics of local government since this system focuses on collaboration with the prefecture and the country.

In [10, 7, 8], the comprehensive disaster prevention information system realized the function of sharing disaster information with related organizations by combining satellite image and disaster information. In addition, this system realized the early grasp function of damage using satellite images before and after the disaster. However, this system is a large-scale system and it is difficult to introduce this system at municipal level.

In [9, 2], the public information commons realized that evacuation recommendations and evacuation instructions can be provided to residents quickly and efficiently through various media at the time of disaster. However, this commons can not share summarized public information at the emergency response headquarters.

A comparison table between our system and related work is shown in Table 1.

4 Objective of The Research

In this article, we describe the integrated disaster information cloud system using a high resolution tiled display system. The integrated disaster information cloud system comprises the disaster information input function, disaster information output function, disaster information transmit function, department management function, and past disaster management function. The disaster information input function realizes digitization of disaster information by registering real-time information reported from residents and disaster information reported from disaster relevant administrative organs using a tablet terminal or a personal computer. Therefore, the emergency response headquarters can quickly collect and summarize disaster information. The disaster information transmit function transmits disaster information necessary for residents to dedicated application from various disaster information registered in this system. Our integrated disaster information cloud system can customize various function freely according to the characteristics of local government. We avoid the risk of data and system loss by constructing the cloud system.

5 System Structure

The structure of integrated disaster information cloud system is shown in Figure 2. At this time, disaster information is registered in each database server via communication with each disaster information

Table 1: Comparison of functions in our system and related work

	Our System	Takahagi et al. [16]	Sanada et al. [13]	Suzuki [15]	Ise et al. [4]	Cabinet Office [10]	MIC [9]
Digitizing Disaster Information	•	•	•	•	•	•	•
Sharing Disaster Information	•	•	•	•	•	•	
Transmitting Disaster Information	•	•					•
Customization of Each Function	•				•		
Interactive Information Sharing	•						
Information Sharing with the Country and the Prefecture				•	•	•	•

application server. On the other hand, the emergency response headquarters displays registered disaster information as Web content on the high resolution tiled display system installed in the emergency response headquarters. The emergency response headquarters can summarize emergency information and can make quick decision making. In addition, the emergency response headquarters can transmit the emergency information necessary for the residents to the dedicated application. In this research, this cloud system realized function selection for each department and browsing past disaster information. As a result, many local governments can joint use this system.

This system consists of seven agents, ten application servers, and ten database servers.

- Municipality information input agent
  This agent inputs user information of each department in the local government and new disaster information to the municipality information management system.

- Disaster information input agent
  This agent inputs each disaster information to the dedicated systems.

- Disaster information output agent
  This agent shares disaster information which was integrated in each database server through the large display installed in the emergency response headquarters. The emergency response headquarters can grasp the integrated damage status etc. at an early stage.

- Disaster information exchanging agent
  This agent reflects various disaster information on the Tablet PC and the smartphone by one touch / one flick in the high resolution tiled display system.

- Evacuation centre agent
  This agent registers evacuee's safety information via the safety information registration system.

- Damage status post agent
  This agent (local government staff and fire corps volunteer) posts a damage picture from smartphone application.
- Residents agent
  This agent can acquire disaster information transmitted from disaster information output agent via dedicated application.

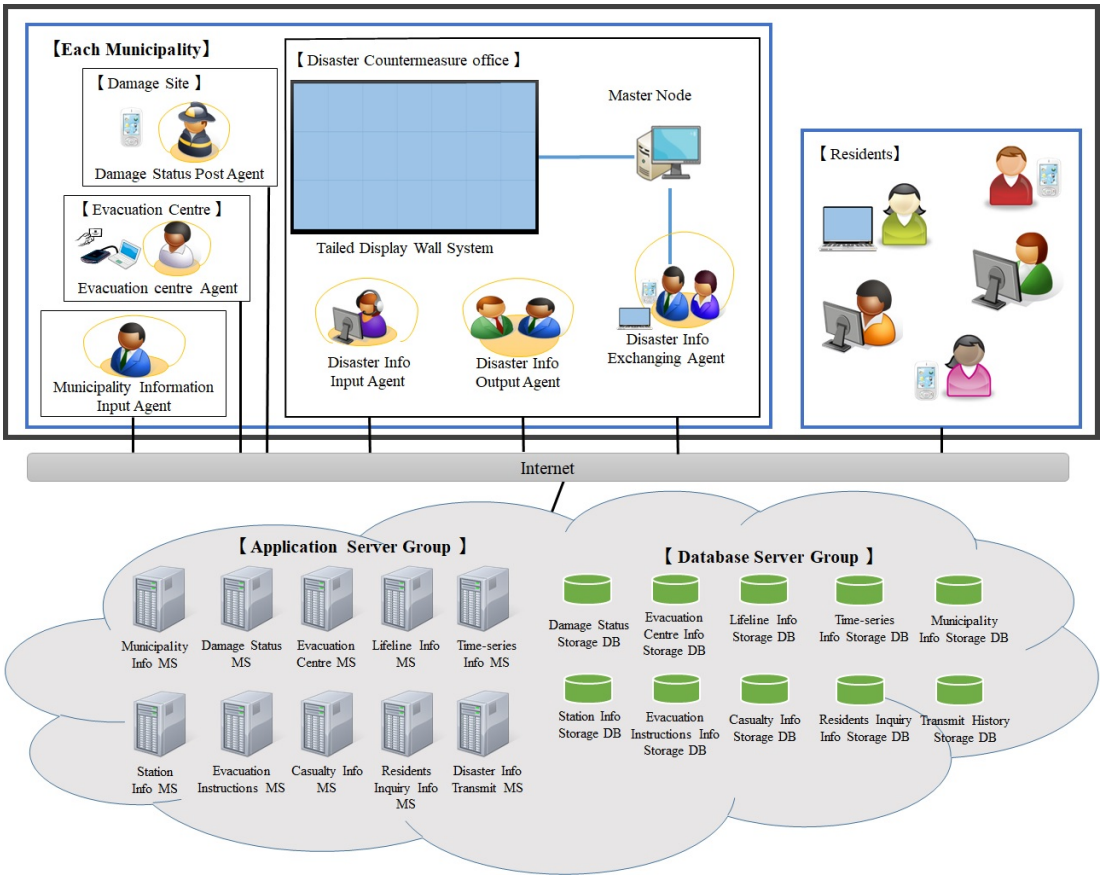

Figure 2: System Structure

6 Integrated Disaster Information Cloud System

In order to use the integrated disaster information cloud system for disaster control, the user should login authentication by inputting ID and password from the login screen as shown in Figure 3. After inputting ”User ID” and ”Password”, login authentication is executed by the user pressing the ”Login” button. Upon successful login authentication, the login screen is shifted to the system selection screen of the integrated disaster information cloud system.

The system selection screen is shown in Figure 4. This cloud system comprises the disaster information input function, disaster information output function, disaster information transmit function, department management function, and past disaster management function. In this paper, we describe the disaster information input function, the disaster information transmit function, the department management function, and the disaster management function below.

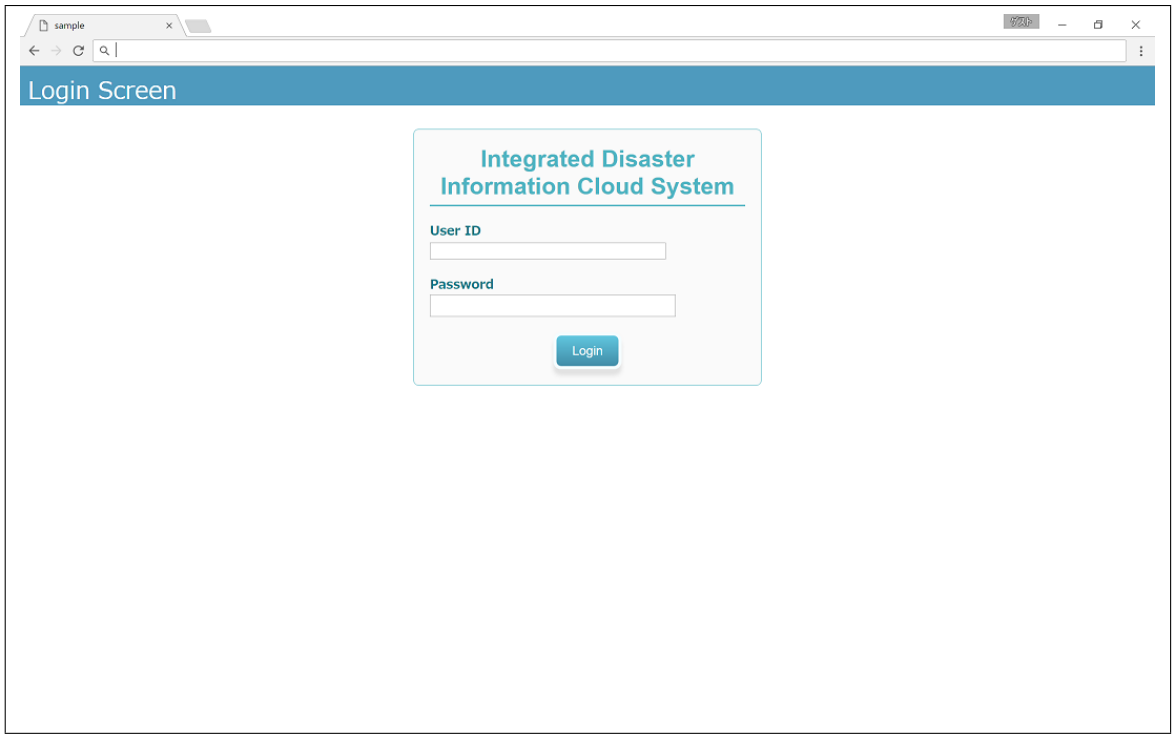

Figure 3: The Login Screen of the Integrated Disaster Information Cloud System

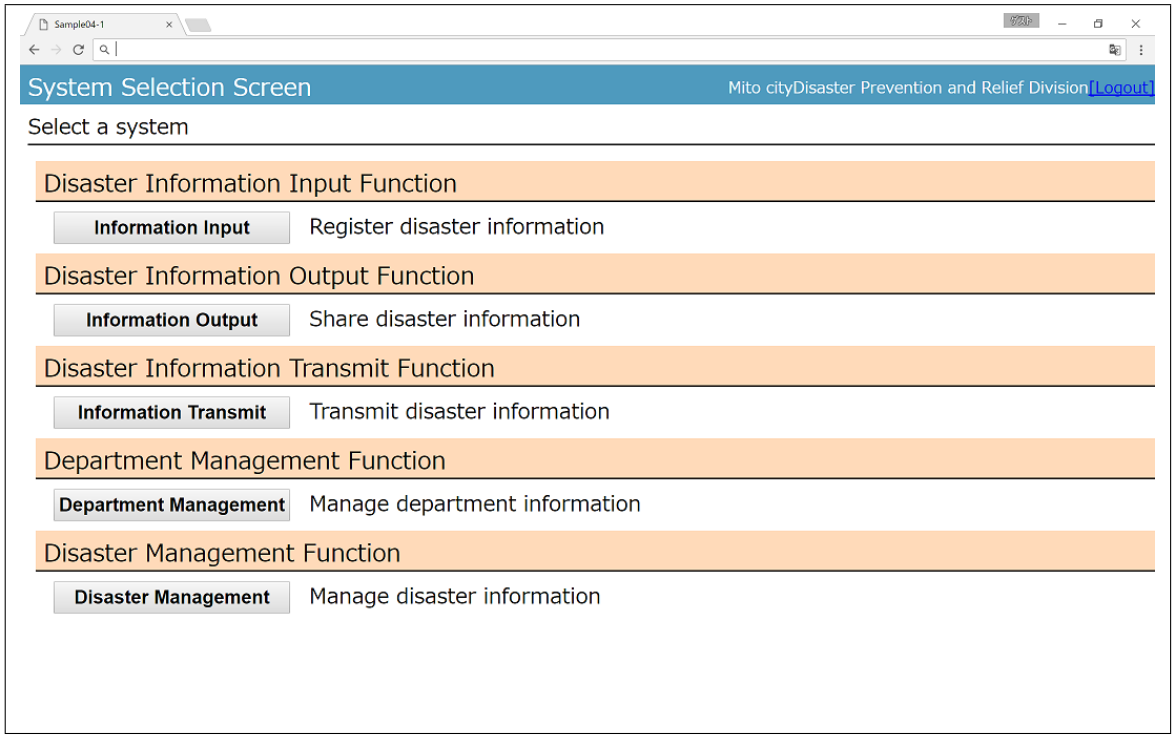

Figure 4: The System Selection Screen

6.1 Disaster Information Input Function

We constructed the disaster information input function to realize easily retrieving disaster information by digitizing disaster information. This disaster information input function comprises the 24 input function. The disaster information input function is shown in Figure 5.

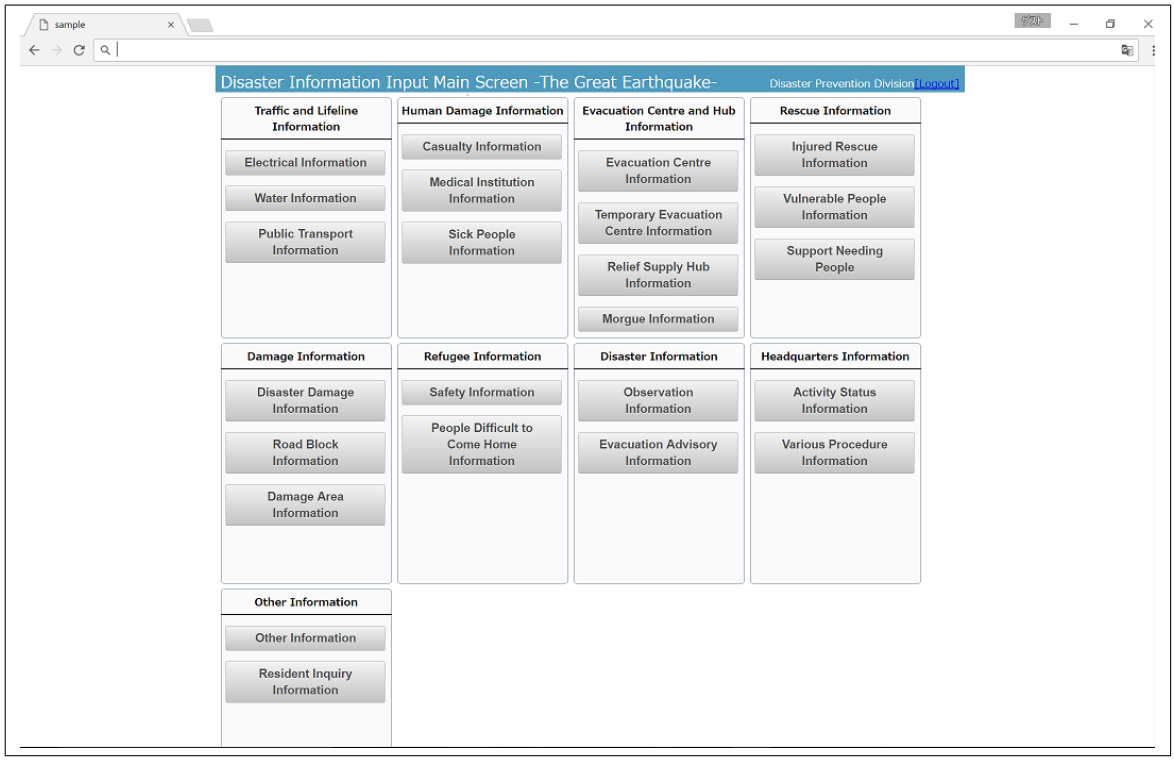

Figure 5: The Main Screen of Disaster Information Input Function

The electrical information input function screen is shown in Figure 6. This input function is used for registering electricity supply. The user communicates with the lifeline information management server and acquires the energization state of the jurisdiction district from the lifeline information storage database server. The user selects a district for registering the energization state. The registration department refers to the login account and is automatically displayed. The user selects importance from the radio button. The disaster damage information input function screen is shown in Figure 7. This input function is used for registering disaster point information. The user selects a disaster point on the map. Thereafter, the marker is displayed at the point selected by the user, and a confirmation dialog is displayed. When the “Decision” button of the confirmation dialogue is pressed, the disaster point is fixed. If the user has a picture of the disaster point, press the “File Selection” button and select the picture. The user selects the type of damage from “Human Damage”, “Facility Damage”, “House Damage”, “Road Damage”, and “Others” in the pull-down menu. The registration department refers to the login account and is automatically displayed. The user selects importance from the radio button. Thereafter, when the user presses the “Submit” button, the electrical information is registered in the damage status information storage database server via the damage status management server.

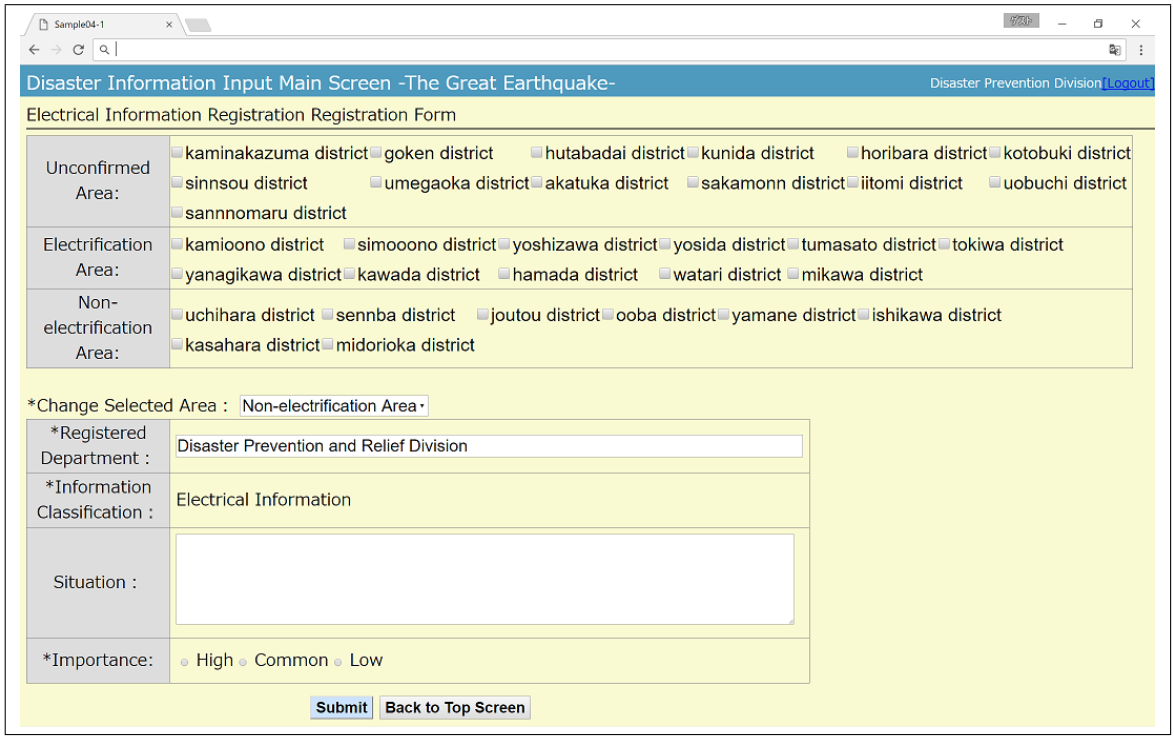

Figure 6: The Electric Power Information Input Screen

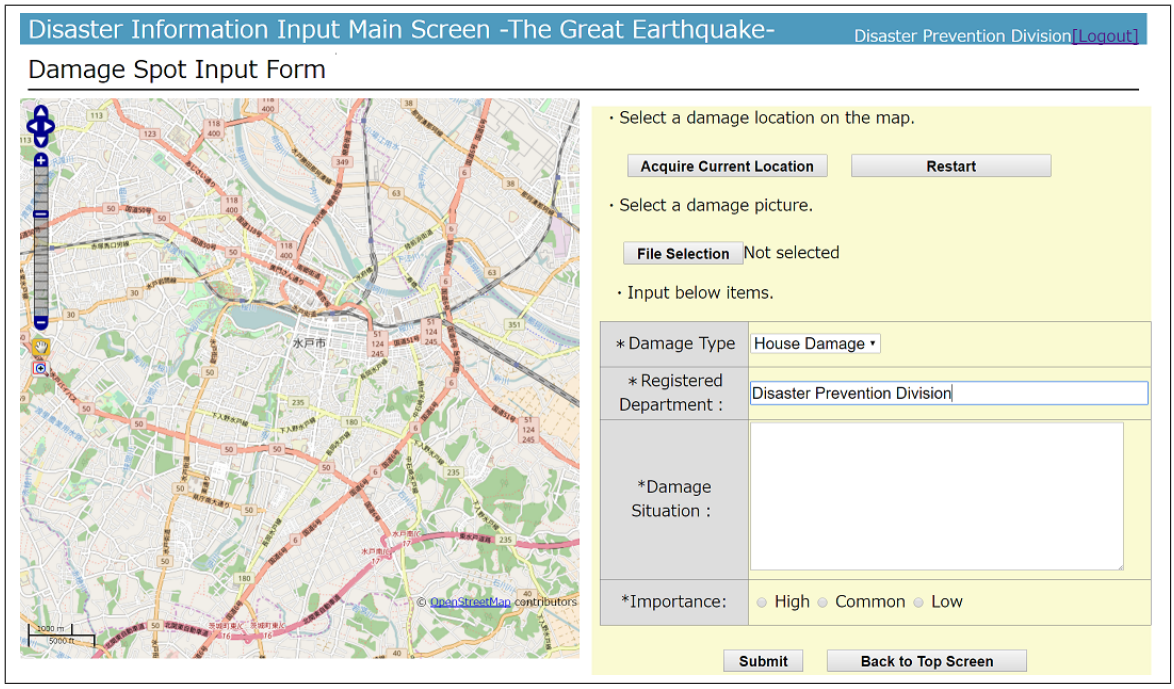

Figure 7: The Damage Spot Information Input Screen

6.2 Disaster Information Transmit Function

When a mega disaster occurs, the emergency response headquarters must transmit disaster information to the residents in order to protect the safety and security of residents. Therefore, in this research, we constructed the disaster information transmit function that transmits disaster information necessary for residents to dedicated applications. A screenshot of the disaster information transmit function screen is shown in Figure 8. The user can transmit the temporary evacuation centre information registered from the temporary evacuation centre information input function, the road block information registered from the road block information input function, the electrical information registered from the electrical information input function, the water information registered from the water information input function, the relief supply hub information registered from the relief supply hub information input function, and the morgue information registered from the morgue information input function on the disaster information transmit screen. The user selects the check box of the disaster information to be transmitted to the residents and presses the "Submit" button. When the "Submit" button is pressed, disaster information is acquired from the database server via each disaster information management server. After that, the JSON file is generated and the information is transmitted to the dedicated application. The transmitted information is registered in the transmit history storage database server.

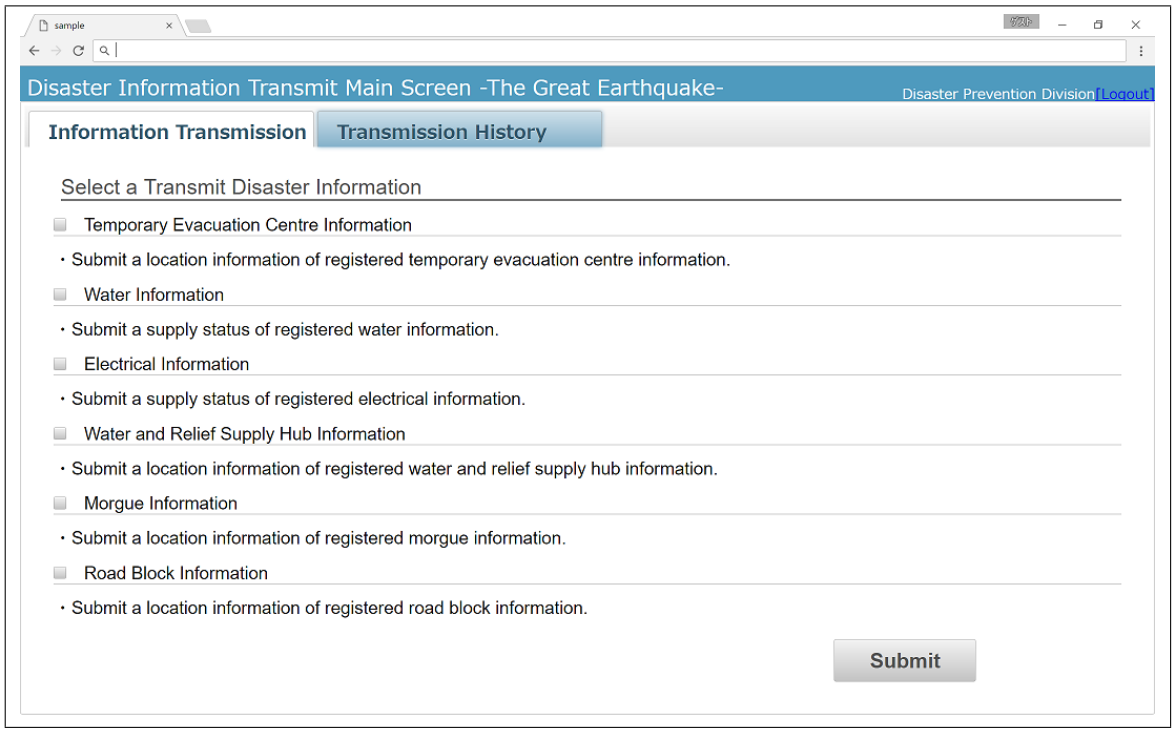

Figure 8: The Disaster Information Transmit Screen

6.3 Department Management Function

The administrator can set the registrable disaster information in each department as shown in Figure 9. The administrator selects a department name, a user ID, a password and the registrable disaster information, and clicks "Register" button. Moreover, the user can confirm the registered department list by pressing the "Back to List Screen" button on the department management screen as shown in Figure 10.

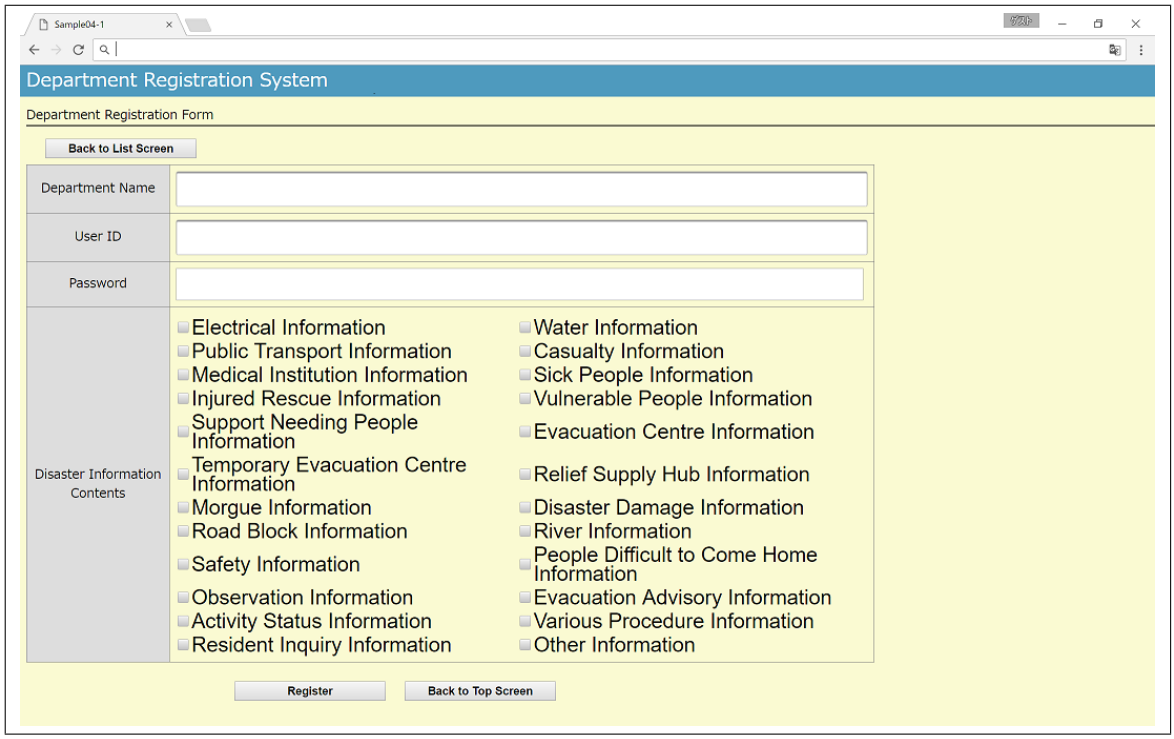

Figure 9: The Department Management Screen

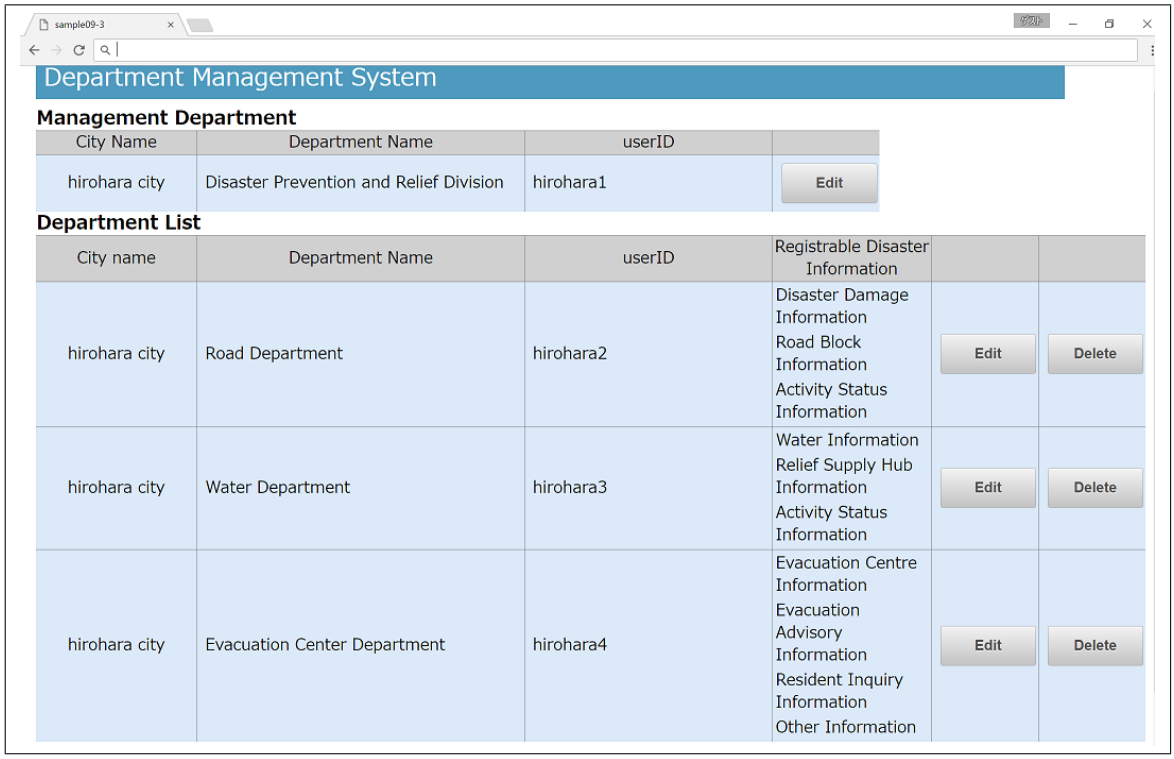

Figure 10: The Registered Department List Screen

6.4 Disaster Management Function

The disaster management function is used to register and edit disasters (e.g. earthquakes, typhoons, eruptions, etc.). The user can register the disaster information by inputting the disaster category, the disaster name, the registration date in the disaster registration form as shown in Figure 11.

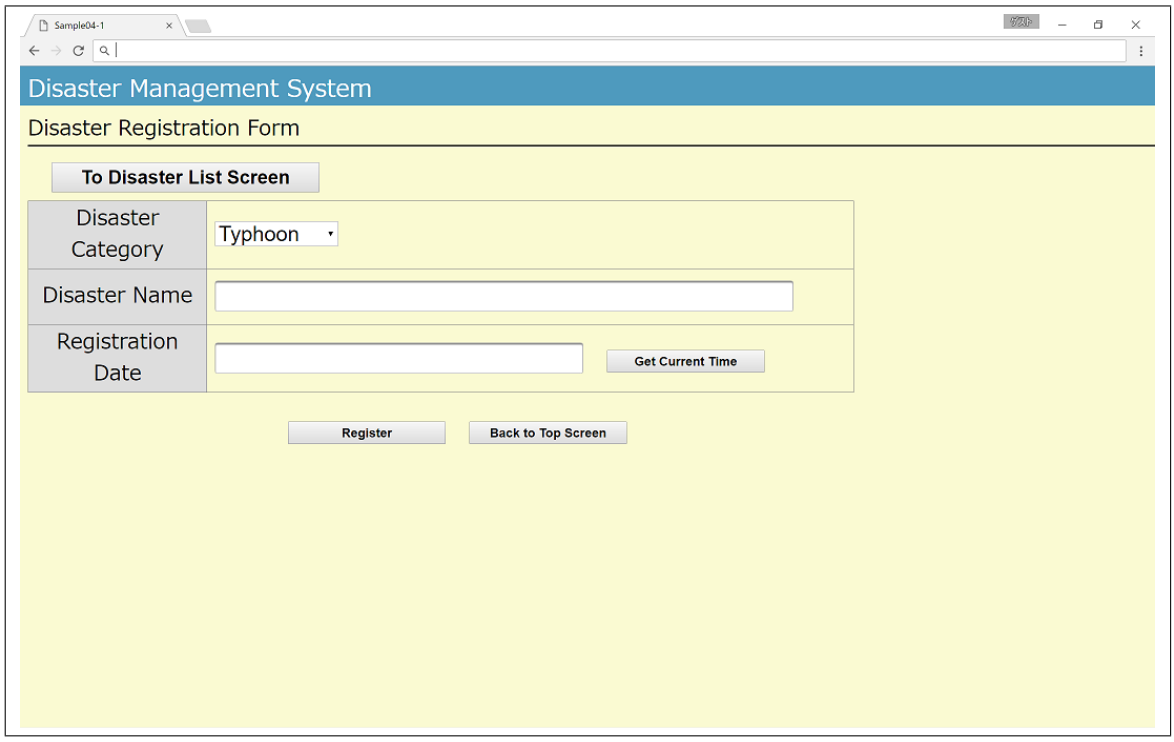

Figure 11: The Disaster Management Screen

6.5 Database Structure

The database server of our system comprises the Municipality Information Storage Database Server (User Information Management Table, Disaster Management Table), the Damage Status Information Storage Database Server (Damage Spot Information Management Table, Road Block Information Management Table, Damage Area Information Management Table), the Evacuation Centre Information Storage Database Server (Temporary Evacuation Centre Information Management Table), the Lifeline Information Storage Database Server (Electric Power Information Management Table, Water-Supply Information Management Table, Public Transport Information Management Table), the Station Information Storage Database Server (Station Information Management Table), the Evacuation Instructions Information Storage Database Server (Evacuation Instructions Information Management Table), the Casualty Information Storage Database Server (Casualty Information Management Table), the Residents Inquiry Information Storage Database Server (Residents Inquiry Information Management Table), the Time-series Information Storage Database Server (Time-series Information Management Table), and the Transmit History Storage Database Server (Transmit History Information Management Table). The entity-relationship diagram of each database server is shown in Figure 12.

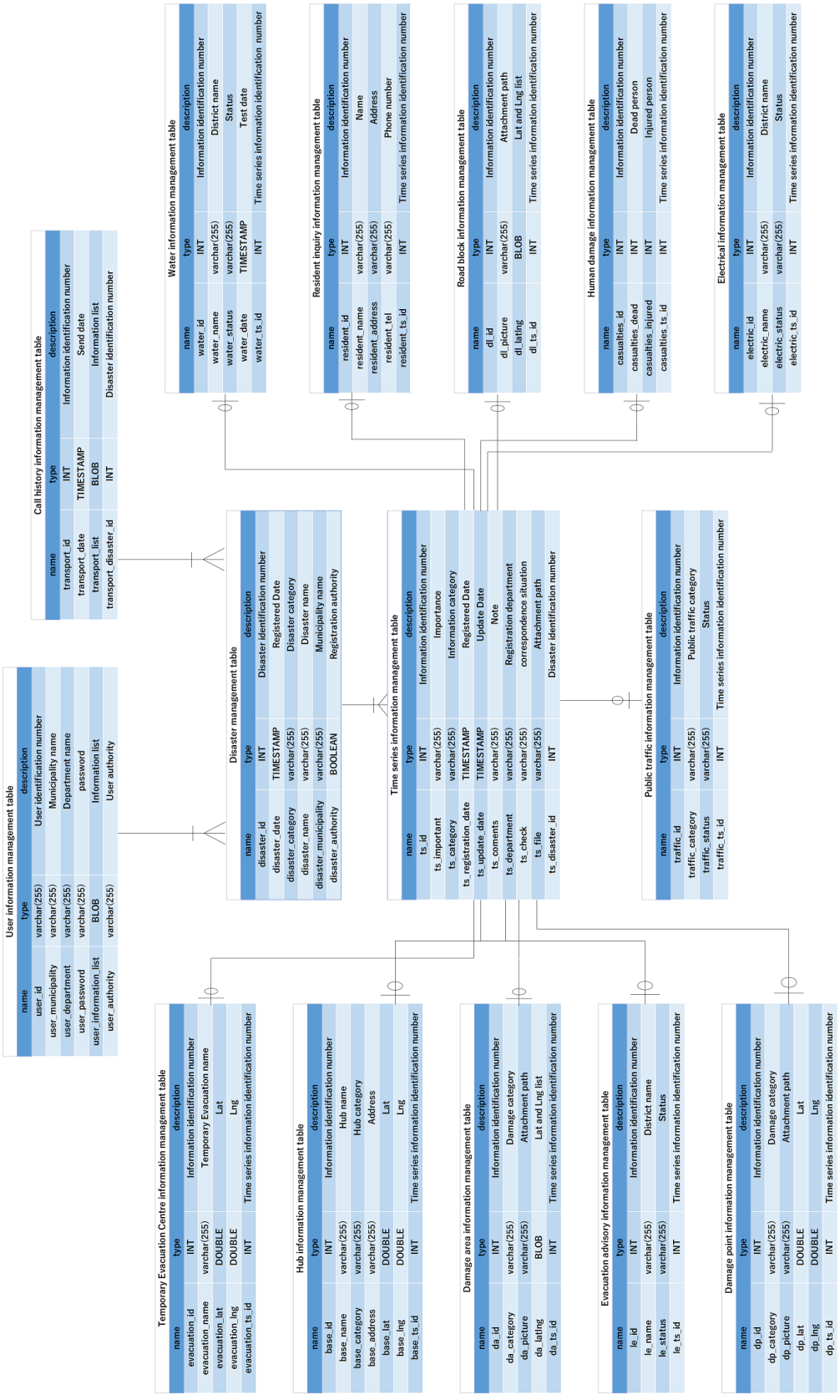

Figure 12: The Entity-Relationship Diagram of Each Database Server

7 System Evaluation

We conducted a questionnaire survey of 23 local government staff to evaluate an integrated disaster information cloud system. In the questionnaire survey, we investigated the operability, readability, functionality, necessity, effectiveness, and applicability of the integrated disaster information cloud system.

7.1 The Operability Evaluation Result

In the operability of the integrated disaster information cloud system, 3 subjects (13%) answered "Easy" and 16 subjects (70%) answered "Somewhat easy". And, 4 subjects (17%) answered "No opinion". From this operability evaluation result, we were able to confirm high operability of the integrated disaster information cloud system (Figure 13).

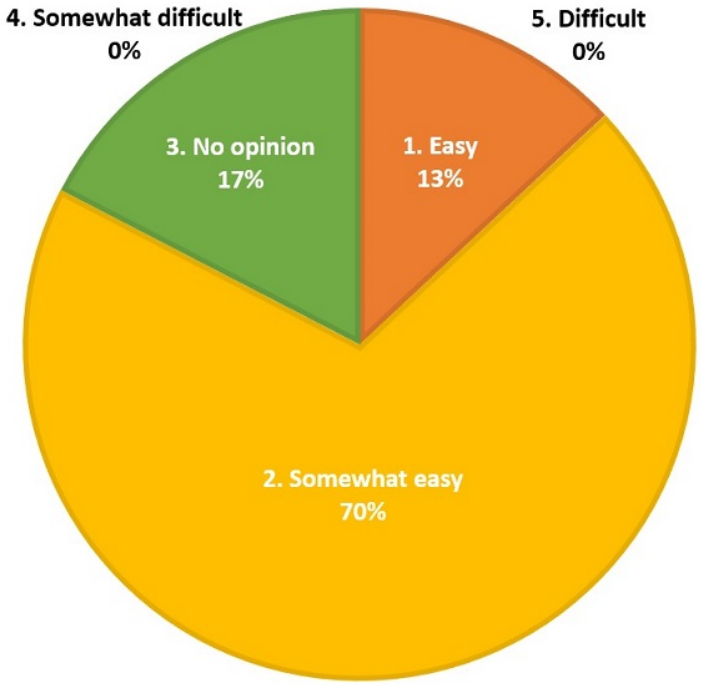

Figure 13: Evaluation Result of the Operability (*n = 23)*

7.2 The Readability Evaluation Result

In the readability of the integrated disaster information cloud system, 7 subjects (30%) answered "Easy to understand" and 13 subjects (57%) answered "Somewhat easy to understand". And, 3 subjects (13%) answered "No opinion". From this readability evaluation result, we were able to confirm high readability of the integrated disaster information cloud system (Figure 14).

7.3 The Functionality Evaluation Result

In the functionality of the integrated disaster information cloud system, 4 subjects (18%) answered "Satisfied" and 14 subjects (61%) answered "Somewhat satisfied". And, 4 subjects (17%) answered "No opinion". From this functionality evaluation result, we were able to confirm high functionality of the integrated disaster information cloud system (Figure 15).

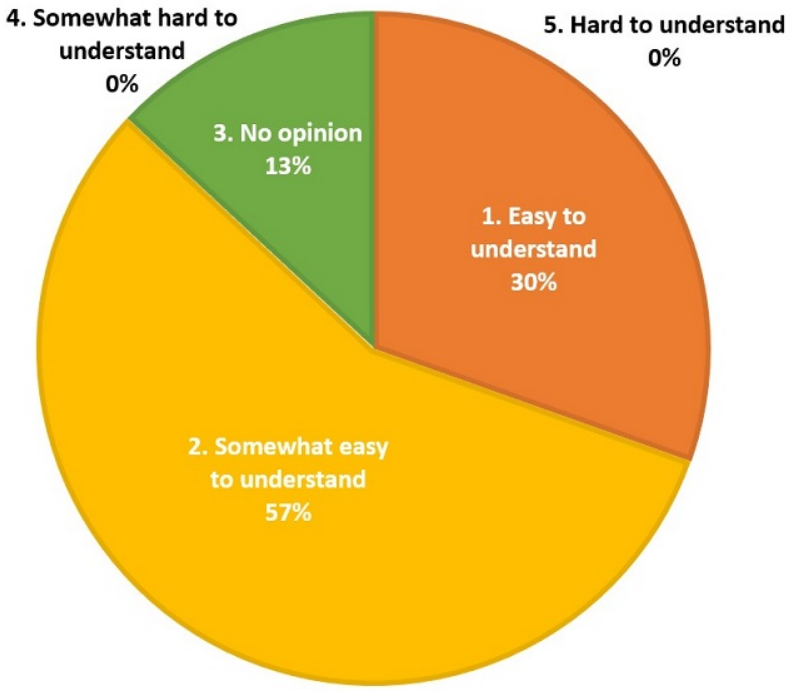

Figure 14: Evaluation Result of the Readability (*n = 23)*

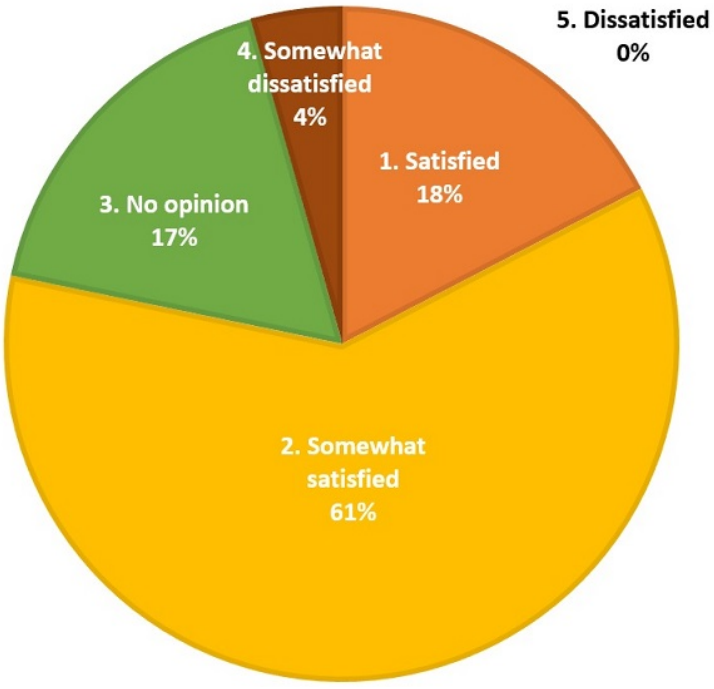

Figure 15: Evaluation Result of the Functionality (*n = 23)*

7.4 The Necessity Evaluation Result

In the necessity of the integrated disaster information cloud system, 13 subjects (57%) answered ”Necessary” and 7 subjects (30%) answered ”Somewhat necessary”. And, 3 subjects (13%) answered ”No opinion”. From this necessity evaluation result, we were able to confirm high necessity of the integrated disaster information cloud system (Figure 16).

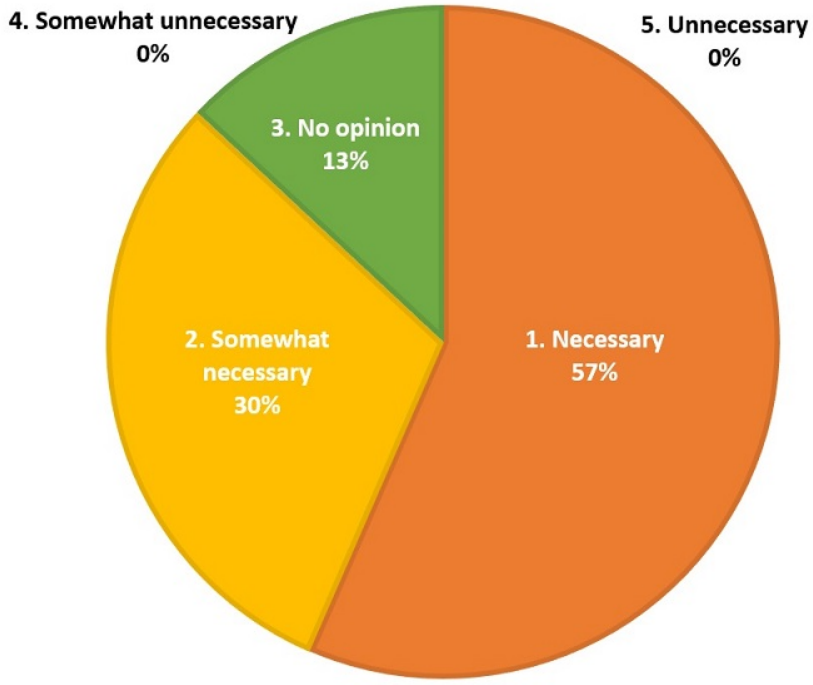

Figure 16: Evaluation Result of the Necessity (*n = 23)*

7.5 The Effectiveness Evaluation Result

In the effectiveness of the integrated disaster information cloud system, 17 subjects (74%) answered ”Effective” and 5 subjects (22%) answered ”Somewhat effective”. And, one subject (4%) answered ”No opinion”. From this effectiveness evaluation result, we were able to confirm high effectiveness of the integrated disaster information cloud system (Figure 17).

7.6 The Applicability Evaluation Result

In the applicability of the integrated disaster information cloud system, 10 subjects (44%) answered ”Possible” and 12 subjects (52%) answered ”Somewhat possible”. And, one subject (4%) answered ”No opinion”. From this applicability evaluation result, we were able to confirm high applicability of the integrated disaster information cloud system (Figure 18).

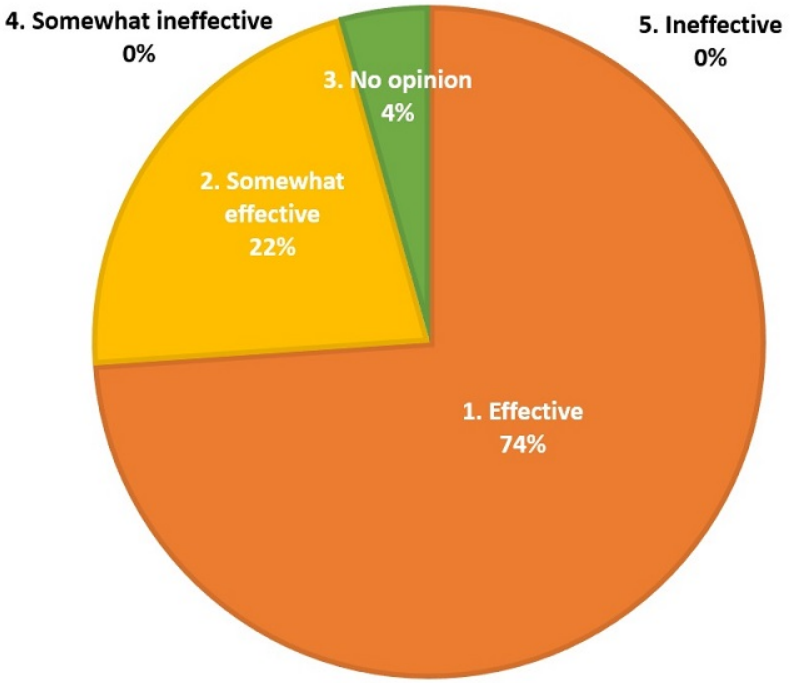

Figure 17: Evaluation Result of the Effectiveness (*n = 23)*

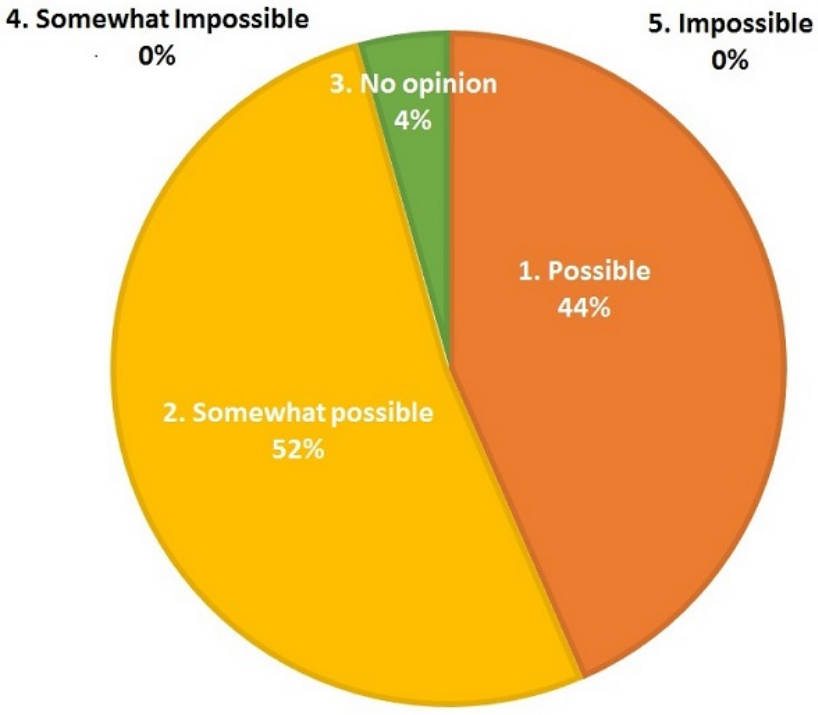

Figure 18: Evaluation Result of the Applicability (*n = 23)*

8 Conclusions

In this research, we constructed the integrated disaster information cloud system using a high resolution tiled display system. The integrated disaster information cloud system comprises the disaster information input function, disaster information output function, disaster information transmit function, department management function, and past disaster management function. In this article, we described the disaster information input function and the disaster information transmit function.

The disaster information input function realized digitization of disaster information by registering real-time information reported from residents and disaster information reported from disaster relevant administrative organs using a tablet terminal or a personal computer. The disaster information transmit function realized to transmit disaster information necessary for residents to dedicated application from electronic disaster information. Residents can receive real-time disaster information from emergency response headquarters via dedicated application. Moreover, our cloud system realized the customization function according to the characteristics of each local government. And, we realized risk avoidance of data and system loss.

We conducted a questionnaire survey of 23 local government staff to evaluate an integrated disaster information cloud system, and our cloud system received high evaluation.

9 Future Works

As a future work, we will try to cooperate with our integrated disaster information cloud system and the disaster prevention system such as J-ALERT or L-ALERT already introduced. In other words, we research and develop a new disaster prevention system capable of sharing and transmitting wide-area disaster information as shown in Figure 19.

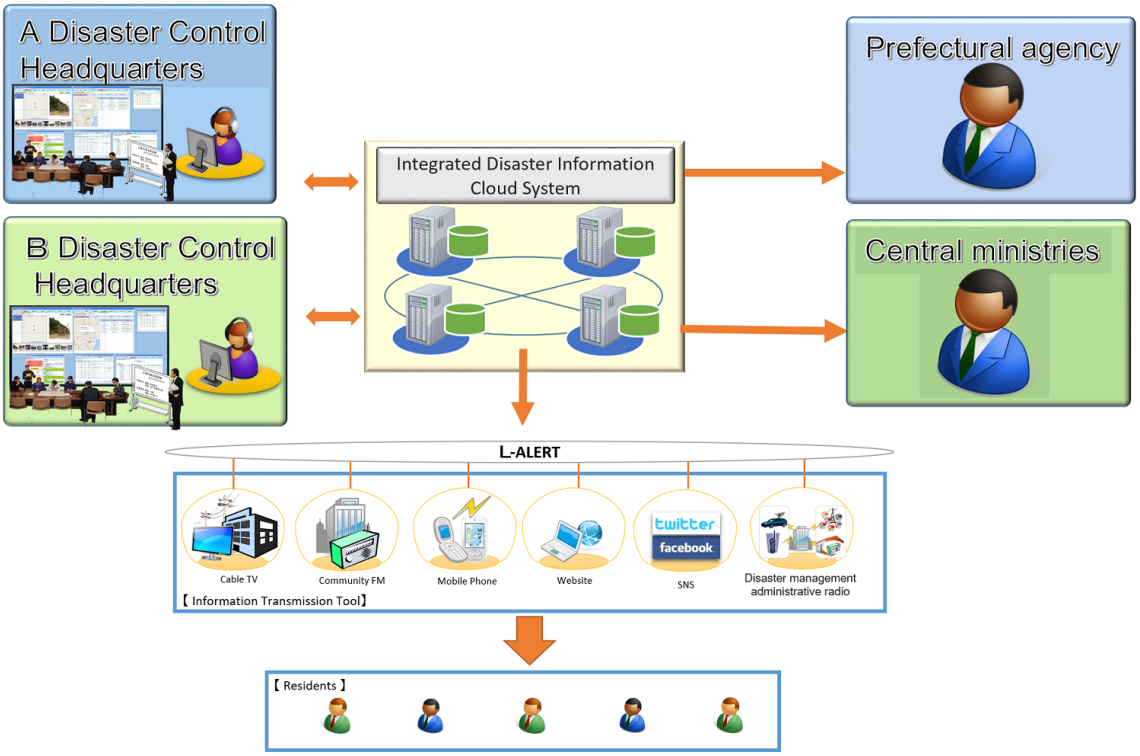

Figure 19: Future Work

Acknowledgments

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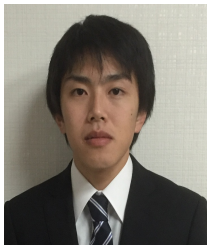

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