Construction of a Mega Disaster Crisis Management System

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Abstract

In this article, we propose and evaluate a Mega Disaster Crisis Management System consisting of the Disaster Information Registration System and the Disaster Information Sharing System. The former categorizes various disaster information on real time reported from residents and the disaster related institutions. This registration system processes a flood of disaster information rapidly. The latter extracts only the information, which should be shared in the disaster countermeasures headquarters from computerized disaster information. This sharing system enables that municipal employees of disaster countermeasures headquarters and disaster sites, and staff of disaster related institutions share various disaster information.

Keywords: Mega Disaster, Crisis Management, Disaster Information Registration, Disaster Information Sharing

1 Introduction

Japan is the region where a natural disaster occurs frequently more than foreign countries [5]. The Great East Japan Earthquake, which occurred on March 11, 2011 caused extensive damage to eastern Japan. The Cabinet Office established on "Promotion of disaster controls based on the Great East Japan Earthquake" in a white paper on disaster management 2012 [6]. Therefore, disaster control to the Nankai Trough Earthquake and the Tokyo Metropolitan Earthquake is currently the most important issue.

A flood of disaster information is brought to the disaster countermeasures headquarters through the telephone and the emergency radio from municipal employees in disaster sites and each disaster related institutions at the time of large-scale natural disaster. Various divisions organize this disaster information depending on the kind of disaster information. A flow of disaster information in the disaster countermeasure headquarters is shown in Figure 1. The main point of the report contents is summarized on paper at many divisions. Important information is shared in the disaster countermeasures headquarters from among this summarized information. For example, disaster information such as collapsed houses and human damages will be reported to the disaster countermeasures headquarters by telephone from residents. The division that accepts information from residents (e.g. general affairs division) receives such information, and it is handwritten on a specified message slip. After that, this massage slip is handed to the division that summarizes information in the disaster countermeasures headquarters (e.g. public relations divisions), and this information is handwritten on the white board. However, all members in the disaster countermeasures headquarters will find it difficult to share disaster information with this method.

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Therefore, a system handling disaster information so that it can be shared smoothly is required. This can be achieved by digitizing all disaster information handled by the disaster countermeasures headquarters for large-scale natural disaster.

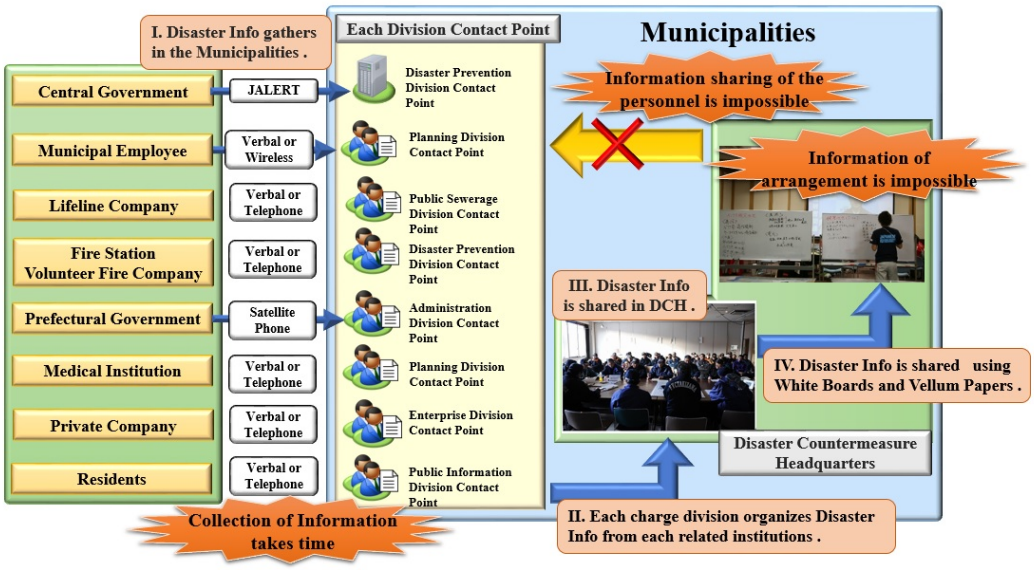

Figure 1: Flow of Disaster Information in the Disaster Countermeasure Headquarters

The rest of the article is organized in the followings way. The purpose of our research is descried in section 2. System configuration and architecture of our proposed Mega Disaster Crisis Management System are explained in section 3 and section 4, respectively. The Disaster Information Registration System and the Disaster Information Sharing System, which constitute the Mega Disaster Crisis Management System, are described in section 5. Section 6 evaluates the Mega Disaster Crisis Management System and, finally we conclude our findings in section 7.

2 Purpose of This Research

In this article, we describe the Mega Disaster Crisis Management System. This system consists of the Disaster Information Registration System and the Disaster Information Sharing System. The Disaster Information Registration System categorizes various disaster information on real time reported from residents and the disaster related institutions. The disaster information is stored in the database through the application server from a tablet terminal, and all disaster information is digitized, and the municipal employees and the volunteer fire department reports various disaster information using the exclusive application which are the Relief Supplies Management System [11], IC Card Safety Confirmation System [3], and the Web-GIS Disaster Management System [4] that we described earlier. All reported disaster information is summarized electronically in the disaster countermeasures headquarters through these systems. The disaster information gathered in the disaster countermeasures headquarters is stored into each database server in order to classify of disaster information. The Disaster Information Registration System processes a flood of disaster information rapidly. The Disaster Information Sharing System extracts only the information, which should be shared in the disaster countermeasures headquarters from digitized disaster information. The extracted information is shared on a large display in the disaster countermeasures headquarters. This sharing system enables that municipal employees of disaster countermeasures headquarters and disaster sites, and staff of disaster related institutions share various types

of disaster information. Moreover, the decisions and the minutes of the disaster countermeasures headquarters are digitized by utilizing the electronic blackboard function instead of using a white board. It becomes possible to process a flood of disaster information and manage many minutes in the disaster countermeasures headquarters by utilizing the electronic blackboard function.

3 System Configuration

The system configuration of our proposed solution is shown in Figure 2. The system consists of the 8 agents, 8 application servers, and 8 database servers. The function of each agent, each application server and each database is described below.

- Evacuation Centre Agent
  The Evacuation Centre Agent confirms the refugee's safety at the time of large-scale natural disaster. The refugees registers own safety information using an IC card. Registered safety information is stored into the Refugees Information Storage Database Server through the Refugees Information Management Server.

- Relief Supplies Accumulation Hub Agent
  The Relief Supplies Accumulation Hub Agent manages the relief supplies storage amount and the relief supply transport status information every evacuation centre. The municipal employees stationed in the evacuation centre registers the status of the relief supplies with the Relief Supplies Management System. Registered information is stored into the Relief Supplies Information Storage Database Server through the Relief Supplies Management Server.

- Damage Status Post Agent
  The Damage Status Post Agent posts the damage situation in real-time from the disaster site. This agent takes a picture of the damage situation such as collapsed houses and road damage using the exclusive smartphone application. The picture is stored into the Damage Status Information Storage Database Server through the Damage Status Management Server.

- Residents Agent
  The Residents Agent reports the disaster situation to registration operator agent by oral and the telephone, etc.

- Each Related Institutions Agent
  The Each Related Institutions Agent points at the lifeline related institution, the prefectural office, the central government ministries, the police station, the medical agency, the volunteer fire department, the fire defence headquarters, the private company, mass communication, and the self-defense forces. These related institutions reports various disaster information to the disaster information registration agent by oral, the telephone, and the emergency radio etc.

- Disaster Information Registration Agent
  The Disaster Information Registration Agent registers the disaster information reported each related institutions agent with the Disaster Information Registration System. Registered disaster information is stored into the database through each server.

- Registration Operator Agent
  The Registration Operator Agent registers reported information from the residents agent with the Disaster Information Registration System. Registered information is stored into the Residents

Inquiry Information Storage Database Server through the Residents Inquiry Information Management Server.

- Disaster Countermeasure Headquarters Agent
  The Disaster Countermeasure Headquarters agent shares the disaster information gathered in each database on the large-scale display [7, 9, 8].

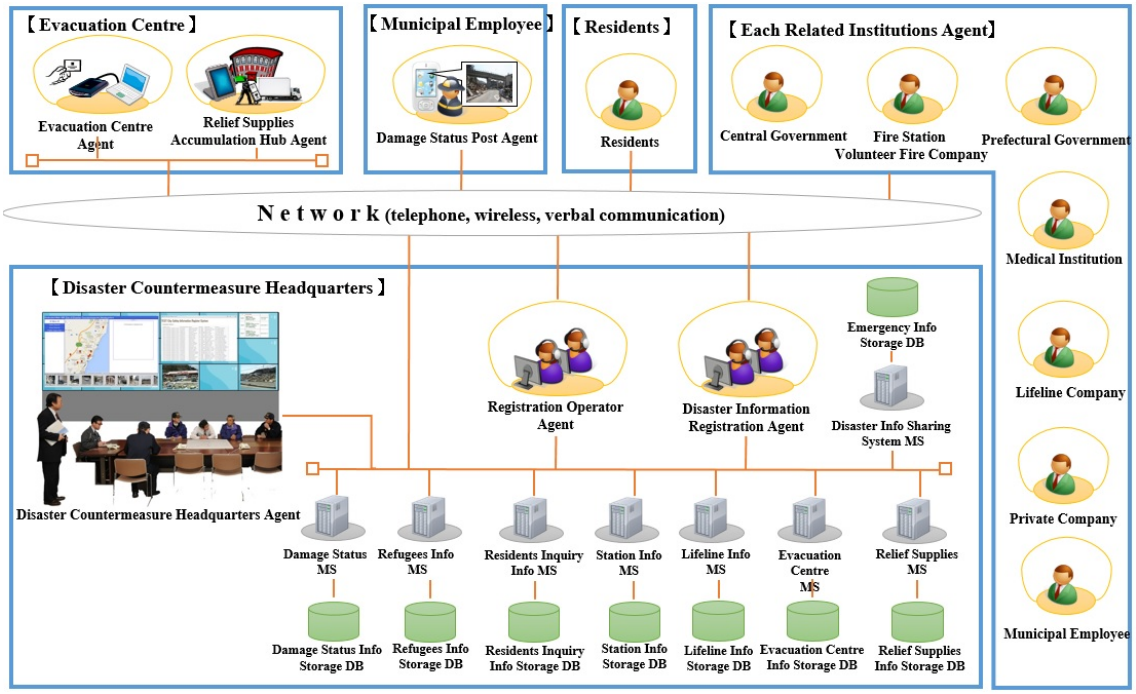

Figure 2: System Configuration

- Evacuation Centre Management Server
  The Evacuation Centre Management Server calculates the number of refugees using the information stored in the Refugees Information Storage Database Server, and stores refugees information into the Evacuation Centre Information Storage Database Server through the Refugees Information Management Server.

- Refugees Information Management Server
  The Refugees Information Management Server stores the refugees information into the Refugees Information Storage Database Server.

- Relief Supplies Management Server
  The Relief Supplies Management Server calculates the number of refugees every evacuation centre using the safety information stored in the Refugees Information Storage Database Server, and calculates the relief supplies amount through the Refugees Information Management Server. Calculated relief supplies information is stored into the Relief Supplies Storage Database Server.

- Damage Status Management Server
  The Damage Status Management Server stores the damage picture registered by the damage picture post agent, and stores the damage situation and the road block information registered by the disaster information registration agent into the Damage Status Storage Database Server.

- Lifeline Information Management Server
  The Lifeline Information Management Server stores the lifeline information registered by the disaster information registration agent into the Lifeline Information Storage Database Server.

- Station Information Management Server
  The Station Information Management Server stores the water and relief supply hub information and the morgue information registered by the disaster information registration agent into the Station Information Storage Database Server.

- Residents Inquiry Management Server
  The Residents Inquiry Management Server stores the resident inquiry information registered by the registration operator agent into the Residents Inquiry Information Storage Database Server.

- Disaster Information Sharing System Management Server
  The Disaster Information Sharing System Management Server stores the casualty information and the other disaster information registered by the disaster information registration agent into the Emergency Information Storage Database Server.

- Evacuation Centre Information Storage DB
  Each evacuation centre information transmitted from the Evacuation Centre Management Server is stored into the Evacuation Centre Information Storage DB.

- Refugees Information Storage DB
  The safety information transmitted from the Refugees Information Management Server is stored into the Refugees Information Storage DB.

- Relief Supplies Information Storage DB
  Relief supplies information every evacuation centre transmitted from the Relief Supplies Management Server is stored into the Relief Supplies Information Storage DB.

- Damage Status Information Storage DB
  The damage situation information and the road bock information transmitted from the Damage Status Management Server are stored into the Damage Status Information Storage DB.

- Lifeline Information Storage DB
  The lifeline information transmitted from the Lifeline Information Management Server is stored into the Lifeline Information Storage DB.

- Station Information Storage DB
  The water and relief supply hub information and the morgue information transmitted from the Station Management Server are stored into the Station Information Storage DB.

- Residents Inquiry Information Storage DB
  The resident inquiry information transmitted from the Residents Inquiry Information Management Server is stored into the Residents Inquiry Information Storage DB.

- Emergency Information Storage DB
  The casualty information and the other disaster information transmitted from the Disaster Information Sharing System Management Server are stored into the Emergency Information Storage DB.

4 System Architecture

The system architecture of this system is shown in Figure 3 and Figure 4. This system consists of the Disaster Information Registration System and Disaster Information Sharing System.

4.1 System Architecture of Disaster Information Registration System

The agent of the Disaster Information Registration System consists of User Interface, Data Registration Manager, Text Information Input Manager, Map View Manager, Get Data View Manager, File Processing Manager, Processing Manager, Map Processing Manager, Server Access Manager, and Network Interface. And, the application server consists of Request Data Create Manager, Database Access Manager, and Network Interface.

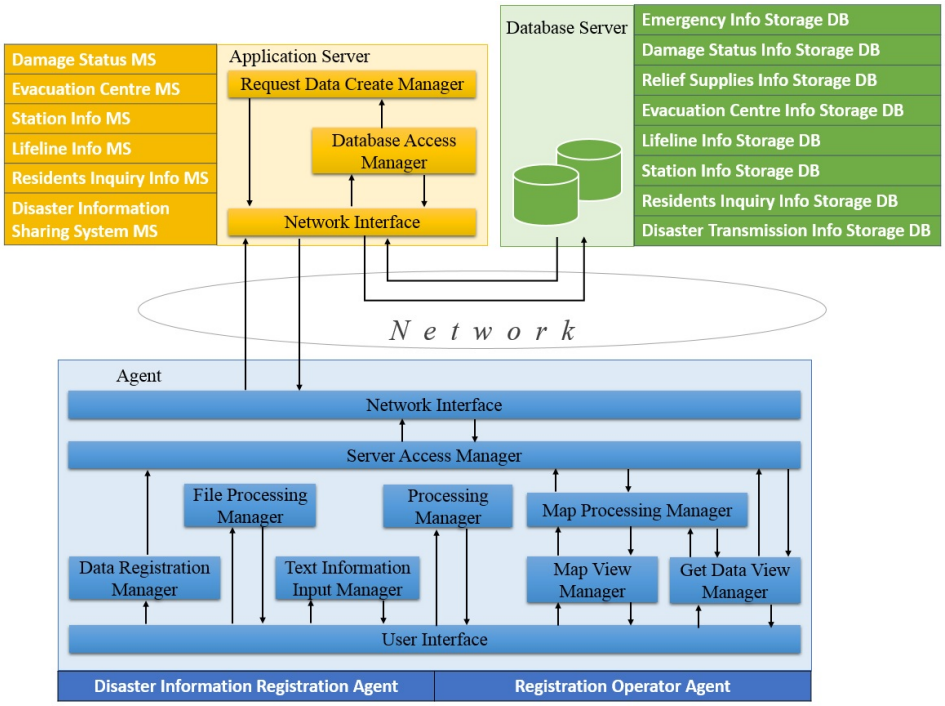

Figure 3: System Architecture of Disaster Information Registration System

(A) Agent

- Data Registration Manager
  When registering or changing the information, Data Registration Manager arranges the contents of damage information, evacuation centre information, water and relief supply hub information, morgue information, casualty information, public transport information, electrical information, water information, resident inquiry information, and this manager transmits information to Server Access Manager.

- Text Information Input Manager
  Text Information Input Manager reflects detailed information of damage information, evacuation centre information, water and relief supply hub information, morgue information, casualty information, public transport information, electrical information, water information, resident inquiry information in User Interface.

- Map View Manager
  Map View Manager integrates the map information generated in Map Processing Manager into User Interface, and provides Web-GIS to the user.

- Get Data View Manager
  Get Data View Manager list displays the disaster information acquired from each Management Server and places damage information and station information on Google Maps.

- File Processing Manager
  File Processing Manager takes a damage picture and a document file as attached file.

- Processing Manager
  Processing Manager has the display restriction function, the sorting display function, and the pagination function.

- Map Processing Manager
  Map Processing Manager mapping damage information, water and relief supply hub information, and morgue information acquired from Management Server to Google Maps.

- Server Access Manager
  When registering and changing the information, Server Access Manager sends and receives information in each Management Server through Network Interface.

(B) Application Server

- Request Data Create Manager
  Request Data Create Manager summarizes disaster information acquired from each Database Access Manager by the JSON form, and transmits information to each registration agent.

- Database Access Manager
  Database Access Manager registers information with each information storage database server by a registration request of disaster information registration agent. And this manager acquires information from each status information storage database server, and transmits acquired information to each Request Data Create Manager in case of an acquisition request from disaster information registration agent.

4.2 System Architecture of Disaster Information Sharing System

The agent of the Disaster Information Sharing System consists of User Interface, Damage Area View Manager, Calendar View Manager, Map View Manager, Thumbnail View Manager, Get Data View Manager, Processing Manager, Map Processing Manager, Server Access Manager, and Network Interface. And, the application server consists of Request Data Create Manager, Database Access Manager, and Network Interface.

(A) Agent

- Damage Area View Manager
  Damage Area View Manager displays a picture of damage information and road block information on the screen.

- Calendar View Manager
  Calendar View Manager classifies an acquired damage picture every date.

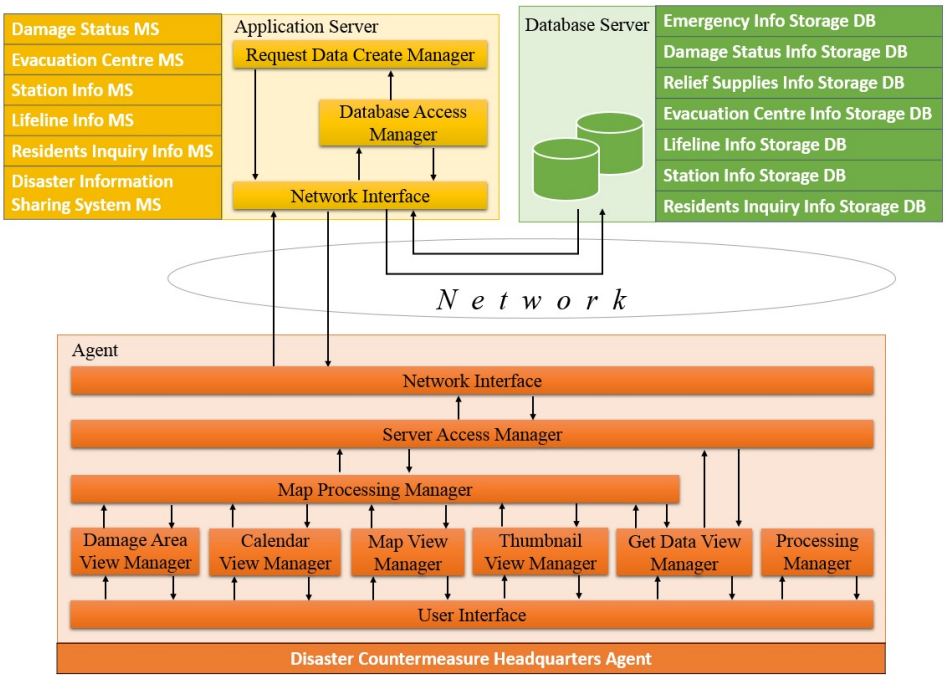

Figure 4: System Architecture of Disaster Information Sharing System

- Map View Manager
  Map View Manager integrates the map information generated in Map Processing Manager into User Interface, and provides Web-GIS to the user.

- Thumbnail View Manager
  Thumbnail View Manager displays latest 10 damage pictures as thumbnail on User Interface. And, this manager mapping thumbnail damage picture to Google Maps.

- Get Data View Manager
  Get Data View Manager reflects disaster information received from each Server Access Manager in User Interface.

- Processing Manager
  Processing Manager has the display restriction function, the sorting display function, and the pagination function.

- Map Processing Manager
  Map Processing Manager mapping damage information, water and relief supply hub information, and morgue information acquired from Management Server on Google Maps.

- Server Access Manager
  Server Access Manager acquires lifeline information, damage information, each evacuation centre information, water and relief supply hub information, morgue information, resident inquiry information from each management server through Network Interface.

(B) Application Server

- Request Data Create Manager
  Request Data Create Manager summarizes disaster information acquired from each Database Access Manager by the JSON form, and transmits information to each registration agent.

- Database Access Manager
  Database Access Manager registers information with each information storage database server by a request of disaster countermeasure headquarters agent. This manager transmits acquired information to each Request Data Create Manager.

5 Mega Disaster Crisis Management System

Mega Disaster Crisis Management System consists of the Disaster Information Registration System and the Disaster Information Sharing System.

5.1 Prototype of Disaster Information Registration System

The disaster countermeasures headquarters has to process a flood of information with rapidity from each related institution and residents at the time of large scale natural disaster. Therefore, in this research, we constructed the Disaster Information Registration System which all municipal employees share computerized disaster information. This system consists of the Damage Information Registration System, the Road Block Information Registration System, the Temporary Evacuation Centre Information Registration System, the Water and Relief Supply Hub Information Registration System, the Morgue Information Registration System, the Casualty Information Registration System, the Public Transport Information Registration System, the Electrical Information Registration System, the Water Information Registration System, the Resident Inquiry Information Registration System, and the Other Information Registration System. The registration screen of these 11 systems is shown in Figure 5. And, classification of disaster information registered from 11 systems is shown in Table 1. On the other hand, refugee information is registered using the IC Card Safety Confirmation System, so it was removed from Table 1.

Table 1: Classification of Disaster Information registered from the Registration System

Classification of Disaster Information	Database
Damage Information	Disaster Status Information Storage DB
Road Block Information	
Temporary Evacuation Centre Information	Evacuation Centre Information Storage DB
Evacuation Centre Information	
Water and Relief Supply Hub Information	Station Information Storage DB
Morgue Information	
Public Transport Information	Lifeline Information Storage DB
Electrical Information	
Water Information	
Relief Supply Transport Status Information	Relief Supplies Information Storage DB
Relief Supply Inventory Information	
Resident Inquiry Information	Residents Inquiry Information Storage DB
Other Information	Emergency Information Storage DB

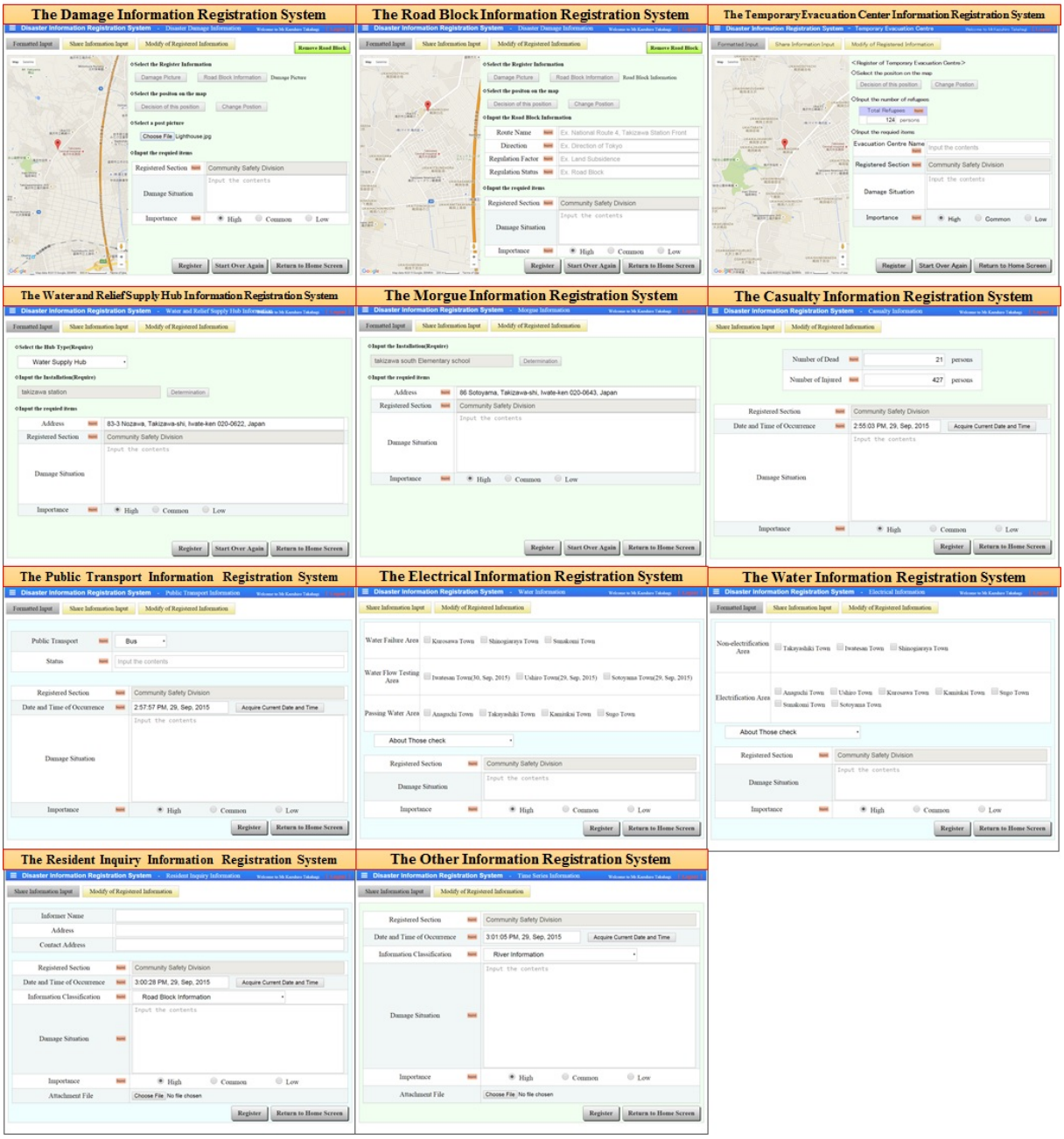

Figure 5: The 11 systems to compose the Disaster Information Registration System

The main screen of the Disaster Information Registration System is shown in Figure 6. The user can register disaster information easily by categorization disaster information on the main screen.

Figure 6: Main Screen of the Disaster Information Registration System

We introduce the Damage Information Registration System from 11 systems in this section. The Damage Information Registration System gathers damage picture reported from each related institution and municipal employees. This system consists two screens of the registration screen to register the damage picture and the control screen to change the registered damage picture. The damage information registered using this system is stored the Disaster Status Information Storage DB. The damage information stored in the Disaster Status Information Storage DB can be confirmed on the Damage Information Sharing System and the Time Series Information Sharing System. The Damage Information Registration System is shown in Figure 7. The step to register damage information is described below. Furthermore, Google Maps [1] was used for Web-GIS of the Damage Information Registration System.

- Step 1. Select the registration information.
- Step 2. Select the damage position on the map.
- Step 3. Select the post picture from a local folder.
- Step 4. Input the required items. The Damage Information Registration System set a registered section and an importance as required item.
- Step 5. The damage information is registered to push a ”Registration” button.

Moreover, the control screen of the Damage Information Registration Screen is shown in Figure 8. When the user push a ”change” button, the Damage Information Registration Screen communicates with the Damage Status Management Server and acquires information from the Damage Status Information Storage DB.

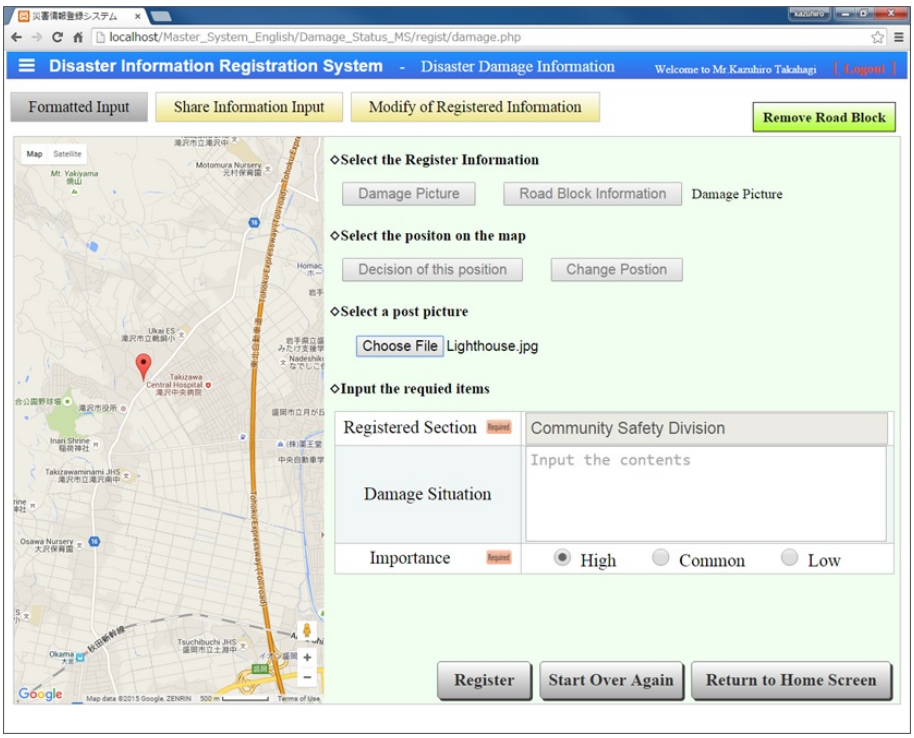

Figure 7: Registration Screen of the Damage Information Registration System

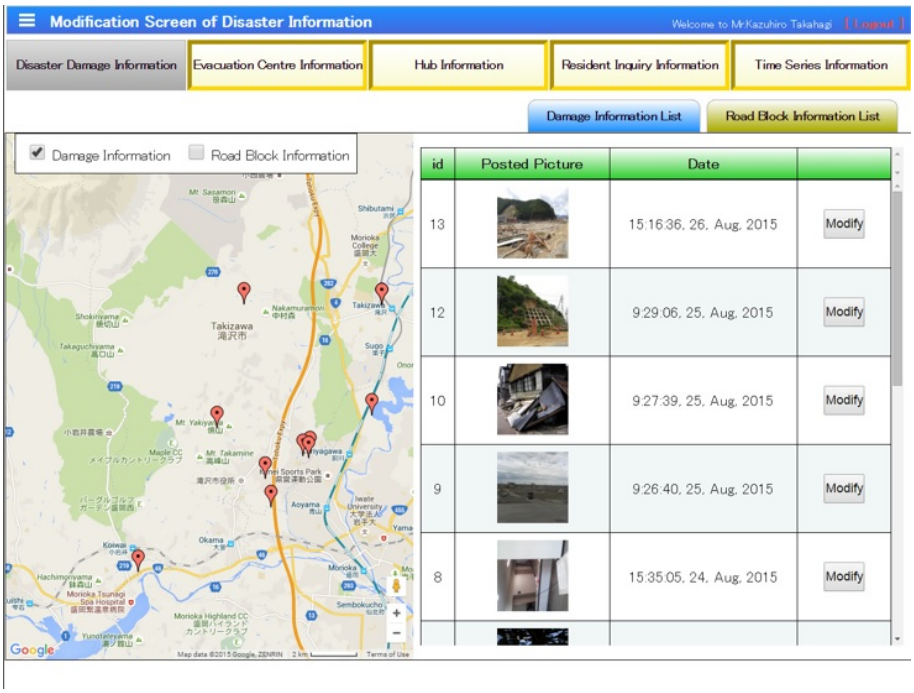

Figure 8: Control Screen of the Damage Information Registration System

5.2 Prototype of Disaster Information Sharing System

In this study, we constructed the Disaster Information Sharing System which the disaster countermeasures headquarters grasps disaster information with rapidity. This system is shared on the large display established in the disaster countermeasures headquarters. This system consists of the Disaster Information Sharing Portal, the Damage Information Sharing System, the Evacuation Centre Information Sharing System, the Station Information Sharing System, the Resident Inquiry Information Sharing System, and the Time Series Information Sharing System. The sharing screen of these 6 systems is shown in Figure 9.

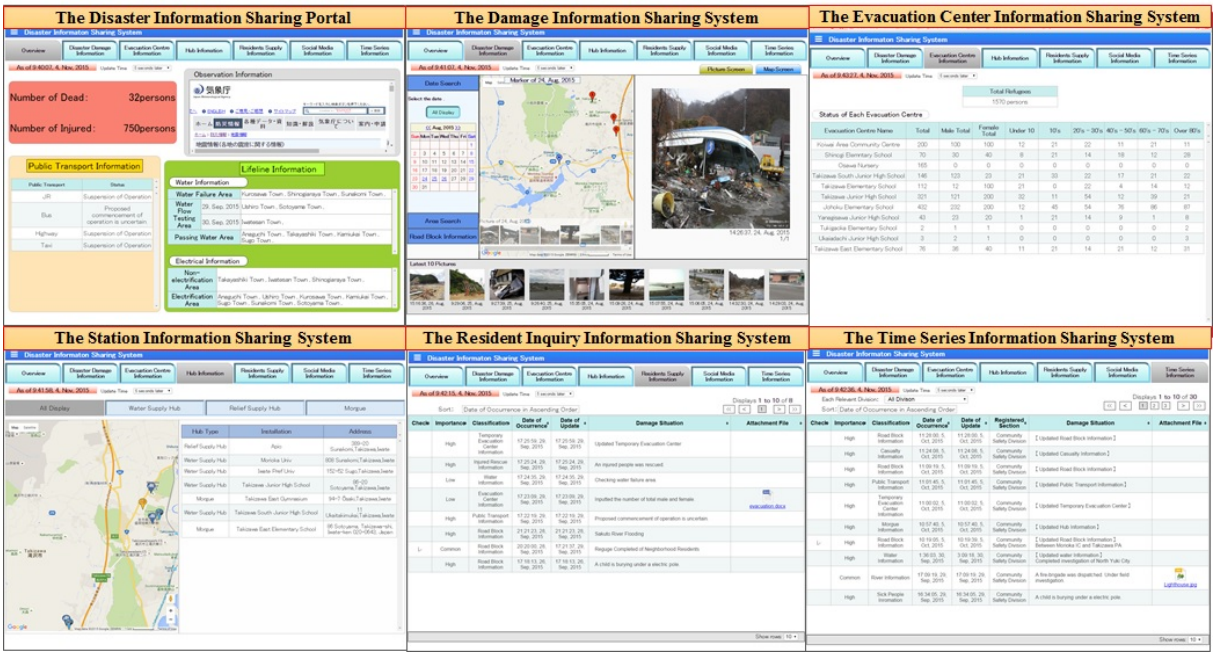

Figure 9: The 6 systems to compose the Disaster Information Sharing System

We introduce the Disaster Information Sharing Portal from 6 systems in this section. The Disaster Information Sharing Portal is shown in Figure 10. This system can share the casualty information registered from the Casualty Information Registration System, the public transport information registered from the Public Transport Information Registration System, the electricity situation of each area registered from the Electrical Information Registration System, the waterworks situation of each area registered from the Water Information Registration System, and the real-time weather information the Meteorological Agency provides [2].

The sequence of the Disaster Information Sharing Portal is shown in Figure 11. When the user accesses the web page, the HTTP request is transmitted to the Lifeline Information Management Server. The Lifeline Information Management Server provides a page of HTTP + JavaScript to the user. After that, the Disaster Information Sharing Portal communicates the Lifeline Information Management Server at regular time intervals, and acquires information from the Lifeline Information Storage DB and the Emergency Information Storage DB.

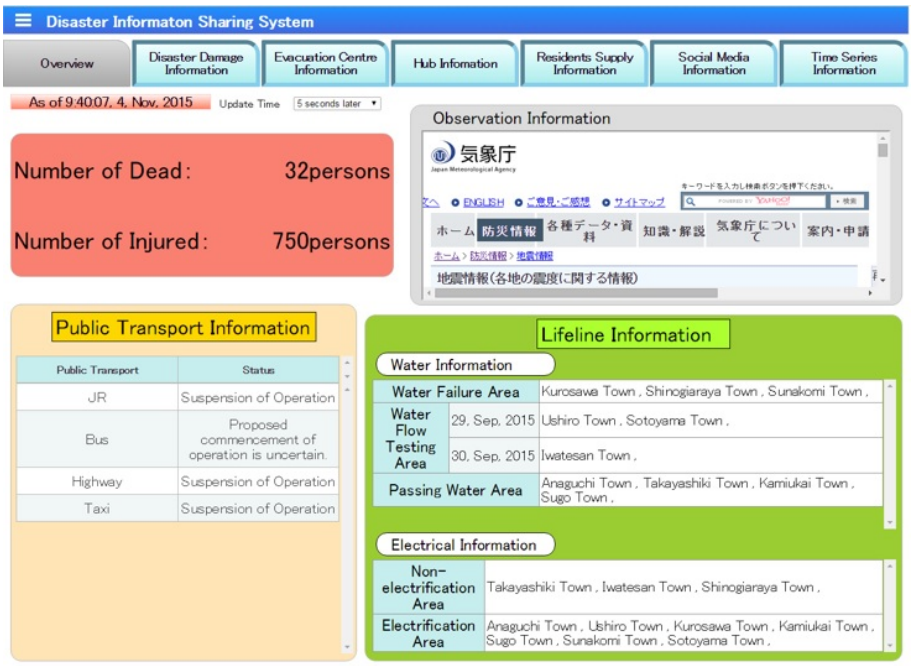

Figure 10: The Disaster Information Sharing Portal

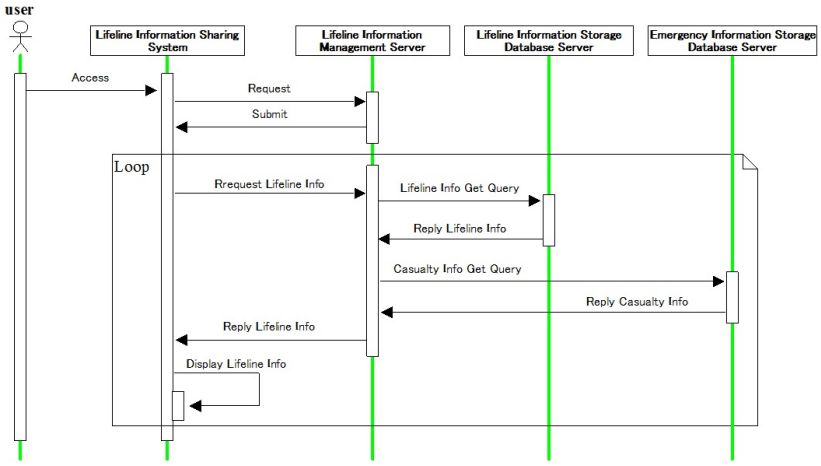

Figure 11: The Sequence of the Disaster Information Sharing Portal

6 Evaluation

In order to evaluate the necessity, the effectiveness, the operability and the functionality of the Disaster Information Registration System and the Disaster Information Sharing System, the questionnaire survey was carried out to 8 municipal employees of disaster prevention division.

6.1 The Necessity of the Disaster Information Registration System

The necessity evaluation result of the Disaster Information Registration System is shown in Figure 12. We investigated the necessity of registering disaster information at the time of large-scale natural disaster

in this item. Regarding the necessity of the Disaster Information Registration System, about 90 percent of the subject answered ”Necessary” or ”Somewhat necessary”. There was no one of the subject that answered ”Somewhat unnecessary” or ”Unnecessary”. Therefore, we were able to confirm the great necessity of the Disaster Information Registration System by this questionnaire survey.

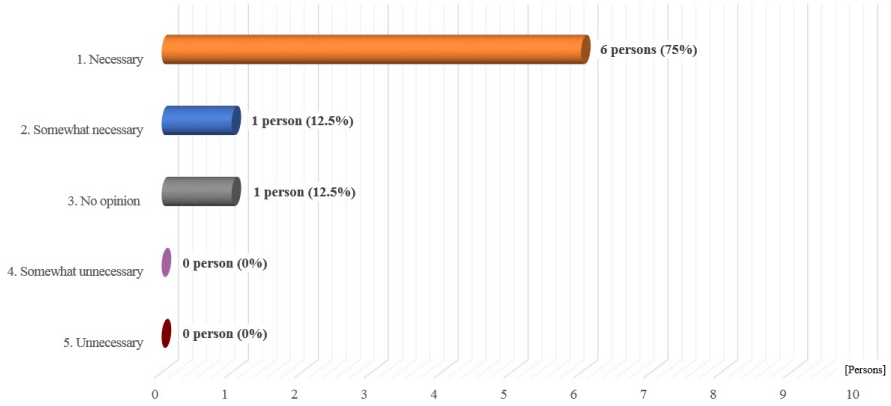

Figure 12: Questionnaire on the Necessity of the Disaster Information Registration System

6.2 The Effectiveness of the Disaster Information Registration System

The effectiveness evaluation result of the Disaster Information Registration System is shown in Figure 13. We investigated effectiveness of registering disaster information at the time of large-scale natural disaster in this item. About the effectiveness of the Disaster Information Registration System, 100 percent of the subject answered ”Effective”. There was no one of the subject answered ”Somewhat ineffective” or ”Ineffective”. Therefore, we were able to confirm the great effectiveness of the Disaster Information Registration System by this questionnaire survey.

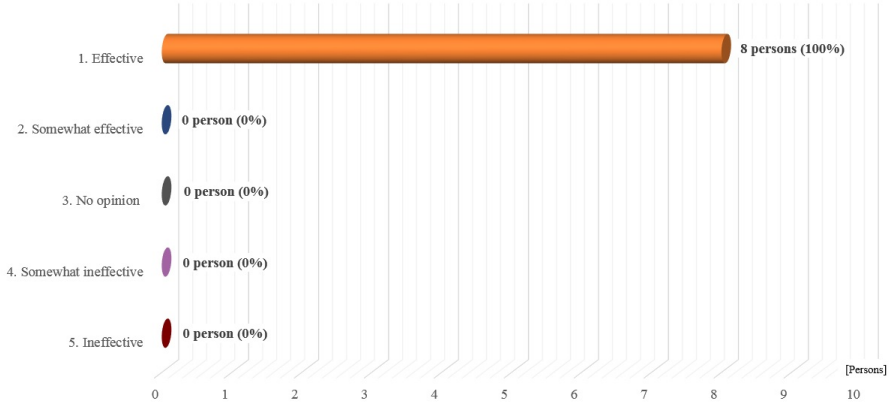

Figure 13: Questionnaire on the Effectiveness of the Disaster Information Registration System

6.3 The Operability of the Disaster Information Registration System

The operability evaluation result of the Disaster Information Registration System is shown in Figure 14. We investigated the operational satisfaction level of the Disaster Information Registration System in this

item. About the operability of the Disaster Information Registration System, 100 percent of the subject answered ”Easy” or ”Somewhat easy”. There was no one of the subject answered ”Somewhat difficult” or ”Difficult”. Therefore, we were able to confirm the great operability of the Disaster Information Registration System by this questionnaire survey.

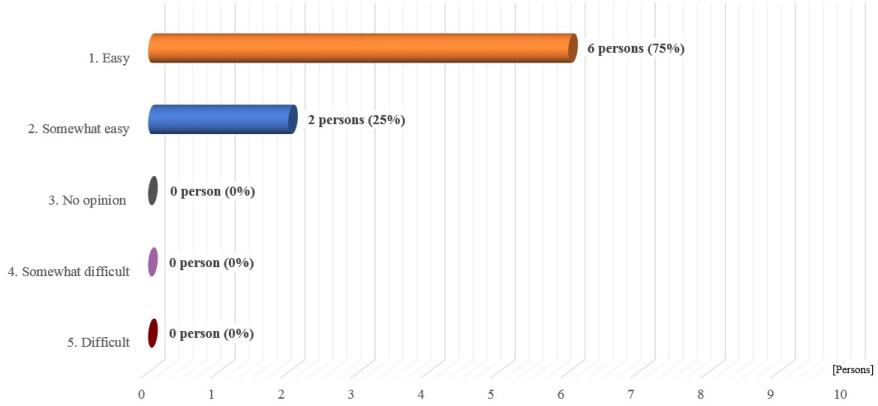

Figure 14: Questionnaire on the Operability of the Disaster Information Registration System

6.4 The Functionality Disaster Information Registration System

The functionality evaluation result of the Disaster Information Registration System is shown in Figure 15. We investigated the satisfaction level of the Disaster Information Registration System providing functions in this item. About the functionality of the Disaster Information Registration System, about 80 percent of the subject answered ”Satisfaction” or ”Somewhat satisfaction”. Therefore, we were able to confirm the great functionality of the Disaster Information Registration System by this questionnaire survey.

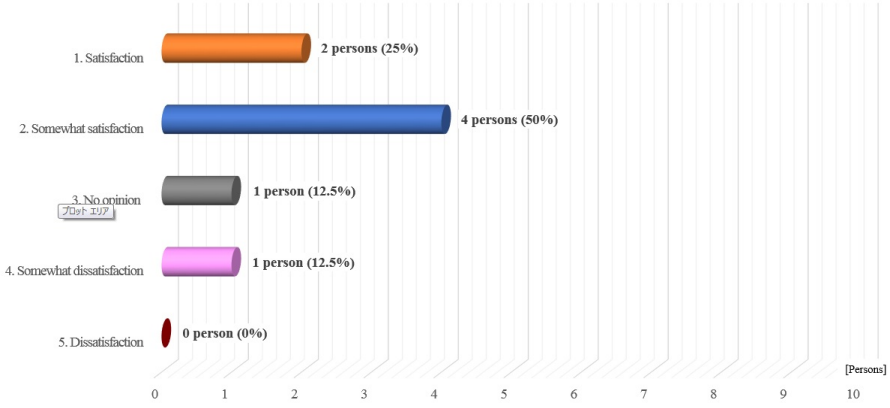

Figure 15: Questionnaire on the Functionality Disaster Information Registration System

6.5 The Necessity of the Disaster Information Sharing System

The necessity evaluation result of the Disaster Information Sharing System is shown in Figure 16. We investigated necessity of sharing disaster information at the time of large scale natural disaster in this

item. About the necessity of the Disaster Information Sharing System, about 90 percent of the subject answered ”Necessary” or ”Somewhat necessary”. There was no one of the subject answered ”Somewhat unnecessary” or ”Unnecessary”. Therefore, we were able to confirm the great necessity of the Disaster Information Sharing System by this questionnaire survey.

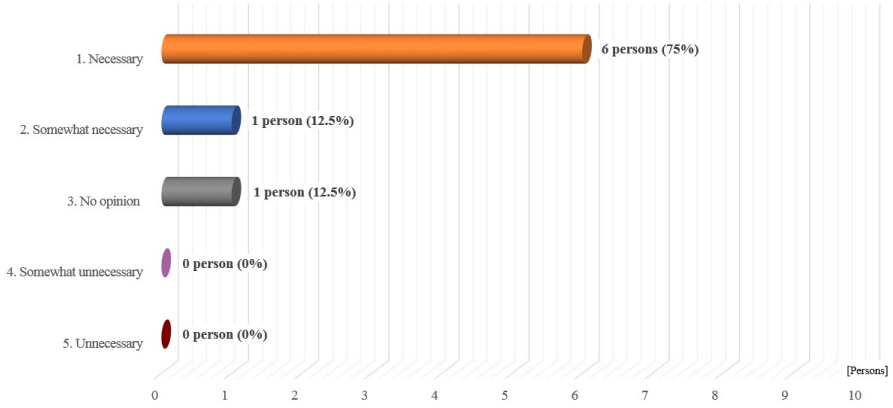

Figure 16: Questionnaire on the Necessity of the Disaster Information Sharing System

6.6 The Effectiveness of the Disaster Information Sharing System

The effectiveness evaluation result of the Disaster Information Sharing System is shown in Figure 17. We investigated effectiveness of sharing disaster information at the time of large-scale natural disaster in this item. About the effectiveness of the Disaster Information Sharing System, 100 percent of the subject answered ”Effective” or ”Somewhat effective”. There was no one of the subject answered ”Somewhat ineffective” or ”Ineffective”. Therefore, we were able to confirm the great effectiveness of the Disaster Information Sharing System by this questionnaire survey.

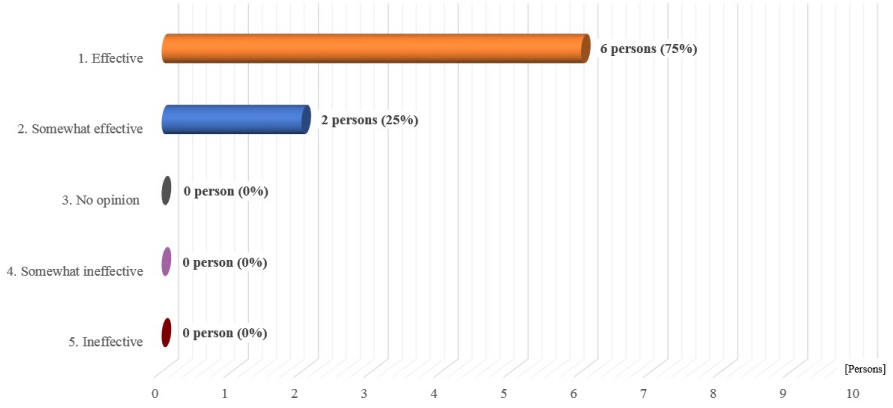

Figure 17: Questionnaire on the Effectiveness of the Disaster Information Sharing System

6.7 The Operability of the Disaster Information Sharing System

The operability evaluation result of the Disaster Information Sharing System is shown in Figure 18. We investigated the operational satisfaction level of the Disaster Information Sharing System in this

item. About the operability of the Disaster Information Sharing System, 100 percent of the subject answered ”Easy” or ”Somewhat easy”. There was no one of the subject answered ”Somewhat difficult” or ”Difficult”. Therefore, we were able to confirm the great operability of the Disaster Information Sharing System by this questionnaire survey.

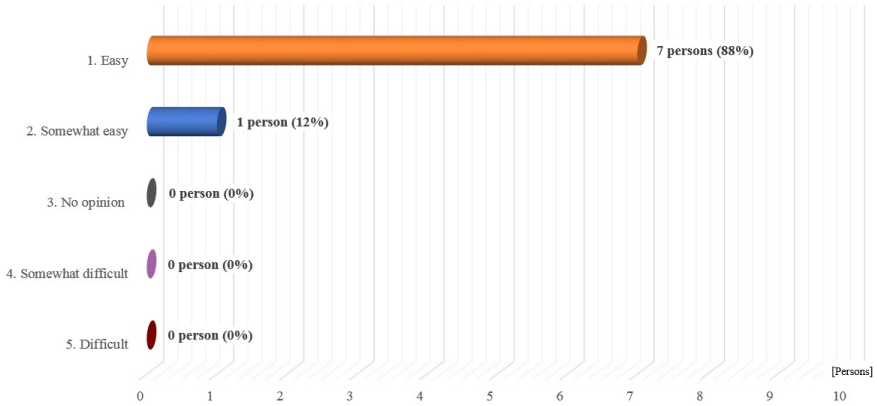

Figure 18: Questionnaire on the Operability of the Disaster Information Sharing System

6.8 The Functionality Disaster Information Sharing System

The functionality evaluation result of the Disaster Information Sharing System is shown in Figure 19. We investigated the satisfaction level of the Disaster Information Sharing System providing functions in this item. About the functionality of the Disaster Information Sharing System, about 90 percent of the subject answered ”Satisfaction” or ”Somewhat satisfaction”. Therefore, we were able to confirm the great functionality of the Disaster Information Sharing System by this questionnaire survey.

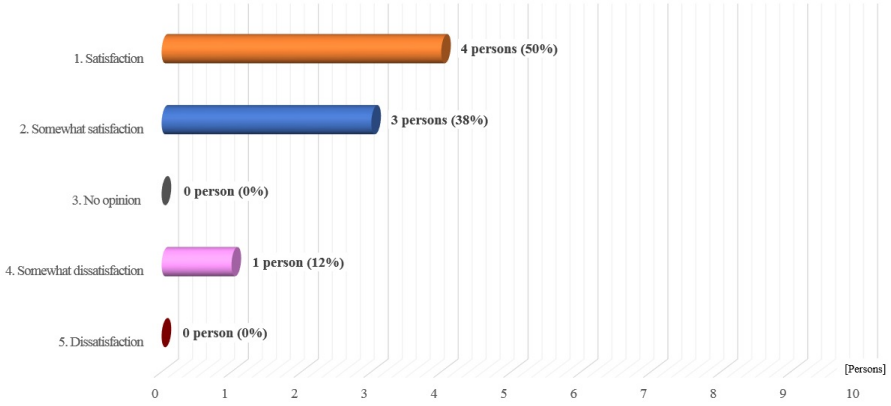

Figure 19: Questionnaire on the Functionality Disaster Information Sharing System

7 Conclusion

In this research, we construct the Mega Disaster Crisis Management System. This Mega Disaster Crisis Management System consists of the Disaster Information Registration System and the Disaster Information Sharing System. The Disaster Information Registration System realized digitization of various

disaster information in real time that is reported from residents and the disaster related institutions. The Disaster Information Sharing System realized sharing of various disaster information on the large display established in the disaster countermeasures headquarters. Moreover, this sharing system enabled that municipal employees of disaster countermeasures headquarters and disaster sites, and staff of disaster related institutions share various disaster information. The decisions and the minutes of the disaster countermeasures headquarters were digitized by utilizing the electronic blackboard function instead of using a white board. We carried out the questionnaire survey to municipal employees of disaster prevention division. We evaluated the necessity, the effectiveness, the operability and the functionality of the Mega Disaster Crisis Management System. As a result, we were able to confirm the great evaluation in all the items.

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