Implementation of an Open Data Visualization System Based on Disaster Information*

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Abstract

We developed an open data visualization system called "VOICE" (Visualization of Open Data Information for a City in Emergency), which is intended to be used by Japanese residents both during normal times (NT) and emergencies and natural disasters. During NT, VOICE would provide open data visualization of disaster prevention and risk reduction. In emergencies, VOICE would provide real-time visual data on emergency or disaster information issued by the disaster control headquarters. In addition, the system would be able to visually represent real-time information on relief supplies requested by emergency shelters. To evaluate the effectiveness of the open data visualization system, we conducted a survey, including 28 municipal employees from the disaster prevention division and 60 residents who were asked to evaluate the system for operability, effectiveness, functionality, usability, and relevance. The results of the survey indicate subjects' overwhelming positive response to the system for all five measures.

Keywords: Open Data, Visualization System, Web Application, Disaster Information Sharing, Disaster Prevention and Reduction

1 Introduction

In 2012, the Strategic Headquarters for Advanced Information and Telecommunications Network Society (IT Strategic Headquarters) compiled the "Open Government Data Strategy" [5] on the basis of the following four principles [12].

(1) Government should actively disseminate public data.
(2) Data should be published in machine-readable formats.
(3) Data utilization should be promoted regardless of their commercial or non-commercial use.
(4) Specific efforts should be made to publish public data.

In 2013, the Japanese government adopted the "Declaration to be the World's Most Advanced IT Nation" [2], linking the promotion of the environment to promote open data. In 2015, the IT Strategic Headquarters released the "Local Governments Open Data Promotion Guideline" [4] and "Let's Start Open Data: First Manual for Local Governments" [3].

Despite the push for open data by local governments, the following issues remain about dissemination and utilization of open data [1].

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- The impact of open data is unclear.
- There is increased burden on local government employees to maintain open data systems.
- Open data processing skills of local government employees are insufficient.
- There is not enough number of engineers in rural areas to support open data systems.
- Open data utilization by residents cannot be assured given the digital divide between urban and rural areas.

Open data visualization helps create value and opens up new services. However, local governments and residents are unable to appreciate the benefits and potential of open data because there are not enough engineers to develop open data applications. To address this situation, contests, workshops, ideathons, and hackathons for promoting open data utilization have been held across Japan. Currently, the use of open data in various fields such as medical care, welfare, and tourism is under consideration. In Japan, wherein natural disasters occur frequently, the use of open data in disaster prevention and reduction is gaining attention.

The rest of the article is organized as follows. The related work is described in Section 2. The purpose of our research is descried in Section 3. System configuration and architecture of our proposed open data visualization system are explained in Section 4 and Section 5, respectively. The open data visualization system is described in Section 6. Section 7 evaluates the open data visualization system and finally we conclude our findings in Section 8.

2 Related Works

Murata et al. developed a disaster evacuation support system using open data and QGIS [11]. This system realizes a route search system that can evacuate people from danger zones. The system utilizes open data with danger zones information gathered from Muroran City, Hokkaido. However, the system could not share real-time disaster information such as lifeline (outage) information and evacuation orders, which need to be directly derived from the disaster control headquarters.

Murakoshi et al. developed a social media GIS to support the utilization of disaster information [10]. In this system, disaster information posted by SNS users is reflected on Web-GIS. This system realizes sharing of disaster information transmitted by residents using SNS. However, this cannot register and share the request information of food items and daily necessities required by each shelter.

Murakami et al. developed a GIS-based web support system for collecting and sharing information [9]. The system supported disaster prevention activities that were the result of collaborations between local governments and residents. During normal times (NT), this system supports regional inspection maps created by residents' postings and supports disaster imagination game based on regional inspection maps. During emergencies, the system collected, transmitted, and shared real-time disaster information. However, because the system required user authentication and because unregistered users could not log in, the system was not useful to users at large during times natural disasters.

3 Purpose of This Research

We created an open data visualization system called "VOICE", acronym for Visualization of Open Data Information for City in Emergency, which is intended to be used by Japanese residents during NT and during emergencies and natural disasters. During NT, VOICE would provide open data visualization of information collected by local governments on topics such as disaster prevention, crime prevention, and shelters. During emergencies or natural disasters, VOICE would provide open data visualization of real-time disaster information and notifications (outage, shelter, etc.) from the disaster control headquarters via text messages to residents from headquarters, provide residents with instructions from local governments on what to do during a disaster, and register requests for food items and daily necessities from shelters and provide the information to the disaster control headquarters to coordinate assistance.

Since residents must be able to conveniently get emergency information, the VOICE system was set up as a web application that could be accessed through people's smart phones and other mobile devices.

4 System Configuration

4.1 System Configuration for NT

System configuration for NT is shown in Figure 1.

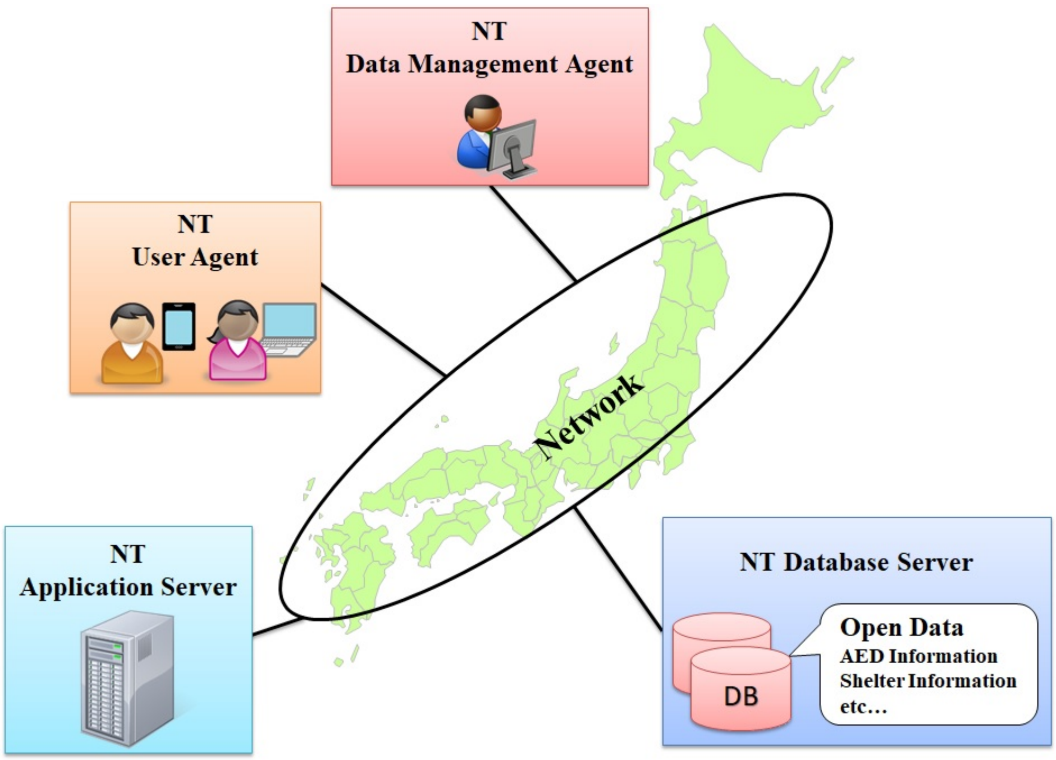

Figure 1: NT System Configuration

- NT Database Server
  Open data are stored in the NT database server, which is provided to the user on request.
- NT Application Server
  The NT application server visualizes data corresponding to the request of the NT user agent on the map. The NT application server updates the NT database server at the request of the NT data management agent.
- NT User Agent
  An NT user agent is a user who browses the VOICE site. Open data visualization is provided to the user based on user selection.

- NT Data Management Agent
  A local government employee who is authorized to update and delete open data in the NT database server.

4.2 System Configuration for Emergencies

System configuration for emergencies is shown in Figure 2.

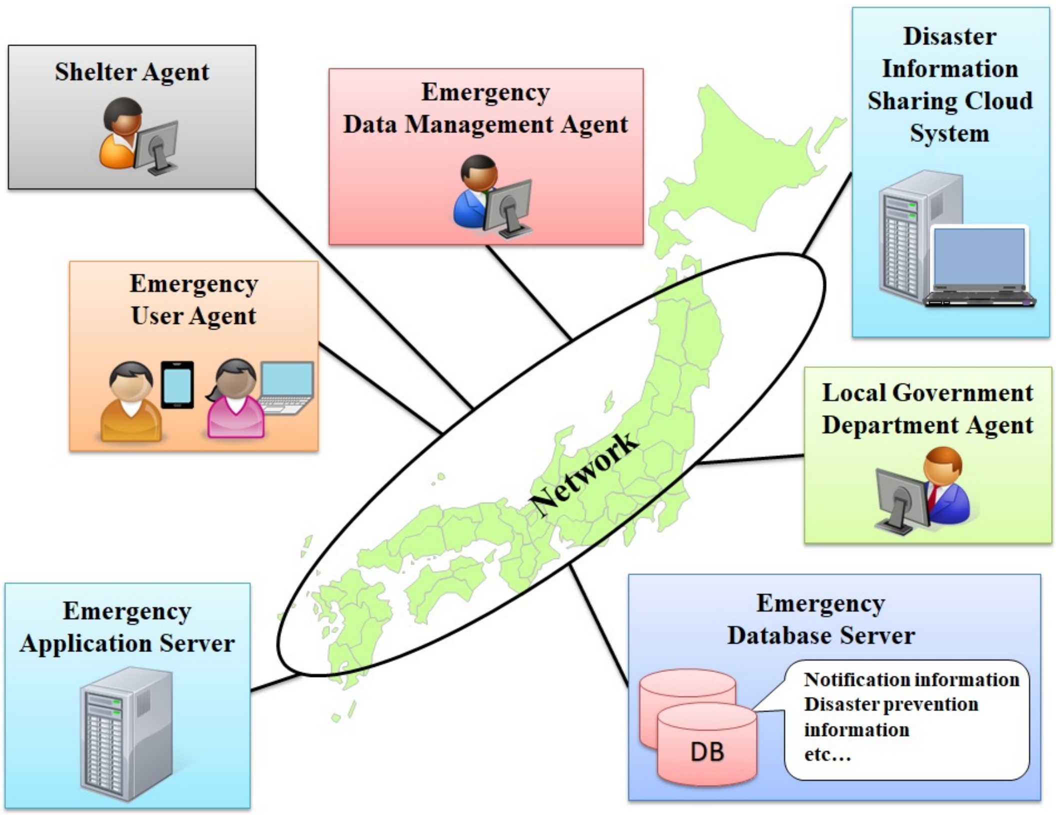

Figure 2: Emergency System Configuration

- Emergency Database Server
  Open data, including notifications from the disaster control headquarters and shelter information, are stored in the emergency database server and provided to the emergency user agent at the request of the emergency application server.

- Emergency Application Server
  The emergencies application server visualizes data corresponding to the request of the emergencies user agent on the map. The server updates the emergency database server at the request of the emergency data management agent.

- Disaster Information Sharing Cloud System [7, 6]
  An information sharing system used by the disaster control headquarters during natural disasters. Disaster prevention information registered in the system is provided through the emergency application server.

- Emergency User Agent
  Any user who browses the VOICE site. Open data visualization and real-time disaster information are provided to the user based on user selection.

- Shelter Agent
  An administrator or authorized representative of a shelter. The shelter agent can register requested relief supply information on the emergency database server via the emergency application server.

- Local Government Department Agent
  Local government administrator who transmits real-time disaster information via the emergency application server.

- Emergencies Data Management Agent
  Local government employee who is authorized to update and delete open data in the emergency database server who can register, edit, or delete a shelter agent and a local government department agent account.

5 System Architecture

The system architecture, as shown in Figure 3, defines the function of the user agent, data management agent, shelter agent, and local government department agent.

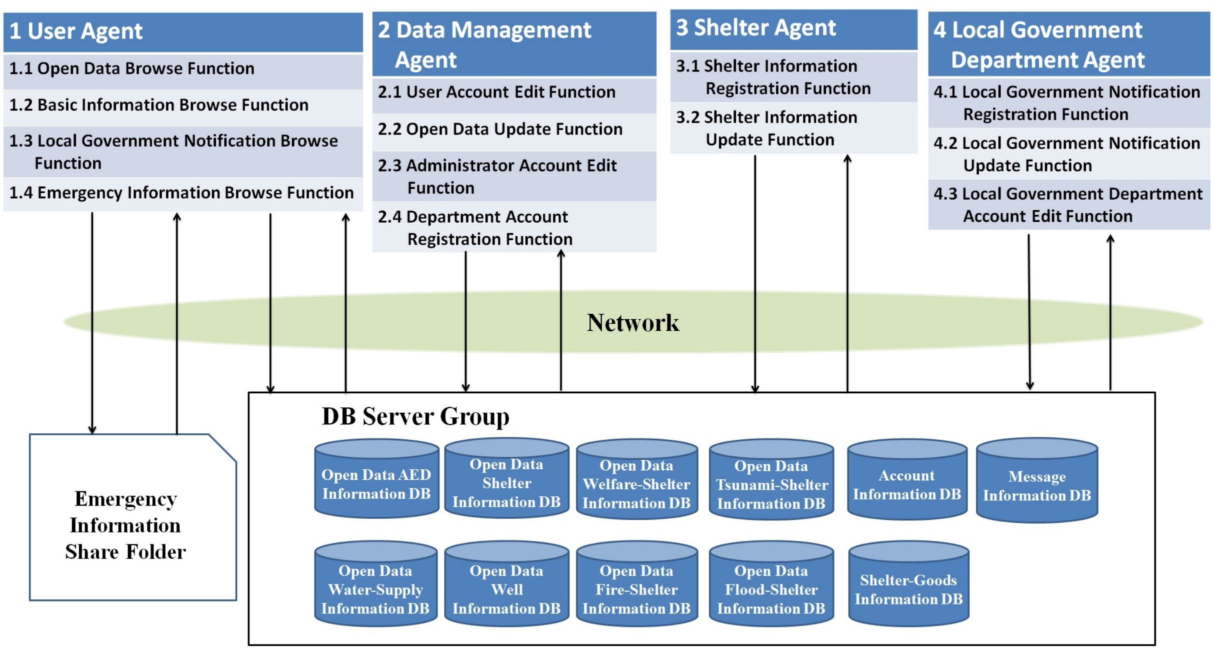

Figure 3: System Architecture

6 VOICE: A Web-Based System

The "VOICE" system was developed with the capability to switch between NT and emergencies, each of which provides different information visualization functions:

[NT]

- To visualize population distribution and population density on Web-GIS using color codes
- To visualize open data on Web-GIS
- To visualize the user's current location

[Emergencies]

- To visualize open data on Web-GIS
- To visualize the user's current location
- To visualize temporary shelter, relief supply, lifeline supply information, and official road block information on Web-GIS
- To transmit request for support, supplies, etc. from each shelter
- To transmit disaster information from the disaster control headquarters

6.1 Top Screen at Normal Times

The NT main screen is shown in Figure 4. The top screen in NT comprises a base map and a menu item. The disaster prevention item comprises eight items of "Designated Shelters," "Welfare Shelters," "Flood Shelters," "Tsunami Shelters," "Fire Shelters," "AED Installation Spots," "Water Supply Hub," and "Domestic Water Cooperation Well." In addition, the basic information item comprises three items: "Base Map," "Population," and "Population Density." We arranged the "Normal Time" button and "Emergency" button at the top of menu. As a result, the user can switch between the NT usage mode and the emergency usage mode.

In this research, we used OpenStreetMap for the base map. In this system, the map data divided for each school district are overlapped on OpenStreetMap. The map data divided for each school district uses boundary information published by the Geographical Survey Institute. The data provided by the Geographical Survey Institute is in the shape file format. However, OpenStreetMap of this system does not correspond to the shape file format. Therefore, in this research, we applied QGIS to OpenStreetMap by converting shape file to GeoJSON file. Moreover, the current location information of the user is displayed on the Web-GIS by selecting the "Current Location" button. This function is realized by using GeoLocation API.

6.2 AED Installation Spot Information Screen at NT

The AED installation spot information browsing screen that visualized AED installation spot information on the Web-GIS in NT is shown in Figure 5. The AED installation spot marks representing the location of the AED spot are displayed. In this research, we adopted open data of Mito City, Ibaraki prefecture, for VOICE. Therefore, the AED installation spot data of 216 AED installation spots located in Mito City are displayed on the Web-GIS. Therefore, the user can confirm the c nearest AED installation location at a glance by selecting the "Current Location" button.

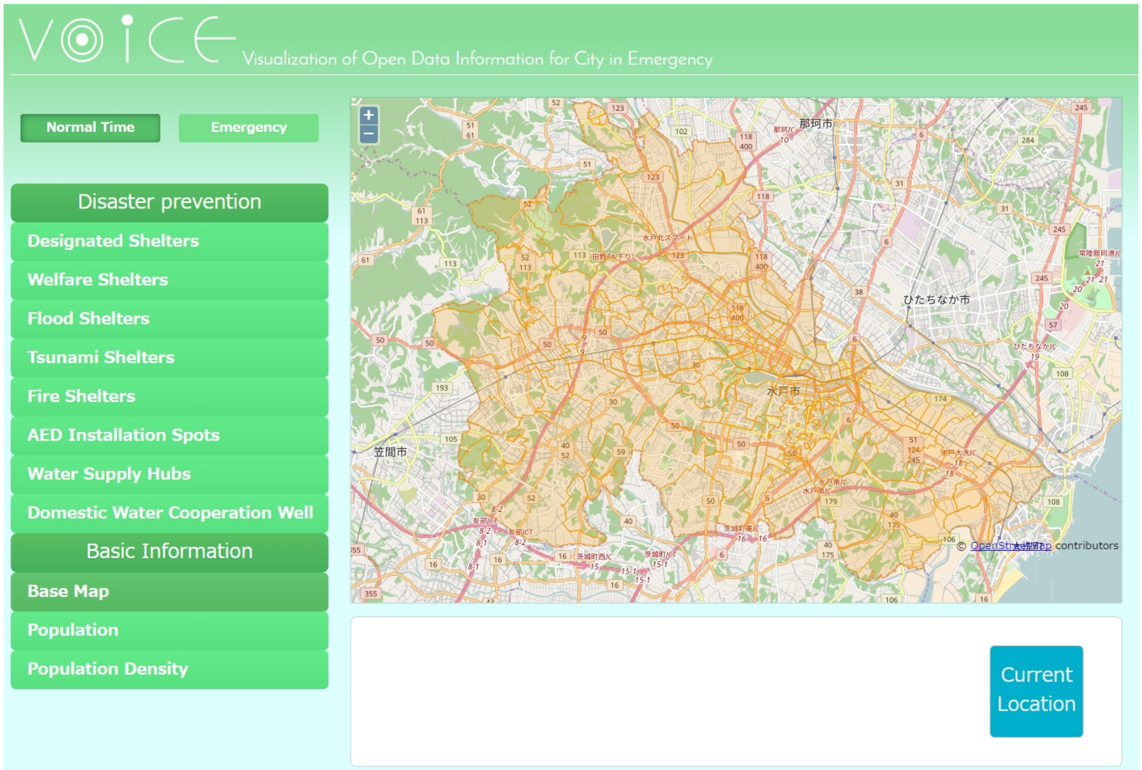

Figure 4: Top Screen at NT

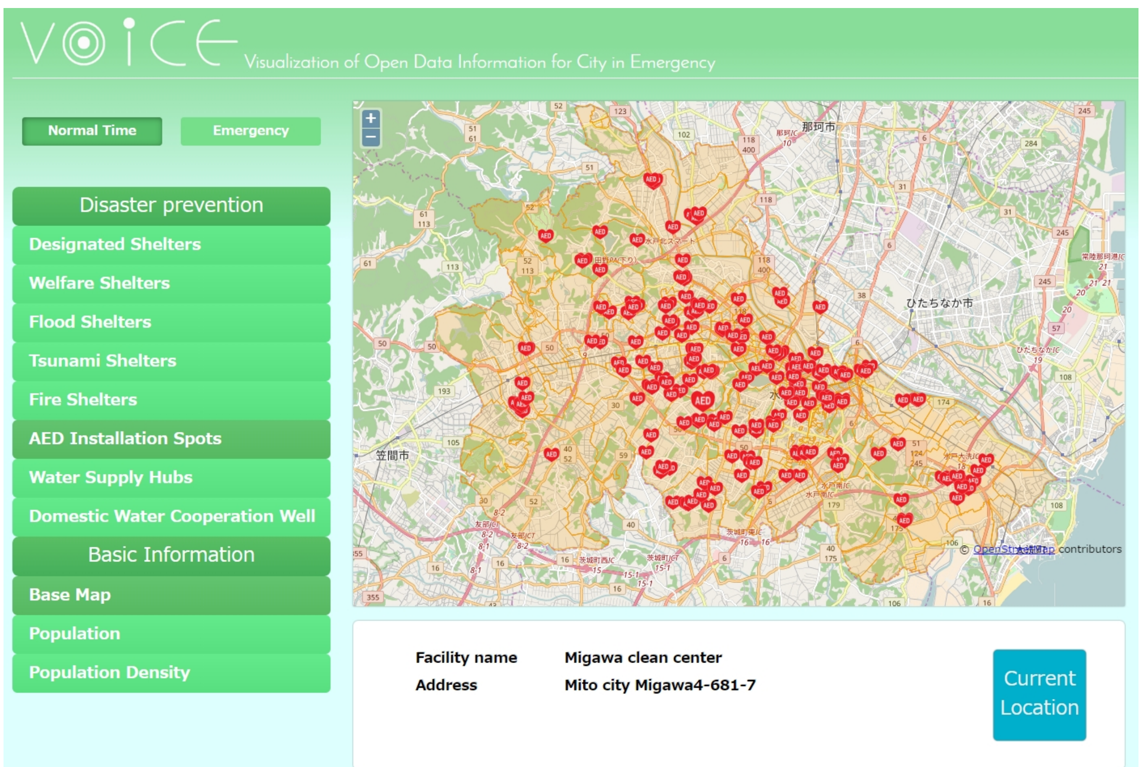

Figure 5: AED Installation Location Information Screen at NT

6.3 Water Supply Hub Information Screen at NT

The water supply hub information browsing screen that visualized water supply hub information on the Web-GIS in NT is shown in Figure 6. The water supply hub marks representing the location of the water supply hub are displayed. The water supply hub data of 86 water supply hubs located in Mito City are displayed on the Web-GIS. Therefore, the user can confirm the c nearest water supply hub at a glance by selecting the “Current Location” button.

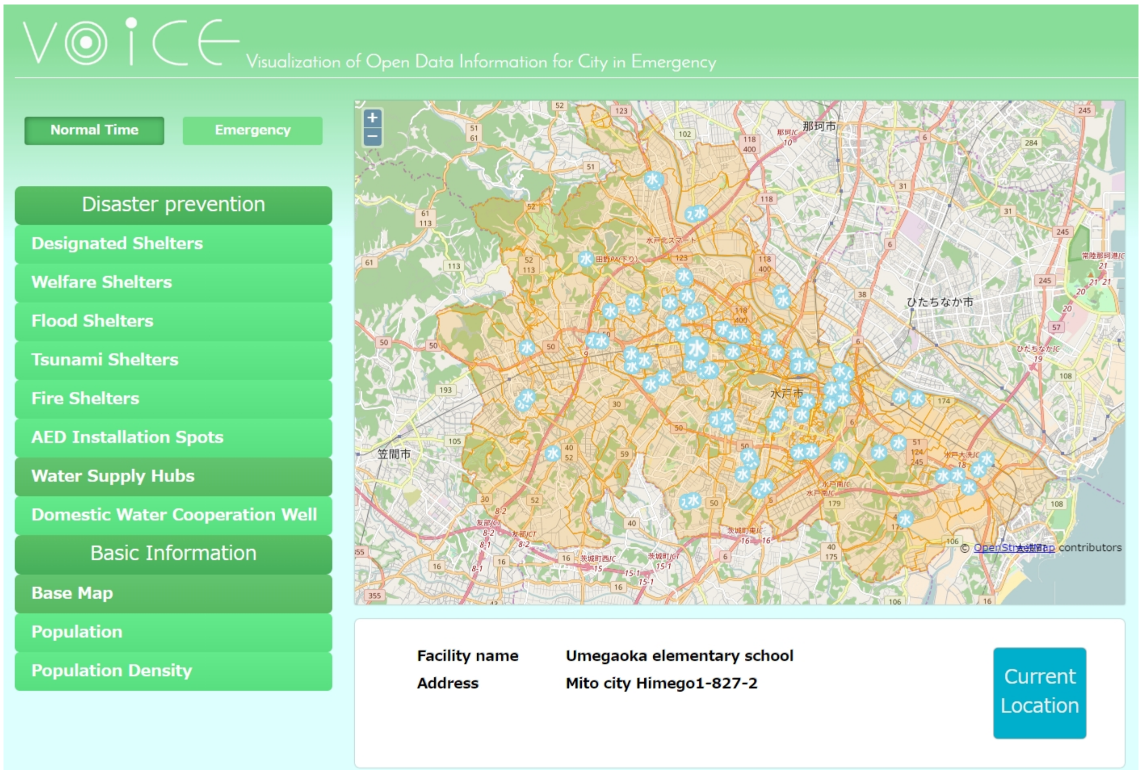

Figure 6: Water Supply Hub Information Screen at NT

6.4 Population Distribution Map Screen at NT

The population distribution map browsing screen that visualized population distribution on the Web-GIS in NT is shown in Figure 7. The population distribution map data divided for each area are displayed. The areas with high population distribution are displayed in dark color, whereas areas with low population distribution are displayed in light color. Moreover, the user can confirm the current location information on the Web-GIS by selecting the “Current Location” button.

In contrast, by selecting various disaster prevention information while selecting this population distribution map, population distribution information and disaster prevention information are simultaneously visualized. Therefore, the user can analyze the relationship between population distribution and various disaster prevention information.

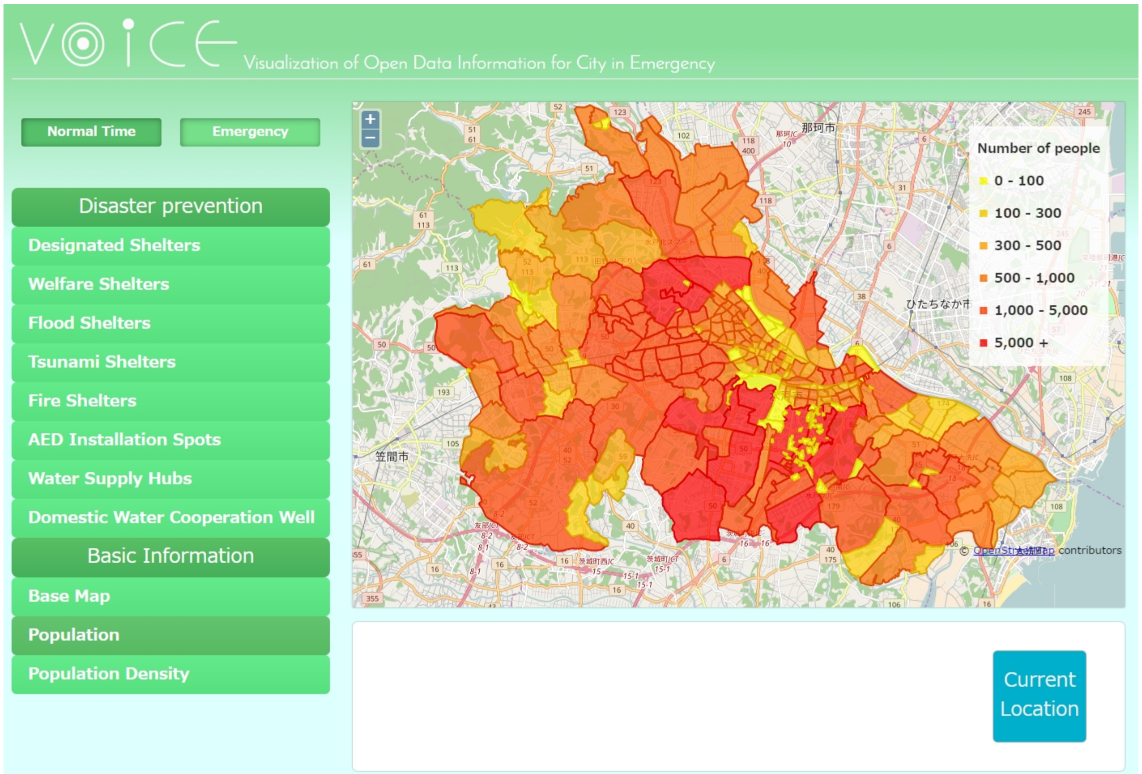

Figure 7: Population Distribution Map Screen at NT

6.5 Top Screen at Emergencies

The top screen in emergencies is shown in Figure 8. As in the NT, the top screen in emergencies comprises a base map and a menu item. The emergency disaster prevention item comprises five items: "Temporary Designated Shelters," "Relief Supply Hubs," "Lifeline (Water)," and "Lifeline (Electricity)." The disaster prevention item comprises five items: "Designated Shelters," "Welfare Shelters," "Flood Shelters," "Tsunami Shelters," and "Fire Shelters." This system provides a user interface that is understood easily by changing the color of the screen at NT and emergencies. Moreover, during a large-scale natural disaster, the local government's disaster control headquarters must provide various disaster prevention information to residents. Therefore, we arranged the "Emergency Notification" button on the emergency top screen. Residents can acquire real-time disaster information from disaster control headquarters by this function.

At the time large-scale natural disaster, the Cloud Disaster Information Sharing System converts disaster data to JSON format and provides data to the application server of this system. The Cloud Disaster Information Sharing System provides the following data to the application server of this system.

- Temporary Shelter Information: Facility name, Address, Latitude and Longitude, and Number of People
- Relief Supply Hub Information: Facility name, Address, and Latitude and Longitude
- Lifeline Information (Water): School District and Supply Status of Water
- Lifeline Information (Electricity): School District and Supply Status of Electricity

- Load Block Information: Latitude and Longitude

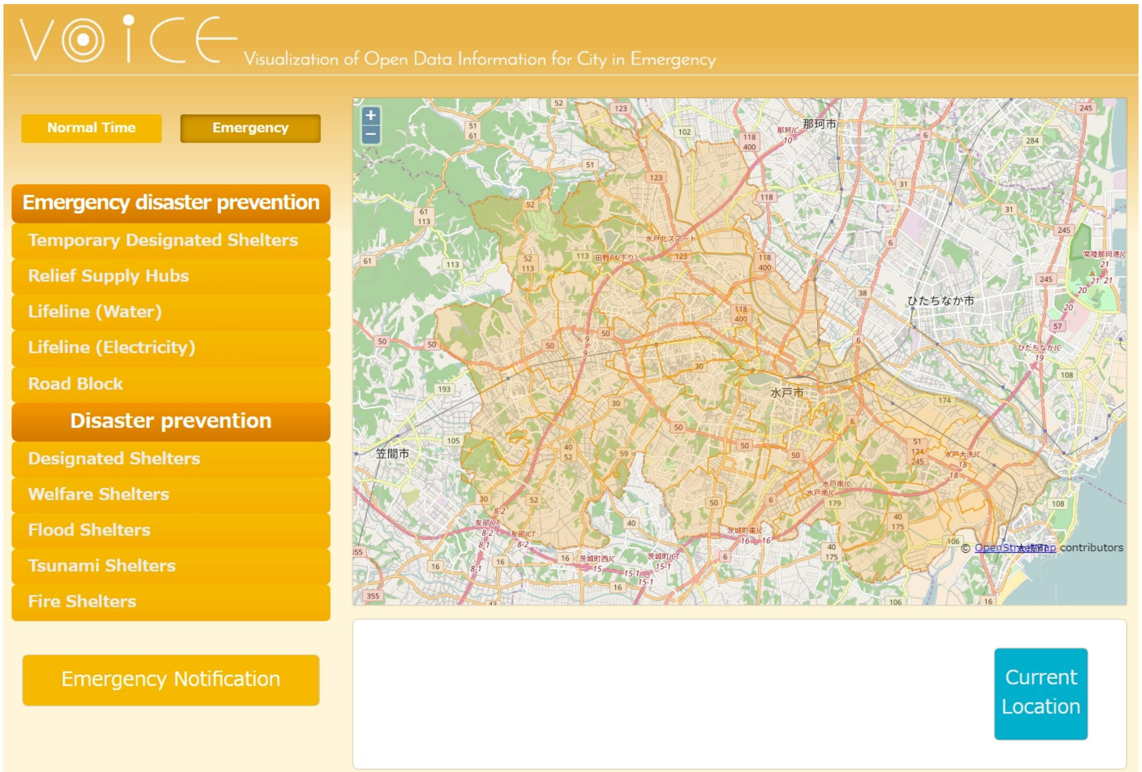

Figure 8: Top Screen at Emergencies

6.6 Lifeline Information (Electricity) Screen at Emergencies

The lifeline information (electricity) browsing screen that visualized electrical information on the Web-GIS in emergencies is shown in Figure 9. The energization and blackout data divided for each area are displayed. The lifeline (electricity) map is color coded into the following three colors. Therefore, the user can confirm the lifeline information of electrical information at a glance by color-categorizing the supply status of electricity every area.

- Unconfirmed Area: Yellow Color
- Energization Area: Red Color
- Blackout Area: Blue Color

6.7 Road Block Information Screen at Emergencies

The road block information browsing screen that visualized road block information on the Web-GIS in emergencies is shown in Figure 10. The road block marks representing the location of the road block are displayed. During a large-scale natural disaster, users can select safe driving routes by using the real-time road block information on the Web-GIS.

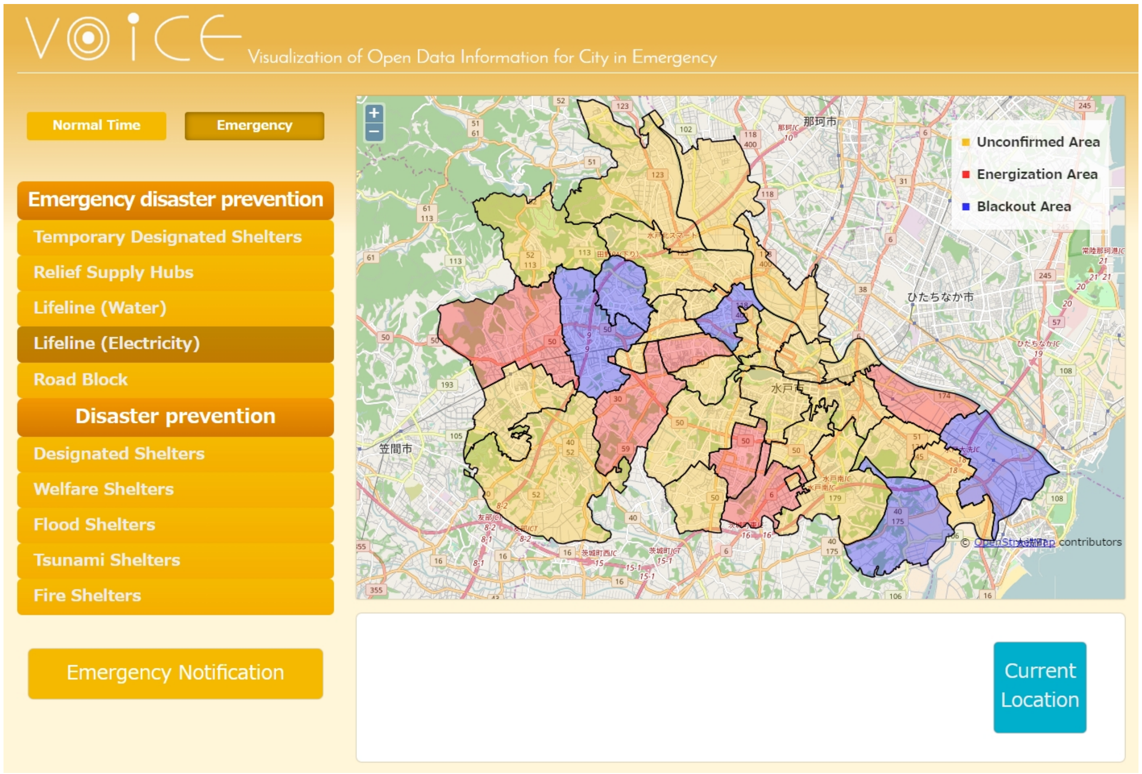

Figure 9: Lifeline Information (Electricity) Screen at Emergencies

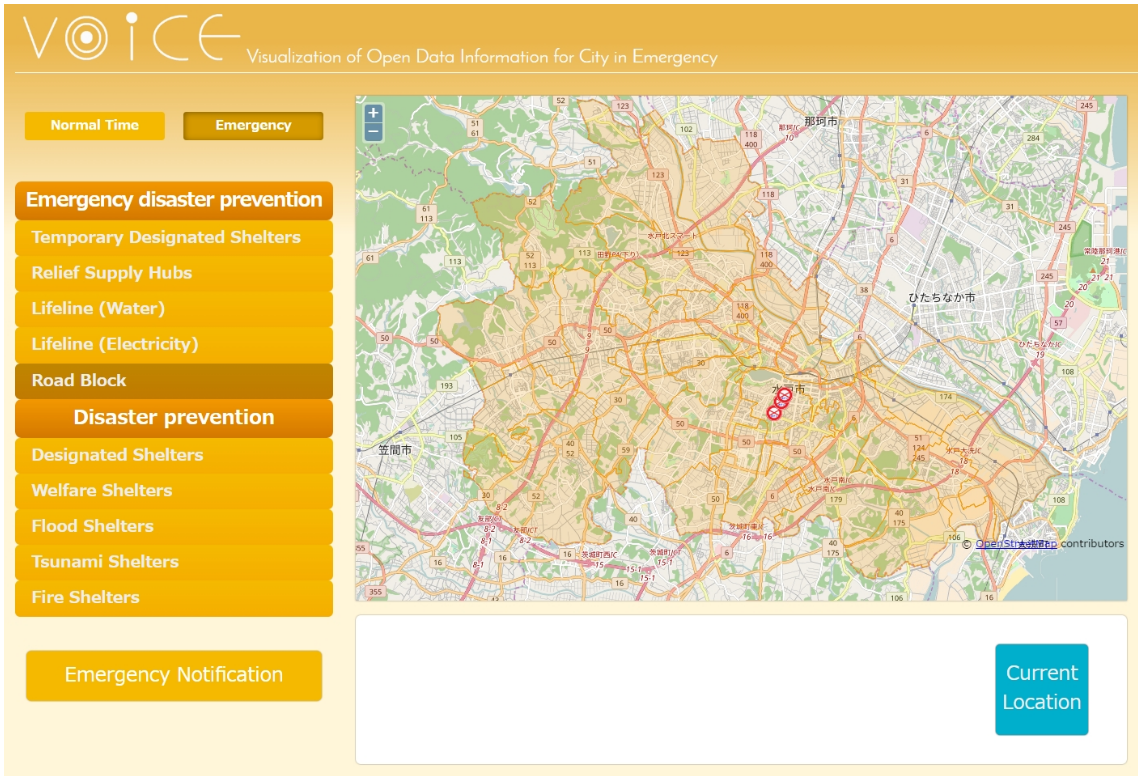

Figure 10: Road Block Information Screen at Emergencies

7 Evaluation

We conducted a survey of the VOICE system, which included 28 municipal employees from the disaster prevention division and 60 residents, to help evaluate the system based on the following measure: operability, effectiveness, functionality, usability, and relevance. The following are the results of the survey.

7.1 Operability Measure

On the operability of the system, 89% of municipal employees and 92% of residents reported that the site was "easy" or "somewhat easy" to operate (Figure 11).

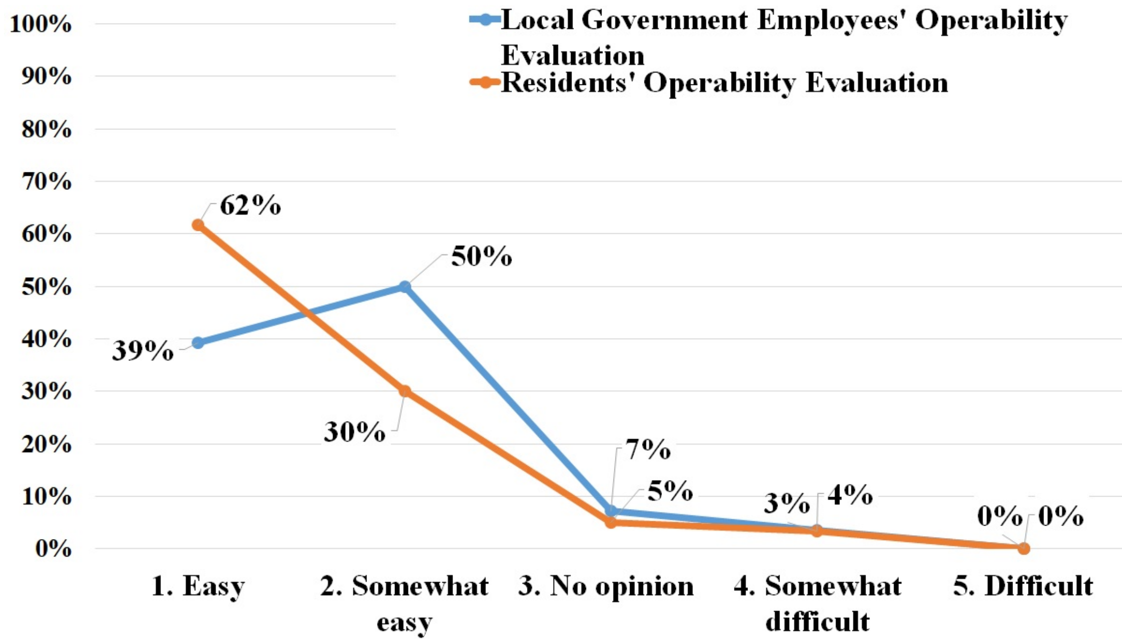

Figure 11: Operability of the system as reported by municipal employees (n = 28) and residents (n = 60)

7.2 Effectiveness Measure

On the effectiveness of the system, 86% of municipal employees and 94% of residents indicated that the site was "effective" or "somewhat effective" (Figure 12). No subject reported that the site was "somewhat ineffective" or "ineffective."

7.3 Functionality Measure

On the functionality of the system, 86% of municipal employees and 78% of residents indicated they were "satisfied" or "somewhat satisfied" with the site (Figure 13).

7.4 Usability Measure

On the usability of the system 85% municipal employees and 80% of residents indicated that the site was "easy to understand" or "somewhat easy to understand" (Figure 14).

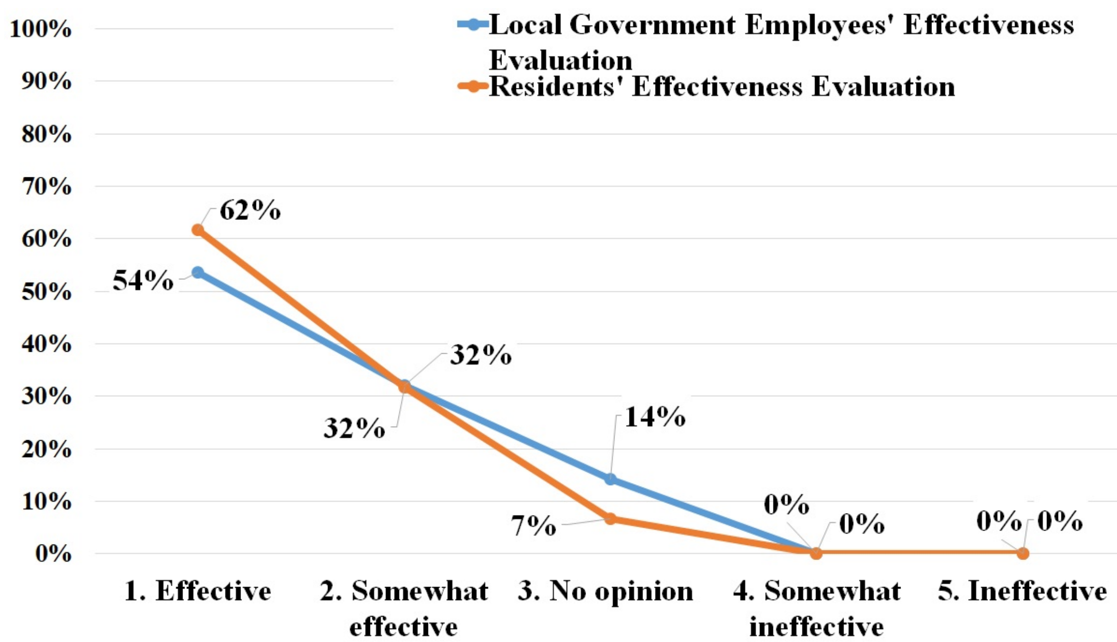

Figure 12: Effectiveness of the system as reported municipal employees (n = 28) and residents (n = 60)

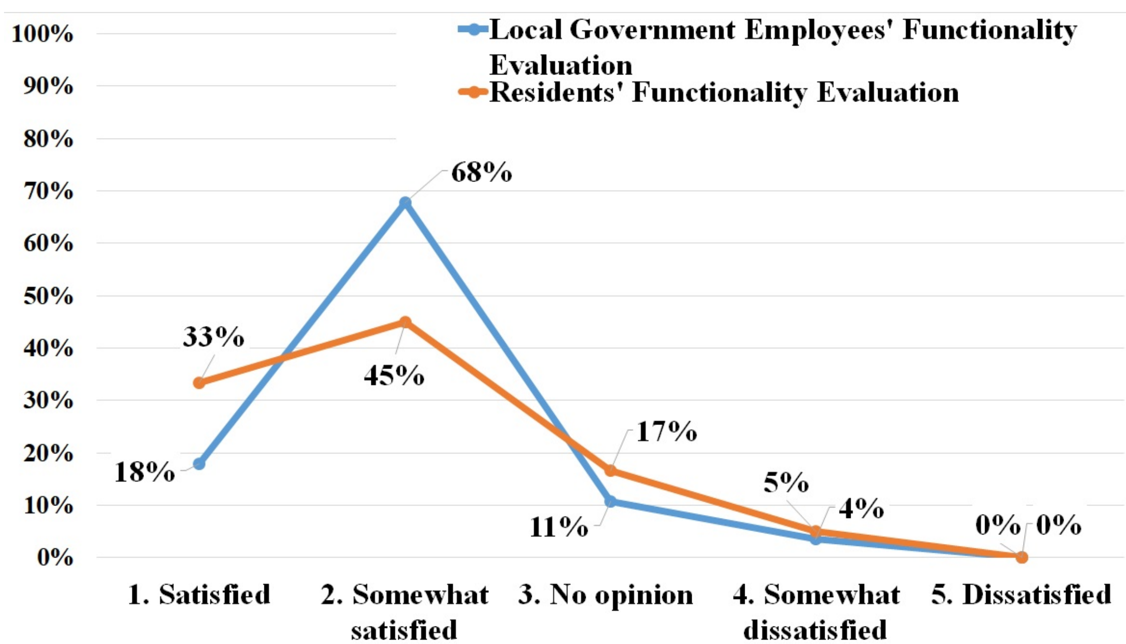

Figure 13: Functionality Evaluation Result by Municipal Employees (n=28) and Residents (n=60)

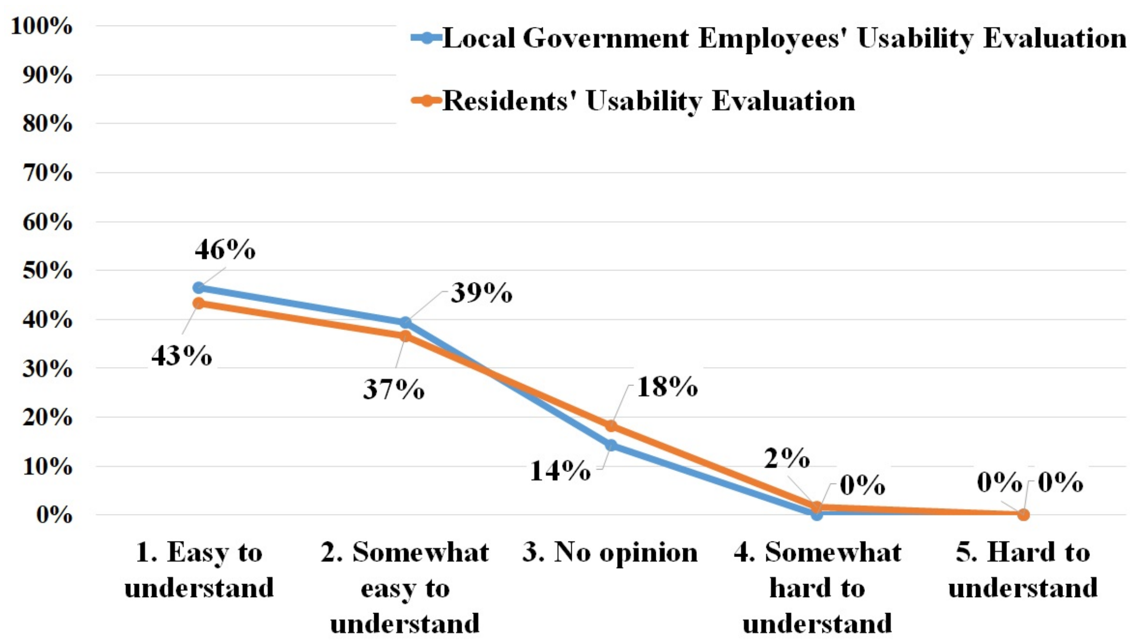

Figure 14: Usability of the system as reported by municipal employees (n = 28) and residents (n = 60)

7.5 Relevance Measure

On the relevance of the system, 87% of municipal employees and 95% of residents indicated that the site was "relevant" or "somewhat relevant" (Figure 15). No subject indicated that the site was "somewhat irrelevant" or "irrelevant."

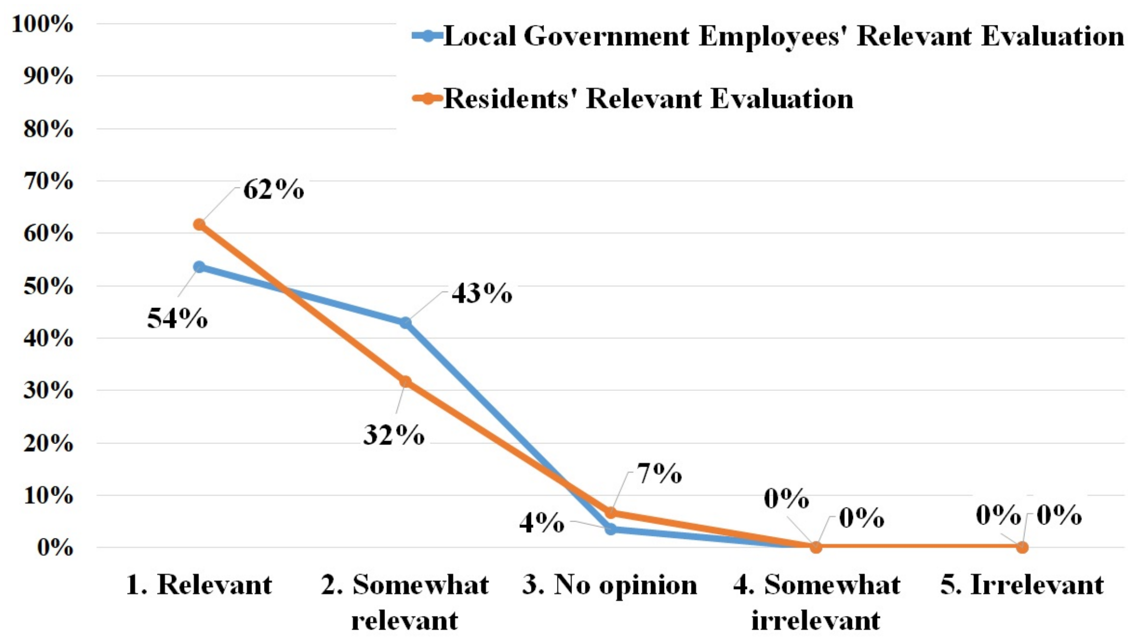

Figure 15: Relevance of the system as reported by municipal employees (n = 28) and residents (n = 60)

8 Conclusion

In order to evaluate the operability, effectiveness, functionality, readability, and necessity of the open data visualization system, we conducted a questionnaire survey that included 28 municipal employees of the disaster prevention division and 60 residents. As a result, we were able to confirm the great evaluation in all the items. In addition, subjects also identified certain issues with the site, which will be used to inform our next design iteration:

- Realization of route search function
- Improvement of layout and design
- Enrichment of contents

As a future work, we will develop the automatic collecting function of disaster information by cooperation with other systems, as shown in Figure 16. Local governments are currently dealing with various types of disaster prevention systems. Therefore, we will develop a single sign-on function with other systems.

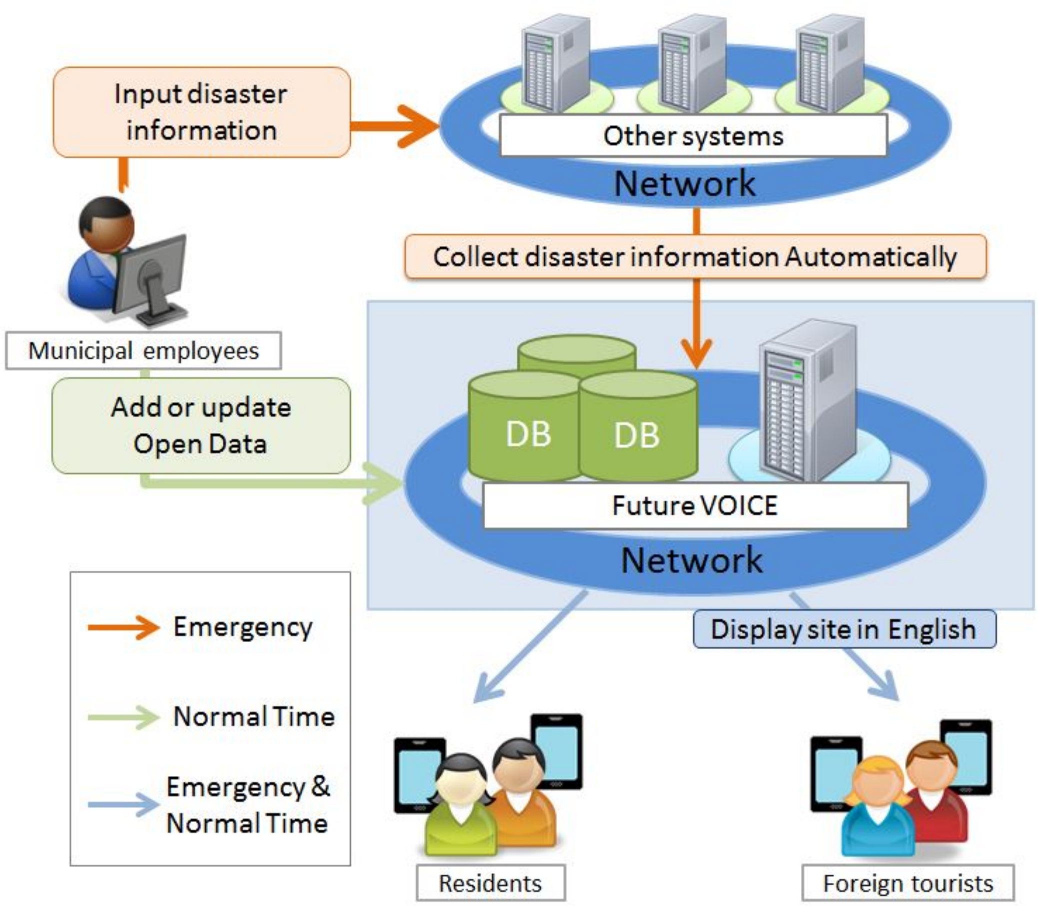

Figure 16: Future Works

Acknowledgments

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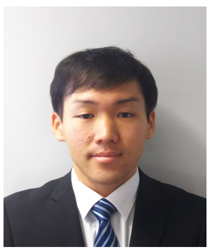

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