Development of Real Time Synchronous Web Application for Posting and Utilizing Disaster Information

Ikki Niwa
Tokyo Institute of Technology, Japan
CREST, Japan Science and Technology Agency
niwa.i.ac@m.titech.ac.jp

Toshihiro Osaragi
Tokyo Institute of Technology, Japan
CREST, Japan Science and Technology Agency
osaragi@mei.titech.ac.jp

Takuya Oki
Tokyo Institute of Technology, Japan
CREST, Japan Science and Technology Agency
oki.t.ab@m.titech.ac.jp

Noriaki Hirokawa
Tokyo Institute of Technology, Japan
CREST, Japan Science and Technology Agency
hirokawa.n.aa@m.titech.ac.jp

ABSTRACT

In a large earthquake, rescue operations and fire-fighting are obstructed by fire-spreading and street-blockages. Therefore, it is important to quickly collect and utilize disaster information for disaster mitigation. In this paper, firstly, we develop a Web application for posting and viewing information collected by users in real time. Using this system, it is possible not only to easily share disaster information among users but also to apply to damage forecast such as fire-spreading. Next, we demonstrate the usefulness of the Web application by the following evaluation view points: (1) relationship between the access time of emergency vehicles from fire stations to the locations of fires and the ratio of collected information on street-blockage which is assumed to be collected with this system; (2) reciprocating time between a server and a client which is dependent on the number of users and band limitation after the occurrence of a disaster.

Keywords

Disaster information, information posting, information sharing, Web application, real time, database.

INTRODUCTION

Background and Objective of This Research

After a large-scale earthquake, there is high possibilities in which fire-spreading and street-blockage occur and rescue and fire-fighting activities are obstructed. In order to reduce the property and human damage under this condition, it is effective to quickly collect and utilize disaster information (Osaragi et al., 2015.) On the other hand, collecting and utilize such information by few people is a heavy burden and takes a long time, therefore, collected information will be different from the actual situation over time.

In this paper, we develop a Web application for posting and viewing information collected by users in real time. Next, as an example of damage estimation by using information collected with the application, we attempt to simulate fire-spreading in densely built-up wooden residential area. Furthermore, we examine whether the system can be used in real time or not through an experiment, which assume the case of disaster.

Comparison with the Previous Studies

In recent years, due to spread of information devices such as smartphones and tablets, there are many trials to actively collect and share information with these devices in case of disaster (Table 1.) Kubota et al. (2013) developed the system for sharing disaster information with the Open-source GIS. Users send disaster information and pictures by email, and the system supports people to use location information added to Exif information of pictures. Also, real-time crisis mapping of natural disasters by Stuart et al. (2014) used the data of social media effectively. On the other hand, the disaster-information-sharing-system developed by Hiruta et al. (2012) is unique because it is not necessary to use a server and able to share disaster information using smartphones under the condition of communication interrupting. Iizuka et al. (2011) developed the mapping system of disaster information able to update it in real time in the university campus. Also, the autonomous wireless network system for sharing disaster information proposed by Matsuno (2011) focused on the use in each evacuation area. As a case study of using disaster information sharing system, there is an activity on collecting geographic information by volunteers and crowdsourcing disaster relief by Matthew et al. (2010)

In case of a disaster, it is important that sharing information will be updated in real time because the situation of cities changes each moment. Additionally, it is desirable that collected information is utilized not only to understand the degree of damages but also to forecast the property and human damages in terms of emergent activities for disaster mitigation. However, there are few preexisting systems for sharing disaster information which are fully satisfied with all aspects

Table 1. Examples of Disaster Information Sharing System

Researches	A	B	C	D	E	F
[1] Kubota et al. (2013)	×	○	×	○	◎	×
[2] Stuart et al. (2014)	◎	○	○	×	○	×
[3] Hiruta et al. (2012)	×	◎	×	○	×	×
[4] Iizuka et al. (2011)	◎	○	×	○	○	×
[5] Matsuno (2011)	○	○	◎	×	×	×
[6] Matthew et al.(2010)	×	○	○	×	◎	×

A = Real-time Property, B = Resistance to Disaster, C = Shareability
D = Independence on Devices, F = Secondary Use of Data
E = Easiness of Constructing Utilization Environment
◎ = Sufficiently Satisfied, ○ = Partly Satisfied, × = Not Considered

(from A to F in Table 1) considered as requirements. In particular, almost all system do not consider secondary use of disaster information, which is not only for viewing but also for active use.

In this paper, we develop a system for posting and utilizing disaster information, which is satisfied with all requirements from A to F (shown in Figure 1), especially focused on real-time property (A) and damage forecast (F).

WEB APPLICATION SYNCHRONIZING IN REAL TIME

Overview of This System

Figure 1 shows the overview of the system we develop. Users access to the system with their own information device through a web browser, and post disaster information and pictures related with the damages of disaster (shown by black arrows.) The information and pictures posted by users are shown on the map

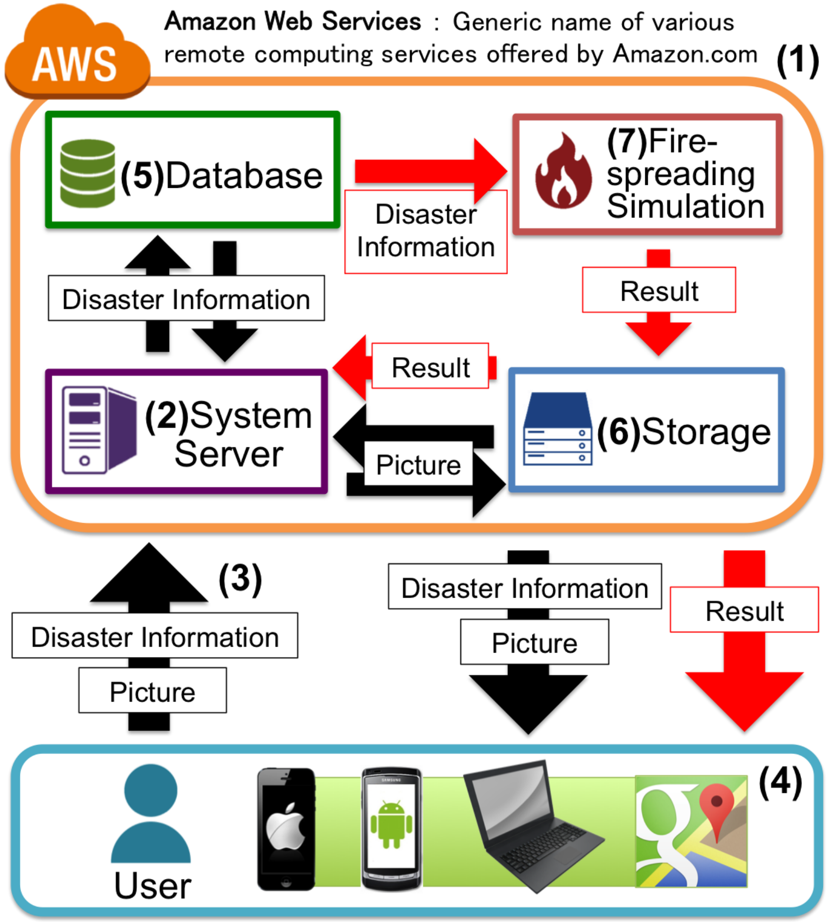


Figure 1. Overview of Our System

screen of all online users in real time, therefore, they can understand the locations, kinds, and level of disaster immediately. Additionally, using the disaster

information stored on the database, it is possible for users to execute fire-spreading simulation and forecast how fire will spread after hours (shown in red arrows.) That is to say, this system is expected to exhibit significant effects for moving to each destination, safety confirmation of their current locations and evacuation areas, and decision making of firefighters. The fire-spreading simulation is just an example of damage forecast, and we are planning to incorporate more functions to more effectively utilize the posted information.

Structure of This System

The components of this system are shown as follows: (1) **AWS Cloud Server (EC2 by AWS)** is locatable at multiple points in each country and can be temporarily changed the processing capability; (2) **System Server (Node.js)** enables to efficiently process a large amount of requests with Non-blocking I/O Model; (3) **Communication Standard (WebSocket)** has the advantages of Real-time Interactive Communication with a dedicated protocol, low server load, and low delay; (4) **WebGIS (Google Map)** is able to draw and map with API and many people have an experience to use it; (5) **Database (mongoDB)** enables high-speed data processing with NoSQL and has high convenience by schema-less; (6) **Storage (S3 by AWS)** can preserves the data by automatic backup and expand capacity without limitation substantially; (7) **Fire-spreading Simulation (Tomcat7)** works fast by multithread response in the environment of Java Servlet.

Users can use the system irrespective of the kind of an information device because it is implemented as the Web application. The system is operated on the cloud servers of Amazon Web Services (AWS), which can be used from all over the world. Therefore, even if a large-scale disaster occurs in Japan, the system does not stop.

For information synchronization between users and the system in real time, we use Node.js and WebSocket. In case disaster information is updated, the information is distributed by push type service from server-side to client-side.

Therefore, it is not necessary for users to repeatedly send the requests to the server, and it is expected to get able to stably synchronize disaster information without a time loss even if accesses are concentrated under the condition of weak communication network after a disaster occurs. Furthermore, using NoSQL for the database, much more data can be processed faster than the previous databases (such as RDB).

How to Use This System

Figure 2 shows a view of screen of user's smartphone/tablet. We incorporate various functions into the system (Table 2.) Disaster information used mainly can be posted by specifying a location on the map and selecting a kind of damage (such as a collapsed-building, a blocked-street, and a burning building.) The details of damage can be added after posting because people cannot afford inputting detailed information in case of emergency. Selecting a marker mapped on the map, the information window is expanded and enables users to view disaster information. Pictures attached to the information are also shown.

Additionally, the system has the function to output stored disaster information as a CSV file format. Therefore, it will to be able to contribute to various activities not only just after a disaster occurrence but also in the process of restoration from disaster.

Linkage with Fire-spreading Simulation

Figure 3 indicates an example of fire-spreading simulation. The simulation enables users to forecast how fire will spread after a certain period of time. The results of simulation are stored on storages as a GeoJSON file format and can be shown on the screen every 10 minutes or 1 hour.

Table 2. Function List

No.	Contents	Function
①	Login	Login using a registered ID and password. Authority to execute functions are set for each account.
②	Reload	Reload the page and initialize the map.
③	Current Location	Show the user's current location based on information by GPS or Wi-Fi network.
④	Post	Select the location of disaster, input some contents, and post the information and picture.
⑤	Correct Position	Correct the location of posted disaster information by dragging the marker on the map.
⑥	Fire-spreading Simulation	Read the result of simulation focused on selected building and show the forecast of fire-spreading.
⑦	Search Name of Places	Search any name input by the user.
⑧	Chat	Chat among online users.
⑨	Output as CSV	Sort information stored in the database in a time-series order and output it as CSV file format.

Figure 2. User's Screen of This System

EVALUATION EXPERIMENT

Evaluation in Terms of Activities of Emergency Vehicles

We evaluate this system based on the simulation experiments which assume that local residents collect the information on street-blockage by using this system as volunteers in a short time. The models of collecting information on street-blockage

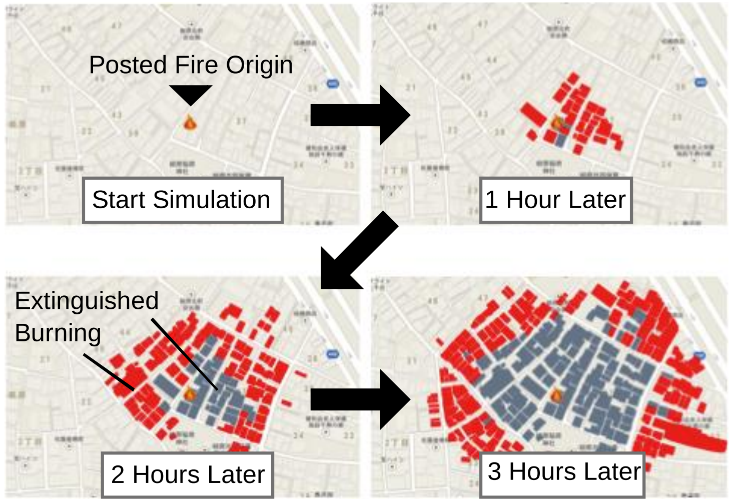


Figure 3. Execution Screen of Fire-spreading Simulation

by local residents and the movement of fire-fighters from fire stations to the locations of fires are based on the previous research (Osaragi et al., 2015.) Using these models, we estimate the percentage of blocked streets shared on the system out of all the blocked streets in the target area and the access time of fire-fighters (Table 3.)

Even if the number of people collecting information is just 0.3% (2,698) of people who live in the target area, more than 80% of information on street-blockage is collected after 10 minutes (Figure 4(a).) In case the number of people collecting information is 0.5% of all residents (4,497 people), the total amount of information collected in just four minutes is nearly equal to 80%. In this case, if the participants collect information in 10 minutes, the access time of firefighters from fire stations to the locations of fires is significantly shortened to near the time in case all the disaster information are obtained (Figure 4(b).) Also, the

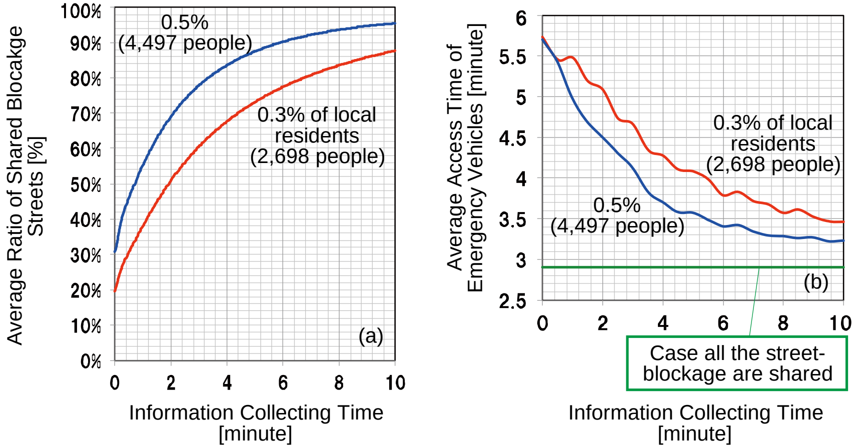


Figure 4. Simulation Results (Ratio of Shared Blockage Streets and Access Time of Emergency Vehicles)

Table 3. Assumption of Simulation

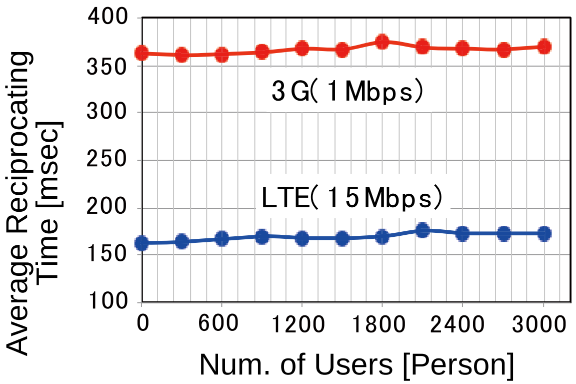
Scenario Earthquake	North Tokyo Bay Earthquake (M 7.3)
Target Area	Setagaya Ward in Tokyo Metropolitan Area
Number of People Collecting Information	(1) 0.3% of local residents (2,698 people) (2) 0.5% of local residents (4,496 people)
Number of Trials	100 times for both case (1) and (2)
Street-blockage	Consider only blockage caused by rubble of collapsed buildings.
Local Residents	Initial locations are uniformly distributed. They collect information while walking to random directions.
Emergency Vehicles	[Destination] Location of fire which the number of damage buildings will be the most. [Route] Select the fastest route to locations of fire. *Street-blockage information is grasped according to start time.

percentage of blocked streets shared on the system out of all the blocked streets in the target area rapidly increase just after beginning of information collection. These results suggest that: (1) the efficient reduction of access time of firefighters can be achieved if 0.3-0.5% of residents post the disaster information around their own locations using this system just after an earthquake occurs; (2) such activities can contribute to assist firefighting and decrease the number of buildings to be burned.

Evaluation Considering the Number of Users and Band Limitation

It is important to confirm whether this system is available or not under the condition of the preceding section. Therefore, we measure time required for synchronization of posting disaster information among all users (reciprocating time between a server and a client) in 100 times while virtually increasing the number of people to 3,000 step by step. Considering the network band limitation after a disaster occurs, two kinds of transmission speed (1 Mbps and 15 Mbps) are examined.

As the result of this experiment, it is found that the time increases to less than 50 milliseconds even if the number of users increases to a certain degree (Figure 5.) That is, as long as a cloud server(AWS) used equivalent to the one we use in this experiment, it is possible to support the activities of emergency vehicles without losing real-time requirement. The cost of server we used is approximately 400 USD per month under the condition of low-priced fee by time unit (AWS EC2 Pricing.) However, the connection state is sometimes unstable in case the number of users is more than 3,000 people. Therefore, it is necessary to improve this system in terms of load distribution in order to enhance the reliability of sharing information in real time.



AWS Cloud Server: vCPU16, Memory 30GB

Assumption of Transmission Speed: LTE (15Mbps) and 3G (1Mbps)

Figure 5. Simulation Results (Reciprocating Time between a Server and a Client)

SUMMARY AND CONCLUSIONS

We developed the system (Web application), which enables users to post, share, and utilize disaster information in real time on the cloud server. We incorporated the function in which fire-spreading can be forecasted based on the stored disaster information. Additionally, through the evaluation experiment under the assumption of disaster, we quantitatively demonstrated the usefulness of the system for supporting the activities of emergency vehicles.

The cost of AWS Cloud Server used by evaluation experiment in this paper is approximately 400 USD per month under the condition of low-priced fee by time unit. This is cheaper than general system servers of monthly flat rate. If we use it in our daily life, costs for implementation / maintenance of the system would be scaled to more realistic. Also, use of system modified for daily life enables users to post and share information more smoothly when disaster occurs. With this in mind, we intend to improve the system focused on both in disaster and in normal times.

In this paper, we evaluated our system through some experiments with the assumption of a large earthquake. The authors believe, the functions of posting and sharing information in the system are available for other disasters (such as flood, typhoon, etc.) by slight modifications of UI parts.

In the future, we are planning to perform demonstration experiments using this system under virtual damages caused by various disasters.

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