

Development of Disaster Evacuation and Safety Inquiry Support System

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Abstract: There has not been established system of supporting evacuation and safety inquiry under disasters. We aim to develop an information system which will aid safety inquiry and request of emergency support by pre-registration of personal information and carrying them as QR codes on stickers or mobile phones. Longitude and latitude will be recorded as part of residing address so that it can be displayed on digital map. Cloud computing will be utilized and anti-disaster headquarters and residents' disaster prevention associations will be able to visually grasp the progress of evacuation process. Registered residents will be allowed to inquire safety of their families, relatives, and friends.

1. Introduction

Many casualties are caused by natural disasters in Japan where number of natural disasters occurring every year has earned us the name of “disaster nation”. Because in natural disasters “residents requiring assistance during disasters” such as elderly and handicapped suffer from difficulties in evacuating, the Japanese government in late 2004 has urged local governments to identify and arrange support plans for each vulnerable resident through its “Guidelines for supporting evacuation of residents requiring assistance during disasters”.

According to survey by the Fire and Disaster Management Agency of the Ministry of General Affairs however, as of April 1st 2011 only 52.6% of 1,647 local municipalities (103 municipalities are excluded due to effect of the Great Tohoku Earthquake) have updated list of residents requiring disasters while 41.5% are still under process of identifying and listing residents requiring disasters. The combined numbers add up to 94.1% (figure was 88.2% in 2010 March). As to arrangement of individual support plans 22.0% have answered that they have completed and is updating the individual plans while 60.7% are on the way of arrangement, totaling to 82.7% (figure was 71.8% in 2010 March). Although local municipalities are making efforts to identify and arrange support plans for residents requiring disaster, there are a number of cases where protection of personal information and sectionalism have become obstacles in following the government’s guideline.

In this paper we will introduce a evacuation support and safety inquiry system which we developed

as part of joint study with Miki City which will support local disaster prevention organizations expected to play a key role in disaster prevention in coordination with local municipal offices. The system implements personal information registration function using QR codes as well as safety inquiry from homes or workplaces through telephones. We will also introduce results of empirical study conducted in Miki City on February 26th 2012.

2. Support System for Residents Requiring Assistance during Disasters

2.1 Overview of Previous Studies

In previous studies (Arima et.al. [1], [2], [3], [4], [5]) we described six functions necessary in supporting residents requiring assistance during disasters: 1. display of selected individual's whereabouts; 2. assignment of evacuation plans to individual residents; 3. means of communication to residents and supporters; 4. support of evacuation and confirmation of its completion; 5. safety inquiry of residents who have not yet evacuated; and 6. managing information on residents requiring special cares at evacuation center.

With these in mind, we have developed a prototype support system for residents requiring assistance and have been continuing to improve its functions based on results of empirical studies and evaluation received from participants in forms of questionnaire surveys. In this series of studies we have received high evaluation regarding functions such as display of residents' whereabouts using GIS and simplification and speedup of evacuation center registration process using pre-registered information and identifying them using individual residents' IC cards or QR codes. On the other hand however, it is confirmed that residents feel uneasy about pre-registering their information in terms of information leakage.

Therefore, we have been considering provision of an alternative method for residents who do not wish to register their information to the municipal office; personal information could be coded into business card sized QR codes and be carried with residents. The QR code cards can be shown at registration desk of evacuation centers which can utilize the embedded information for evacuation registration and safety confirmation. This way registration of personal information to municipal office is no longer necessary and residents will be able to manage security of their own personal information.

Also, in previous systems safety confirmations had to be proceeded by completing the evacuation center registration i.e. residents had to come to evacuation centers. However, there are cases when waiting at homes is safer than traveling to evacuation center or residents can not come to evacuation center for various reasons such as injuries. In order to cope with these various possibilities we needed a function to distinguish between residents who require support at home and residents who are safe at home. With such function it is possible for the disaster prevention headquarters to effectively use their limited resources to support those who are in need of or those whose safety is not yet confirmed.

2.2 Overview of Previous Studies

The basic idea of the system we are aiming to construct in this study is as shown in figure 1; the main goal is to construct a system where status of residents—need of support and completion of evacuation—can be managed easily and quickly by utilization of geographic information system (GIS). A sample screen is shown in figure 2.

In prior system pre-registration of personal information was necessary and those who did not register had to fill and submit a handwritten registration form. However, there was a problem that there are many items that are needed to be filled such as family's names, address and phone numbers, in addition to problems associated with handwritten forms such as miswritten characters and difficulties in reading. Even if data addition function was added to the system it would still be difficult to operate the system efficiently under disorder. It is one of the characteristic and novelty of our system to utilize QR codes in order to solve such problems.

Furthermore, prior system only distinguished between those who registered to evacuation centers and those who did not based on the assumption that all residents would evacuate to evacuation centers. In our improved system residents who have not yet completed evacuation will be categorized into three groups: 1. residents at home who require assistance or rescue, 2. residents at home who have secured safety, and 3. residents whose safety status is not confirmed. Function to update these statuses through telephones and emails will be added as well.

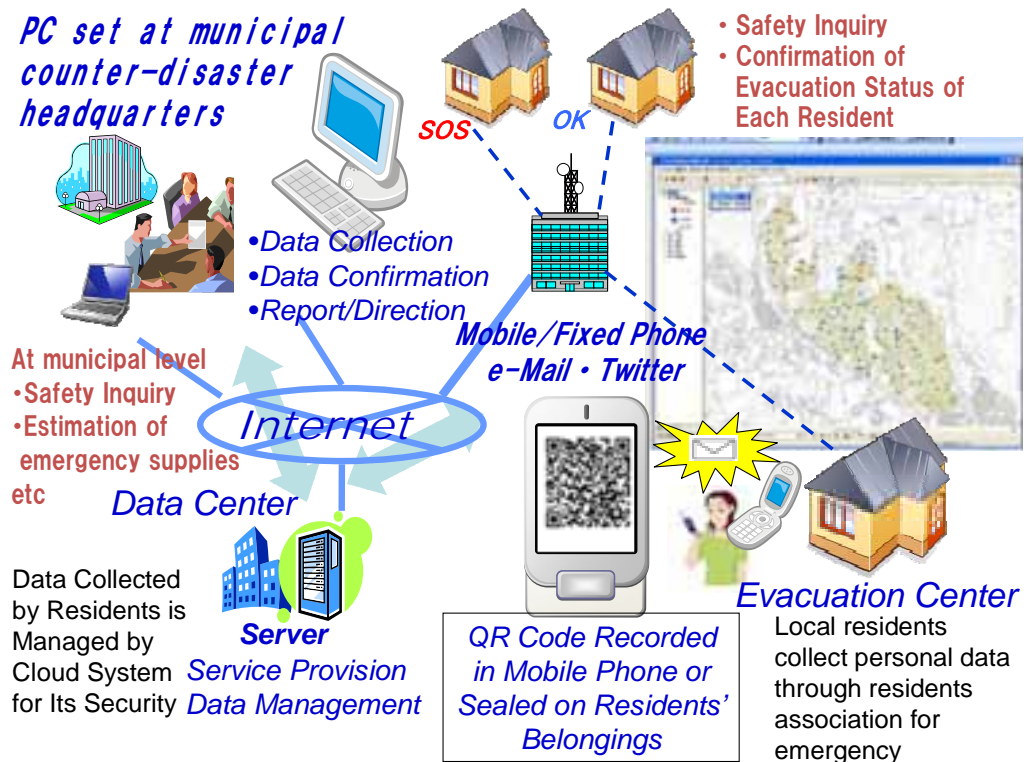


Figure 1 Overview of the Developing System
(Cloud computing shown in bottom left is under consideration)

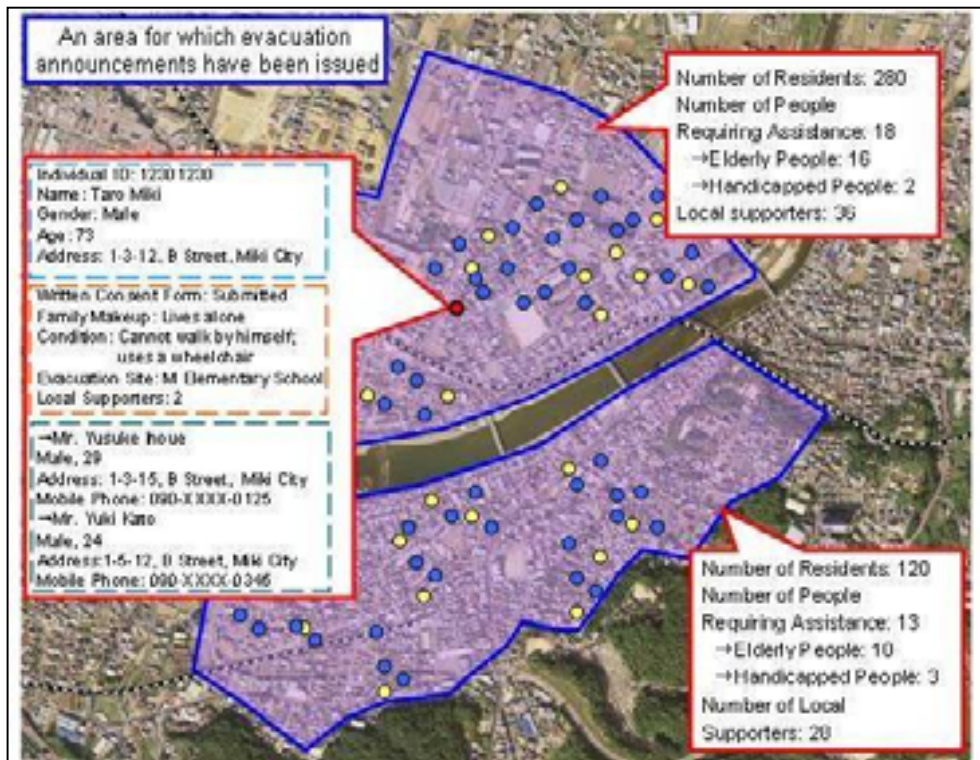


Figure 2 A Sample Screen of Our Prototype System

2.3 Registration through QR Codes

The theoretical limit to the size of information embedded into QR code invented by a Japanese Corporation Denso Wave Incorporated is 7,089 numerical characters, 4,296 alphabetical characters or 1,817 Japanese and Chinese characters. However, as size of embedded information increases, dots which compose the two dimensional code becomes smaller and smaller, making it difficult for QR code readers to identify them. In our study we intended to print QR codes onto standard Japanese name card sized paper of 55×91mm, which placed a limitation on the size of QR code to 39×39mm. As a result of our trials we have confirmed that practical limit to information carried in a QR code of that size is approximately 1,200 numerical characters, 600 alphabetical characters or 350 Japanese and Chinese characters. An example of Personal Data and its QR-coded figure is shown in figure 3.

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<sex>male</sex><name>Masahiro Arima</name><address>7-1-28,Minatojima-Minami,Chuo,Kobe</address><latitude>34.654251</latitude><longitude>135.220542</longitude><birthday>1954/01/23</birthday><tel>078-303-1901</tel>
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Figure 3 An Example of Personal Data and its QR-coded Figure

Since XML format will be used to embed information, 178 alphabetical characters will be necessary for XML tags apart from the payload itself. At present information embedded will be: name, furigana (reading of kanji names in Japanese kana), gender, year and date of birth, address, X and Y coordinates of address, phone number, and extra space for other necessary information such as emergency contact address. Out of these information, name, gender, date of birth and address will be used for matching with the Basic Residents Register which is a Japanese unique information system that register residents' personal records on household basis. QR codes will be created and carried personally by individuals who do not wish to register information to local municipal offices. Registration process at evacuation centers will be completed by reading the data embedded in QR codes.

3. Overview and Results of Empirical Study

3.1 Disaster Prevention Drill at Minagi-dai Elementary School District, Miki City

Taking opportunity of a disaster prevention drill conducted in the school district of Minagi-dai elementary school (2,447 residents and 699 households), we conducted an empirical study to test our system with cooperation from Miki City office and united residents association of Minagi-dai district. The drill itself aims to train residents in communication and gathering of information, management of evacuation center and supporting evacuation under disaster.

The drill was conducted based on supposition that an earthquake has occurred at 8:30 AM. At 8:40 AM evacuation advisory was issued through the director of disaster prevention organization of Minagi-dai school district along with local FM radio station. Residents were notified of the evacuation advisory through members of disaster prevention organization and then first evacuated to temporary evacuation sites such as local meeting halls. At 9:00 AM evacuation center was established at Minagi-dai elementary school and registration procedures began. Our study involved setting up two mock registration desks—one for QR code registration and another for handwritten registration—and actually conducting the registration procedure. Evacuation drill was finished at 10:30 AM.

3.2 Use of System at Evacuation Registration Desk

At the registration desk 178 pre-registered residents and 19 residents who had their personal information on QR codes were directed to registration desk using our system while the remainder filled the handwritten forms. For pre-registered residents last four digits of their phone number were used as an identifier and registration was completed upon confirmation of personal information displayed on screen according to the four digits. For those whose four digit number did not return hit upon query, name was used instead and all pre-registered residents were able to be registered through system. For those carrying QR codes a similar procedure was used. Upon reading QR codes embedded information were displayed on screen and with confirmation from the resident the data was added automatically to our system's database and registration process completed.

3.3 Safety Inquiry by Phone

In order to confirm the safety status of residents who have not completed evacuation we prepared two mobile phones—one for residents who are safe and another for residents needing support—and had 11 residents make one-ring call to either of two prepared phones. System operator then used the history of received calls to make a query on system's database using the phone number and then updating that resident's status.

4. Evaluation of Empirical Study

In order to test effectiveness of our newly developed residents support and safety inquiry system we distributed questionnaire surveys to each participant upon completion of registration procedure and collecting them at end of the drill. Out of 214 survey sheets handed out 148 were retrieved. The survey sheet asked evaluation of the following in addition to personal attributes such as age and gender: simplification and speedup of registration, increasing accuracy of registration, supporting operation of evacuation centers, effectiveness of safety inquiry using GIS, effectiveness of registration using QR codes, effectiveness of safety inquiry using one-ring calls, whether respondent have fear of information leakage upon pre-registration, whether respondent wishes to register to our system, and whether respondent wishes to use QR code.

Number of respondents who registered through our system and number of respondents who registered by conventional method are roughly equal, and that a high proportion of 73.0% have some fear regarding information leakage. As to our system itself a large proportion—over 80%—of respondents have evaluated favorably: 89.9% for simplification and speedup, 87.8% for increasing accuracy, 83.1% for supporting management of evacuation centers, and 91.9% for safety inquiry utilizing GIS. Also, responses are also positive for safety status confirmation through telephone calls (74.3) and embedding personal information in QR codes (79.1%) leading to a positive feedback to our system in general where 89.2% responding they wish to consider about pre-registration and 79.0% responding they wish to consider using QR coded cards. We believe that this confirms effectiveness of the system we have developed in this study.

5. Conclusion

In this study in addition to previous studies we proposed a system with added function of carrying QR code embedded information which can be utilized during disasters and use of one-call rings to confirm safety status of residents who have not evacuated to designated evacuation centers. Through our empirical study effectiveness of the system was verified and as a next step we would like to consider the following two enhancements: utilization of QR code readers on mobile phones instead of dedicated QR code reading machines and automatic update of residents' safety status by integrating the telephone system into our database system.

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