Communication platform for disaster response

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Abstract. The present research proposes an information platform for enhanced communication and information sharing in municipalities struck by disasters. Once a disaster happens, collecting and sharing information with and among citizens is the most important tasks for municipalities. However, empirical research of the Great East Japan Earthquake in 2011 revealed a marked lack of tools supporting municipal communication and data sharing activities at the initial stage. A smartphone and tablet based application was subsequently developed and evaluated in the field as a means of first response in future disasters. The application is based on the notion of frugality, which proved to be very useful in the field drill. Frugality is shown to be a requirement of the system as well as an evaluation indicator.

Keywords: disaster management, communication, frugal information system

1 Introduction

The largest earthquake on record struck Japan on March 11, 2011. The movement of tectonic plates along the Pacific Rim created a rupture zone 500 km long. Measuring 9.0 on the Richter scale, the earthquake produced a tsunami of 40 meters hitting the coastline and devastating cities and towns. The earthquake was named the Great East Japan Earthquake. The Fire and Disaster management Agency reported 19,335 deaths, 6,219 injuries and 2,600 missing as of September 2015. It also reported 124,690 houses totally lost and more than 1,000,000 partially destroyed. This earthquake was unique in that it caused severe damage to a very wide area, above all due to a massive tsunami beyond any prior assumptions.

All business operations including public organizations were suspended and remained so for some time in areas directly affected by the earthquake and tsunami. In some areas power supply and connectivity were completely lost at the most critical life saving phase immediately after the earthquake. In those areas people were instantly faced with a situation they had never experienced and which had never been anticipated in any disaster management plan.

Constrained by a severely degraded information and communication technology (ICT) environment, local authorities in the most damaged areas had to conduct five critical life-saving missions following the disaster, namely (1) confirming the whereabouts and safety of residents, (2) establishing and operating evacuation centers, (3) transporting and managing relief goods, (4) supporting evacuees and recording their

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status, and (5) issuing disaster victim certificates. To conduct these operations smoothly, information sharing among relief staff is important. Due to ICT failure and lack of supportive tools, however, information sharing among municipal offices was mostly done with pencil and paper, which made it quite difficult to share information readily.

The most intricate job that information department personnel had to undertake immediately following the earthquake was to prepare a list of evacuees and confirm the names of survivors. In some towns, more than hundreds of people evacuated to gymnasiums of elementary schools and community centers. Relatives of evacuees simultaneously ran to these places to find their families or friends. A message board with evacuee names was set up at each evacuation center, which helped to find dislocated people. Collecting evacuee names and writing them down on the message board was a labor-intensive task that turned out to be a severe burden on information department personnel.

2 Design of the Artifact

The present study has the purpose of designing a communication platform that can be used for information sharing between local authorities, i.e., staff at municipal governments, and citizens. In earlier research this author has shown that in a disaster situation simple tools have an increased likelihood of readiness and ease of use than other more complex devices [1]. Whereas other studies insist on the importance of exploiting existing infrastructure when designing a communication platform [2], the approach suggested here minimizes the adoption barrier for the user and lowers implementation cost [3].

In addition to these findings, design principles of the artifact employ the notion of a frugal information system [4]. The frugal information system is defined as an information system that is developed and deployed with minimum resources to meet the preeminent goal of the client. The notion is useful especially after a disaster because it forces people to manage with very limited resources. The frugal information system has four information requirements, i.e., universality, ubiquity, uniqueness and unison [5]. Universality is the drive to overcome the friction of information systems' incompatibilities. Ubiquity means information access unconstrained by time and space. Uniqueness requests to know precisely the characteristics and location of a person or entity. Unison refers to information consistency.

Looking toward the future, the smartphone is likely to be the tool to meet frugal design requirements better than any other device. First, it can be kept operational easily with a manually cranked charger. Second, it can be connected either via a cellular network or, if the cellular network is down, via WiFi. Third, a smartphone carries a unique phone number and SIM card. By associating the information of individuals collected with the number of a personal smartphone, the compatibility of the individual data is maintained. It is also be easy to link information of the same individual collected in different locations. In addition to this, a smartphone is a readily available tool with which people are already familiar.

Based on design the features described above, the author and a Japanese systems developer created a prototype information sharing system, which is predominantly a smartphone and tablet based application. Expected users are both municipal officials and citizens. The application can be used in evacuation centers and disaster management headquarters within municipal government. The application enables five key operations; (1) interactive information sharing on specific situations between disaster management headquarters and evacuation centers, (2) identification and registration of people at evacuation centers, (3) recording individual arrivals and departures, (4) assessing required relief resources (water, food and so on) at each evacuation center and, (5) creating an evacuee and resource list. These key operations were derived from empirical research on the Great East Japan Earthquake which the author conducted eight months after the earthquake. Smartphones were used mainly by evacuees (citizens) and tablets were used by city officials. This was based on the assumption that a tablet device has a more suitable interface for browsing the database.

3 Evaluation of the Artifact

A drill which used the prototype system in the field was conducted in November 2014 in Tome City, which occupies about 536 square km of land and holds a population of around 80,000. This city was not included in the empirical research on the earthquake but is one of the municipalities damaged by the Great East Japan Earthquake. During the earthquake, Tome accepted over 800 evacuees from a neighboring town, Minamisanriku. They had never assumed to have evacuees from outside the city. This caused all-round confusion. It was difficult to figure out the whereabouts of people, what was happening in the field, what was needed, who needed it and what resources they already had or did not have. As a result, the city was quite eager to develop a solution for sharing such information in any future disaster situation.

The initial test was planned with the operation of evacuation centers, which would test the use of smartphones and tablets for supporting disaster relief. In this drill, we set up two temporary evacuation centers. Each center was located 10 to 14 km away from headquarters, a drive of about 20 minutes. Since important conditions for system development are said to be a small team and simple technology [6], the number of participants was kept small with two officials from headquarters and five officials and five citizens at each evacuation center.

A dummy unison database was prepared in advance and available to be accessed through a tablet application. Once the drill started, the tablet application provided officials with access to information on the stages of the disaster as posted by headquarters and other staff (key operation 1). Five evacuees in each evacuation center registered their location to the smartphone application (key operation 2 and 3). At the same time, they were able to send their demands for relief goods such as water, food, medicine through the application (key operation 4). The system created an evacuee database automatically and officials were able to reference the evacuee list and needs for relief goods through their tablet application (key operation 5).

The drill was accomplished smoothly because people were already familiar with the devices and easily got to understand how to use it in these operations. Nevertheless, the result of the drill was mixed. The use of smartphones and tablets for accessing the database was effective. In other words, *universal* devices enable *unison* of evacuee information. In this regard we could verify that the use of smartphones is certainly a possibility, although the scalability of the system should be questioned because of the limited number of smartphones tested. While accessing the database was realized, using *universal* devices to share posted information on disaster status caused information overflow. This is an issue for future research. In addition, the identification of evacuees by using the phone number of their SIM ID was not realized because of a privacy issue. *Uniqueness* was not accomplished in this sense. To compensate, a dummy database was created in advance and once the fire drill started, evacuees logged in the application and updated their status (location) by themselves. We should also note that we did not conduct any connectivity measures (*ubiquity*) in this drill. Rather we simply assumed continuous network connectivity. Although it was dummy information, we confirmed the importance of both preparing a unison database which every relief staff could access and providing information uniqueness on the database. This allowed smooth information sharing among different sites at the same time.

4 Significance to Research and Practice

Massive disasters like the Great East Japan Earthquake will likely become more common, as the number of natural disasters in the world is increasing.[1] There were three times as many natural disasters between 2000 and 2009 as there were between 1980 and 1989.[2] Thus, a communication platform which enables smooth information sharing between stakeholders during an emergency situation will be demanded both in Japan and around the world. Not only local authorities but also the notional governments tend to build large, complex and robust systems to support disaster management operations. While noting its limitations, we conclude that a frugal solution that employs devices that citizen use in their daily lives are worth incorporating in the lists of options which may save countless lives under severe conditions.

Let us briefly look at the significance of this paper to research and practice. First, the field drill focused mainly on the response stage which in emergency management literature is defined in terms of mitigation, preparedness, response, and recovery [7-9]. However, we found little discussion of information systems at those stages. Given the drill we could evaluate five key operations and see how the prototype application might work out for each of them. The result of the field drill convinces us that each operation is essential in responding to a situation. However, the drill also pointed to some issues to be solved in the future. Information overflow, scalability of the system and evacuee identification by unique number will be future issues which we expect to

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[1] Last accessed Mar. 3rd 2016, at http://www.emdat.be/disaster_trends/index.html

[2] Last accessed Mar. 3rd 2016, at http://www.accuweather.com/en/weather-blogs/climatechange/steady-increase-in-climate-rel/19974069

affect design requirements. In addition, the drill made clear the importance of both keeping the citizen database up-to-date in its daily basis operations and connecting it to emergency operations.

Second, the aim of designing an information system based on the notion of frugal IS has been accomplished in the present research. In this sense, we can say that we took both the bootstrap and adaptability approach [2]. While design requirements were generated from experience in the field, the application employs four information requirements advocated in the literature. The drill tells us that those requirements are useful as indicators in evaluating the system itself. This finding contributes to research in this area by proposing how to evaluate the artifact from the view of requirements, rather than functional perspective.

There are several directions for future research. This research is based on a single type of disaster, i.e., an earthquake and tsunami that occurred in Japan. For further generalizations of findings, a comparison with other types of disasters and cases is necessary. To make the application useful in practice, we also need to consider how to create and maintain the database and how to connect it to an ordinary residential record system. Because of privacy issues, the registration of evacuees would perhaps be the most difficult part of this challenge.

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