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THE POTENTIAL USE OF A PUBLIC WEB SERVICE TO GUIDE CONVERGING CONSTRUCTION EQUIPMENT IN US&R

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ABSTRACT: During disaster response, prioritization of limited resources is one of the most important bust challenging tasks. At the same time, it is imperative to timely provide the rescuers with the adequate equipment to facilitate lifesaving operations. However, supply of high demand equipment was insufficient during the initial phase of disaster response, challenging lifesaving operations in the case of the 9-11 terrorist attacks. In respond to the Haiti Earthquake, spatial information of the geographic area was not sufficient to support the search and rescue operations in the early phase of disaster response. However, with the help of civilians, information such as road names, infrastructure damage, and victim locations were updated into the spatial data repository. At the same time, resource outside of the disaster affected zone converges into the area to assist the response efforts, which is the effect of convergence that often made resource coordination challenging in large scale disasters. To efficiently collect information and utilize the converging resources, this paper proposes a flexible data repository for information update for equipment utilization in large scale disaster response scenarios.

Keywords: Construction Equipment, Disaster Response, Resource Convergence, Urban Search and Rescue (US&R).

1. INTRODUCTION

During disaster response, it is imperative to timely provide the rescuers with the adequate equipment to facilitate lifesaving operations [1,2]. However, management of geographically distributed resources has been recognized as one of the most important but challenging tasks in response to disasters [3,4]. Challenges include resource demand and search and rescue task identification, and resource assignment, location tracking and delivery [4,5]. In addition, the convergence of resources makes coordination of response actions and resources difficult [6]. For disaster response efforts to be more effective, these challenges must be addressed.

2. BACKGROUND

In response to disasters, the initial efforts including information gathering and victims search and rescue are usually and mostly carried out by civilians, which are within the area at the time when the disaster occur [7,8,9]. Organizations and individuals from different industry and background emerged and worked together in response to the crisis collectively [8,10,11,12]. Individuals collect relief supplies, provide shelter, and are engaged in a variety of services [7,13]. At the same time, the establishment of the official command and control by the Emergency Management Agencies (EMAs) from the local, state and federal usually takes time, to coordinate and respond to the disaster [7,8,9]. Meanwhile, volunteers and response organizations outside of the disaster affected zone converges into the disaster affected area to assist the response efforts. This is the effect of convergence that often made the already complex problem of resource coordination even more challenging [3,6,7,10]. For example, the on-site congestion of volunteers, material, and equipment hinders an efficient logistical coordination [7,10]. However, provided with the convergence of resources, such as volunteers, equipment and organizations, the response to the incident could be more efficient and effective [7,9,14,15,16]. In the rapidly changing environments of disasters, the convergence could bring certain capabilities and flexibilities that do not exist or is not sufficient in the official command and control system [10]. How to properly manage the converging resources is then the important task.

One of the greatest challenges of utilizing the converging resources is their ability to be deployed immediately to the incidents without the appropriate and required skills, training and the familiarity to the command and control structure and EMAs [10]. Nevertheless, there are still great potential to utilize the converging resources. For example, Red Cross [11] is one of the specialized organizations, along with other specialized entities, that contributed to the response operations in the 9-11 terrorist attaches [10]. In addition, Kendra and Wachtendorf [10] pointed out that to have an efficient and effective disaster response, it is vital to develop, maintain and take action based on a “Shared Vision” of emergency goals, critical tasks and their need of critical resources. It is difficult to have the volunteers obtain such Shared Vision without any prior training and communication with the EMAs.

3. OBJECTIVE

When disasters occur, information required is not always available. For example, before the Haiti Earthquake, there is very little information regarding the road network and the spatial entities. After the earthquake, this lack of information hindered the response operations. However, volunteers in Port-au-Prince filled in cartographic blanks in maps and created far more detailed maps that are accessible to the public online [17]. It is also important to understand that initial information collected about the disaster is often inaccurate [18]. For this reason, assessment of resource needs has to be an ongoing procedure that continues throughout the duration of the incident to update information for all entities involved within the disaster response operations to have an accurate view of the needs [9]. In the case of Haiti, the volunteers used text messages, GPS, and hand drawings to dispatch thousands of updates for road names, building collapse, and victim locations [17,19]. The officials used the information to guide their emergency workers, including the Marine Corps and Red Cross [19]. Although there are drawbacks in this approach of information update, the benefits outweighed in the case of the Haiti earthquake [17,19].

As a result, the objective of this paper is to establish a public web service for information discovery and update that could be potentially used by officials in the official command and control system and volunteering personal, equipment and materials.

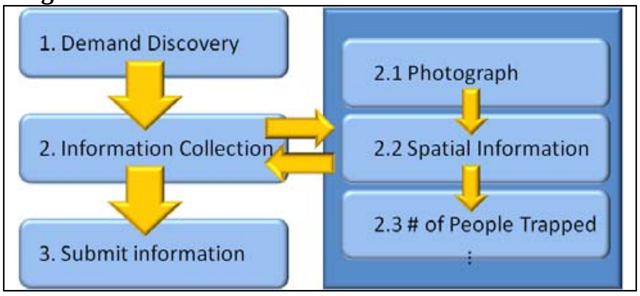
4. APPROACH

An innovative approach that facilitates immediate equipment distribution in response to disasters is proposed by Chen and Peña-Mora [20]. An Equipment Control Structure, which is inspired by the behavior control structure of honeybees’ foraging [21], enables a decentralized and collective decision making process for equipment prioritization. With the Equipment Control Structure applied to facilities management such as construction equipment distribution, disaster response operations have the potential to become more efficient. Each volunteering Equipment Unit will make its own decision on where it will carry out the disaster relief effort. How each Equipment Unit makes decisions based on the information it perceives is inspired by Honeybees’ foraging behavior [20].

Based on the decentralized approach the authors proposed for the converging resources [20], the web service could provide the converging resources a source of information as to guide where the resources should converge.

Figure 1 shows the outline process a user would follow for using the server.

Figure 1. Outline Process



When a person in the disaster affected area discovers a location where there are victims that need help, e.g. they are trapped under collapsed structural elements, the person could report such situation to the web server through a handheld device with network capability such as a personal device assistance (PDA), a smart phone, or a touchpad device. The information uploaded by the person and all other information provided by other people could be seen through a webpage. As a result, the webpage could serve as an information hub for unassigned disaster response resources. This way the productivity of the unassigned resources could greatly increase, avoiding unnecessary idle due to the overload of the official command and control system.

To achieve this goal, there are certain assumptions. First, we assume that there will be access to computer network such as a wireless 3G network. In cases if infrastructure based networks are not presented, an ad hoc network approach could be taken [22]. Secondly, we assume there will not be malicious injections of information into the database. In addition, for this web service to be worth using, the situation of the disaster response scenario is assumed to be when the official command and control system is saturated. In other words, the command and control system is overloaded by the massive tasks to be carried out, such as urban search and rescue, resource location, assignment and coordination.

The system architecture of the web service is shown in Figure 2 and the implementation of the web service is as follows. MySQL is chosen as the database to store the discovered information. The database table that holds such information includes attributes such as the entry key/id, the timestamp of when the piece of information is received, the latitude and longitude coordinates of the location, a photograph of the situation, potential number of victims, the condition/severity of the victims, and textual comments. The web interface is written in a mixture of PHP and HTML. PHP is selected for its easy access to databases and the ability to program logic in HTML web pages. In addition, the Google Maps JavaScript V3 API is used to display spatial information. The web service is programmed to automatically annotate the reported victim location with the photograph taken and the textual information.

Figure 2. System Architecture

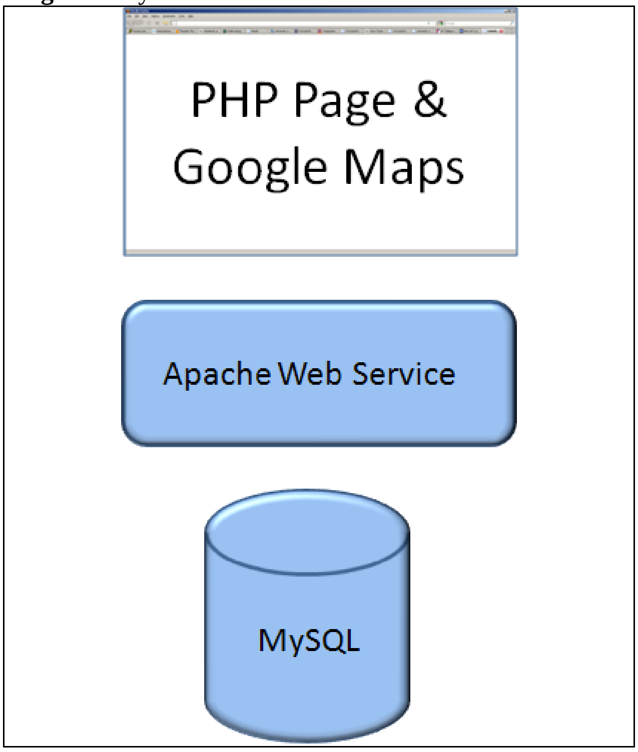
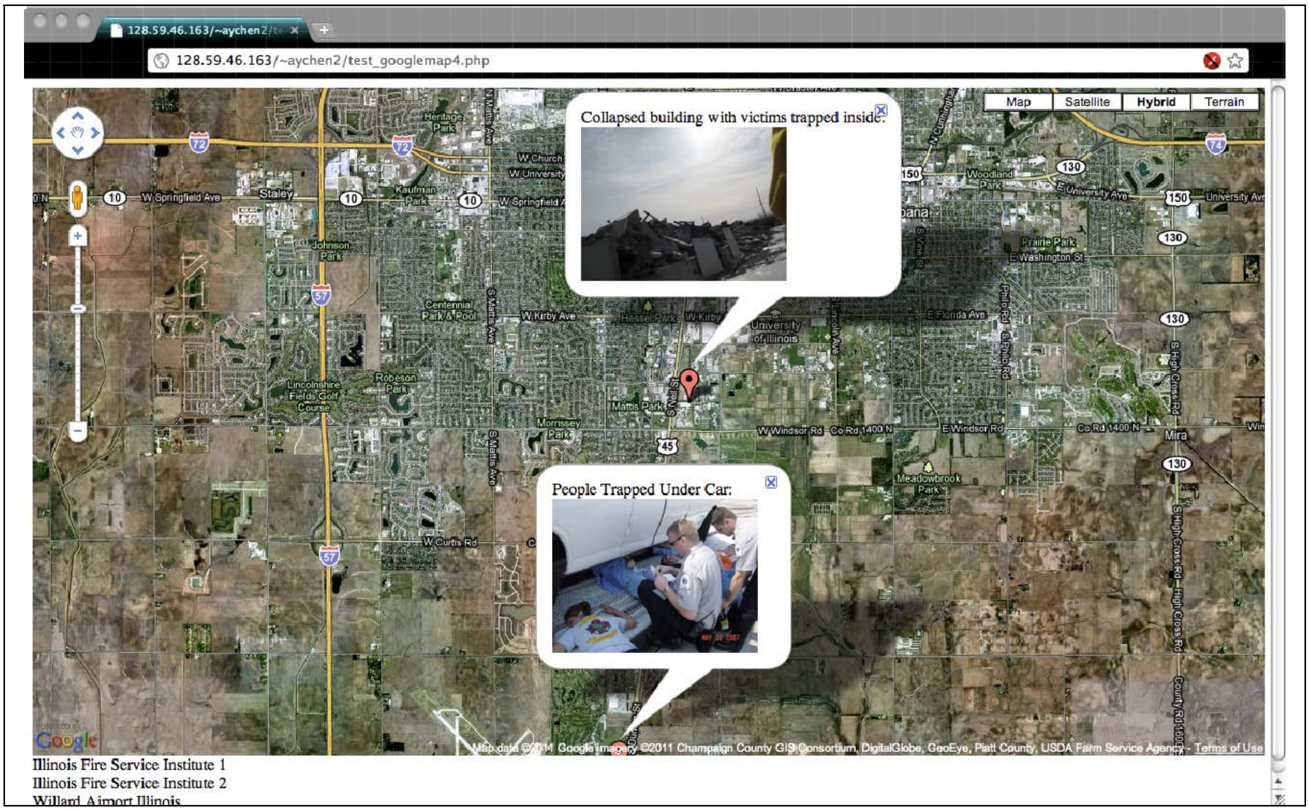


Figure 3. Map Interface of the Server

The result of the civilians reporting of equipment demand could be viewed via the server through an internet browser (Figure 3). People who are interested in helping the disaster relieve efforts could visit the web service and see where help is needed. For example, if a track mounted crane and its crew is volunteering to help while the official command and control system is overloaded, the crew could visit this webpage. Through the information the web service provides, the crew could decide where they could be most helpful.

5. CONCLUSION

In this paper, a web service that takes information from users who discover equipment demand on the disaster affected area and publishes the information on a map is presented. The context of when the server would be used, along with the process of how a user would use the server, assumptions, the architecture of the server, and a sample result are discussed.



Although this ad hoc approach of equipment distribution could result in non-optimal assignment and arrangement of equipment utilization, it is under the condition that the official command and control system is saturated. As a result, this web service could potentially be useful to guide volunteering construction equipment.

Future work would be to further implement algorithms to make this process more efficient. In a large scale setting when the official command and control system is overloaded, demand for equipment could be in a great number. As a result, clustering of discovered demands needs to be performed on the server side, to avoid overwhelming information on the map interface. In addition, an algorithm to rank demand locations for a crew based on the number of demand, spatial attributes, severity of demand and the capacity of the piece of equipment could be highly useful to help decision making of the crew with automation when using the web service. Further more, duplication of demand reporting must be carried out to avoid confusion.

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