Promoting Coordination for Disaster Relief – From Crowdsourcing to Coordination

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Abstract. The efficiency at which governments and non-governmental organizations (NGOs) are able to respond to a crisis and provide relief to victims has gained increased attention. This emphasis coincides with significant events such as tsunamis, hurricanes, earthquakes, and environmental disasters occuring during the last decade. Crowdsourcing applications such as Twitter, Ushahidi, and Sahana have proven useful for gathering information about a crisis yet have limited utility for response coordination. In this paper, we briefly describe the shortfalls of current crowdsourcing applications applied to disaster relief coordination and discuss one approach aimed at facilitating efficient collaborations amongst disparate organizations responding to a crisis.

Keywords: Disaster Relief, Crisis Map, Crowdsourcing, Groupsourcing, Response Coordination, Relief Organization

1 Introduction

Natural disasters have severe consequences including causalities, infrastructure and property damages, and civilian displacement. The 2004 Indian Ocean earthquake and tsunami killed 230,000 people in 14 countries. Hurricane Katrina occurred in 2005 killed at least 1,836 people and resulted in approximately $81 billion [4] in economical loss. The catastrophic magnitude 7.0 earthquake in Haiti on January 12, 2010 resulted in more than 230,000 deaths, 300,000 injuries, and one million homeless.

Quality data collection from disaster scenes is a challenging and critical task. Timely and accurate data enables government and non-governmental organizations (NGOs) to respond appropriately. The popularity and accessibility of social media tools and services has provided a new source of data about disasters. For example, after the devastating Haiti earthquake in January 2010, numerous texts and photos were published via social media sites such as Twitter, Flickr, Facebook, and blogs. This is a type of data collection and information sharing that strongly leverages participatory social media services and tools known as crowdsourcing [3]. Crowdsourcing is characterized by collective contribution and has been adopted in various applications. For instance, Wikipedia depends

on crowds to contribute wisdom without centralized management. Customer reviews are helpful in buying products from Amazon.

Collaboration is a process to share information, resources, and cooperate among various organizations. Collaboration in disaster relief operations is usually decentralized because of the relative independence of relief organizations. Attempts have been made to help the relief community to enhance cooperation. *Haiti Live*[1], which leverages web 2.0 technologies to collect data from various sources such as phones, the web, e-mail, Twitter, Facebook, etc., provides an up-to-date publicly available crisis map that is in turn available to relief organizations. However, without centralized control, it is difficult to avoid conflicts such as responding to the same request repeatedly by different organizations. An approach to enable efficient collaboration between disparate organizations during disaster relief operations is imperative in order for relief operations to be successful in meeting the needs of the people impacted by the crisis.

This paper is organized as follows: we summarize related work in disaster relief management systems. We discuss the need for a collaboration system and highlight our approach.

2 Related Work

Dynes et al. [1] propose a disaster zone model which consists of five spatial zones of *Impact*, *Fringe*, *Filter*, *Community*, and *Regional* and eight socio-temporal disaster stages [1]. Goolsby et al. [2] demonstrate the possibility in leveraging social media to generate community crisis maps and introduce an *inter-agency* map not only to allow organizations to share information, but also to collaborate, plan, and execute shared missions. The inter-agency map is designed to share (some) information between organizations if the organizations share the same platform or have similar data representation formats. In [5], Sophia and Leysia summarize 13 crisis-related mashups to derive some high-level design directions of next generation crisis support tools.

Ushahidi is a crisis map platform created in 2007. The platform has been deployed in Kenya, Mexico, Afghanistan, Haiti, and other locations. Ushahidi can integrate data from various sources: phones, a web application, e-mail, and social media sites such as Twitter and Facebook. This platform uses the concept of crowdsourcing for social activism and public accountability to collectively contribute information, visualize incidents, and cooperate among various organizations.

Sahana [2] is an open source disaster management system which was started just after the 2004 Indian Ocean tsunami. It provides a collection of tools to help manage coordination and collaboration problems resulting from a disaster. The major functions are supporting the search for missing persons, coordinating relief efforts, matching donations to needs, tracking the status of shelters, and the reporting of timely information. Additionally, Sahana facilitates the management

[1] http://haiti.ushahidi.com/
[2] http://www.sahanafoundation.org/

of volunteers by capturing their skills, availability, allocation, etc. This system has been deployed in several countries [6].

3 Why Crowdsourcing Falls Short for Disaster Relief

Although crowdsourcing applications can provide accurate and timely information about a crisis, there are three reasons why current crowdsourcing applications fall short in supporting disaster relief efforts. First, and most importantly, current applications do not provide a *common mechanism* specifically designed for collaboration and coordination between disparate relief organizations. For example, microblogs and crisis maps do not provide a mechanism for apportioning response resources. Second, current crowdsourcing applications do not have adequate *security features* for relief organizations and relief operations. For example, crowdsourcing applications that are publicly available for reporting are also publicly available for viewing. While this is important for providing information to the public it can create conflict when decision must be made about where and when relief resources are needed. Additionally, in some circumstances, relief workers themselves are targeted by nefarious groups. Publicizing the details of relief efforts can endanger relief workers. Third, data from crowdsourcing applications, while providing useful information, does not always provide all of the *right information* needed for disaster relief efforts. There are often duplicate reports and information essential for relief coordination is not readily available or easily accessible such as lists of relief resources or communication procedures and contact information for relief organizations.

4 How to Facilitate Disaster Relief

In order to facilitate efficient coordination during relief efforts, relief organizations need to leverage the information available from the group. Supplementing the crowdsourcing information that is available through social media, the relief organizations can contribute to a unified source of information customized for the group or "groupsourced." We define *groupsourcing* as intelligently using information provided by a sanctioned group comprised of individuals with disparate resources, goals, and capabilities. Essentially, the response group is performing crowdsourcing but specialized for the entire group and taking it a few steps further. Using information provided from the crowd and the sanctioned members of the group, a relief response can be coordinated efficiently.

In order to be most efficient and most effective in helping to resolve the crisis, the members of the response group should subscribe to the centralized administrative control of an information management system to ensure data integrity, data security, accuracy, and authentication will be realized for each member of the response group. One member of the response group can field the response coordination system ensuring equal access to other members of the response group. This data management system can leverage the latest social media technology and supplement functionality customized for the group.

5 What an Application Needs

A disaster relief information system designed for better collaboration and coordination during a crisis should contain four technical modules: request collection, response, coordination, and statistics, as shown in Figure 1. User requests are collected via crowdsourcing and groupsourcing and stored in a requests pool after preprocessing. The system visualizes the requests pool on its crisis map. Organizations respond to requests and coordinate with each other through the crisis map directly. A statistics module runs in the background to help track relief progress. ACT (ASU Coordination Tracker) is an open disaster relief coordination system that implements the groupsourcing system architecture.

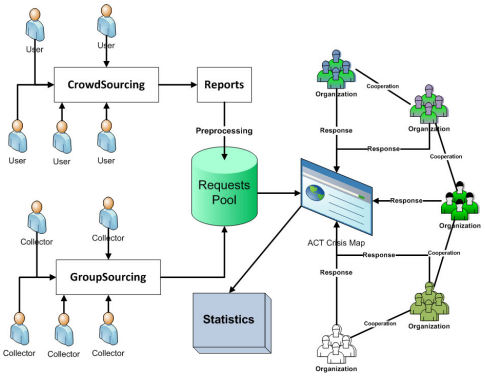

Fig. 1: Groupsourcing System Architecture

5.1 Request Collection

Relief organizations need two types of requests: requests from crowds (crowdsourcing) and requests from groups (groupsourcing). Crowdsourcing refers to requests submitted by people (e.g. victims, volunteers) who are not from certified organizations. Crowdsourcing data from disaster scenes are valuable for damage assessment and initial decision making. However, these data are usually subjective, noisy, and can be inaccurate. The groupsourcing requests originate from responding organizations such as United Nation, Red Cross, etc. The key difference between these two types of requests is the level of trustworthiness. Requests from the relief organizations are more likely objective and accurate compared to those from crowds. Sample requests are shown in Figures 2 and 3.

Figure 4 shows an example crisis map (left picture) viewing fuel requests. Each green node represents an individual fuel request and each red node represents a *request cluster*, which consists of multiple individual requests (or additional request clusters) that are geographically close to each other. The number

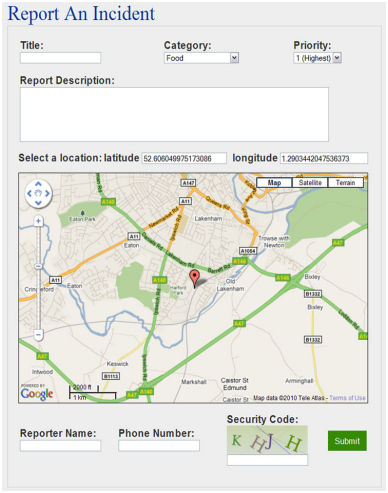

Fig. 2: Crowdsourcing

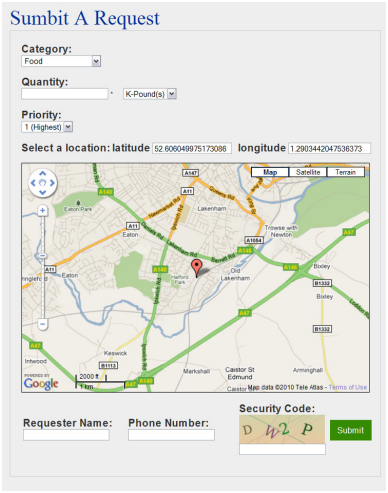

Fig. 3: Groupsourcing

and the node size of each individual request represents the requested quantity, for example, 113 (left picture) means this request asks for 113 k-gallon fuels in that region. Individual requests in each cluster can be further explored by zooming-in (right picture).

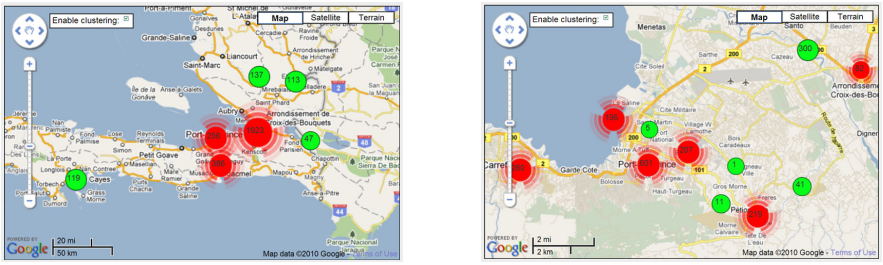

Fig. 4: ACT Crisis Map

5.2 Request Response

A key aspect of efficient coordination is enabling relief organizations to respond in an organized and collaborative manner. Response actions need to be supported by the information system such that all of the relief organizations can contribute, receive, and understand the response options and planned response actions. The system must be available on heterogeneous hardware and software platforms (i.e. web services and contemporary commercially available portable devices).

Figure 4 shows how a requests pool can be visualized on a crisis map. As the map resolution changes, nodes indicating the same type of requests will merge or split based on their location closeness.

Here is how a response transaction may flow. Once an organization decides to respond to a request, it selects the node and adds it into a relief package. Responders are allowed to add multiple nodes of various categories into the relief package. The requests that are being fulfilled will be removed from the relief package and invisible on the crisis map. The response process and a sample relief package are demonstrated in Figures 5 and 6.

Fig. 5: ACT Response Process

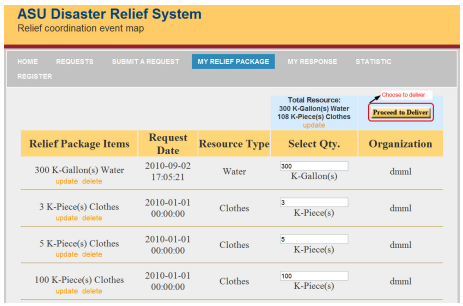

Fig. 6: ACT Relief Package

5.3 Response Coordination

Relief organizations that respond independently can complicate relief efforts. If independent organizations duplicate a response, it will draw resources away from other needy areas that could use the duplicated supplies, delay response to other disaster areas, and/or result in additional transportation and security requirements. We base our approach to response coordination on the concept of "inter-agency [2]" to avoid response conflicts while maintaining the centralized control.

To support response coordination, all available requests (i.e. requests that have not been filled) are displayed on the crisis map. Relief organizations look at available requests and selectively respond to the requests they can support. To avoid conflicts, relief organizations are not able to respond to requests another organization is fulfilling. Claimed requests that are not addressed for 24 hours become visible again on the crisis map.

Each request is in one of four states: *available*, *in process*, *in delivery*, or *delivered*. After necessary preprocessing, submitted requests are put into the requests pool. Requests become *available* and visualized in the crisis map. If a request is selected by an organization, the state changes to *in process*. The request becomes *available* again if it is not addressed in 24 hours. The request state becomes *in delivery* if it is on the way to the final destination. Finally, the

state becomes *delivered* if the request is fulfilled. A detailed state transition is summarized in Figure 7.

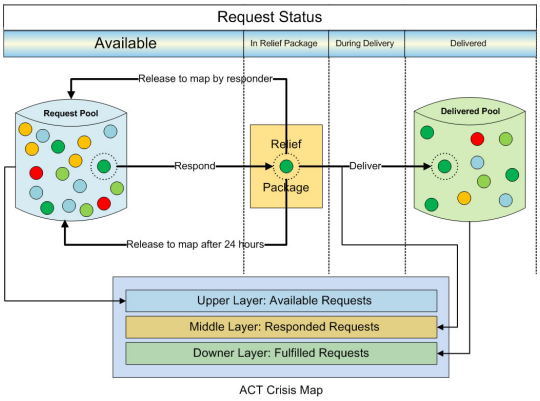

Fig. 7: Request States Transition in ACT

5.4 Statistics for Improved Communication

Relief organizations are usually not informed of other responders' actions since they are only aware of the available requests. Statistics such as organizational contribution during relief operations are helpful in evaluating the relief progress, adjusting relief strategies and making further decisions. The following statistics give insights into the relief effort:

- Current request delivery status. Information about current fulfillment status for each type of requests.
- Spatio-temporal distribution of requests. *Where* and *when* information about requests and responses.
- Distribution of contributed resource types of each organization. Each organization has its own specialization and strength in relief operations as well as different budgets on various resources.

An example of distribution statistical reporting is shown in Figure 8. The left pie graph represents an example of detailed water requests, note that 10% of the requests are not fulfilled. The right bar graph represents the water delivery at a 10-day resolution in an earthquake for the Red Cross and United Nations.

6 Conclusion and Future Work

Social media is being used as an efficient communications mechanism during disasters. In this work, we discussed the challenges with coordination for disaster

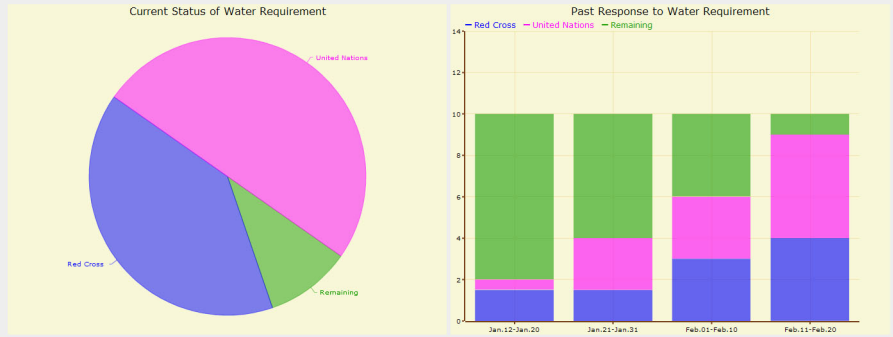

Fig. 8: Statistics on water fulfillment and organizational contribution

relief and present an architecture aimed at improving disaster response beyond current practice. We believe this approach will enable organizations to cooperate with each other more efficiently.

We are developing an open system, ACT, with the primary goal of providing relief organizations the means for better collaboration and coordination during a crisis. The system implementation is ongoing and additional work needs to be done to test our approach. We are investing approaches to enable collaboration and provide appropriate security to relief organizations and workers. We are designing reporting functions that are insightful for disaster relief.

By both leveraging crowdsource information and providing the means for a groupsource response, organizations will be able to assist persons affected by a crisis more effectively in the future.

7 Acknowledgments

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