Introduction: Social Media and Collaborative Systems for Crisis Management

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ACM Reference Format:
Hiltz, S. R., Diaz, P., and Mark, G. 2011. Introduction: Social media and collaborative systems for crisis management. ACM Trans. Comput.-Hum. Interact. 18, 4, Article 18 (December 2011), 6 pages.
DOI = 10.1145/2063231.2063232 http://doi.acm.org/10.1145/2063231.2063232

1. INTRODUCTION

Planning and response for crises usually require the cooperation of many different organizations located in different places [Waugh and Streib 2006]. The convergence of information and communication technologies and the growth of the Internet, including the mobile Internet and social media, have contributed to our ability to collaborate over great distances both synchronously and asynchronously. Our aim in this special issue is to gather and summarize a set of empirical studies of the design and use of these technological advances to support collaboration in crisis management and response with implications for the design of future systems for crisis management.

Disaster, crisis, catastrophe, and emergency management are sometimes used synonymously and sometimes with slight differences by scholars and practitioners. We use "crisis management" to refer to disasters and catastrophes that have a significant impact on a society (whether from natural causes or from human actions such as terrorist activities). A *disaster* is defined by the United Nations (UN) as a serious disruption of the functioning of a society, and a *catastrophe* refers to disasters causing such widespread human, material, or environmental losses that they exceed the ability of the affected part of society to cope adequately using only its own resources. Both disasters and catastrophes create a crisis situation: Emergency managers must communicate and act to save and preserve human lives, infrastructure, and the environment [Van de Walle et al. 2010]. However, the public participants in the crisis also need to obtain and use information and communication systems in order to decide upon actions, for example, do they evacuate? Where is it safe to drive? Where are their loved ones? How can they inform others that they are safe or need aid? Importantly, they can also use these systems to help themselves recover from the effects of crises.

Dr. Hiltz's work on this project was partially supported by a Cátedra de Excelencia appointment at Universidad Carlos III of Madrid 2010–2011, sponsored by the Santander Bank and Universidad Carlos III de Madrid.
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DOI 10.1145/2063231.2063232 http://doi.acm.org/10.1145/2063231.2063232

The literature on disaster management typically identifies at least four phases of the emergency management process: *mitigation, preparedness, response* (also called *emergency management*), and *recovery*. *Mitigation* refers to pre-disaster actions taken to identify risks, reduce them, and thus reduce the negative effects of the identified type of disaster event on human life and personal property. This phase is not included in the articles in this collection, but the other phases are. *Preparedness* refers to the actions taken prior to a possible disaster that enable the emergency managers and the public to be able to respond adequately when a disaster actually occurs, including warning systems. The *response* phase includes actions taken immediately prior to a foretold event as well as during and after the disaster event, which help to reduce human and property losses. The *recovery* phase is sometimes never completed; its objective is to enable the population affected to return to their "normal" social and economic activities [Van de Walle et al. 2010]. Usually, different organizations and different ICTs are used in each of these phases to support cooperation and communication [Aedo et al. 2010]. This variety of users, tools, and contexts of use makes crisis management a challenging area for HCI research.

By definition, one is not sure ahead of time who will be using a system, where, and for what types of information and decisions. Hundreds to hundreds of thousands of new users might make use of a particular system for a specific crisis, and they have to be able to use it without prior training. Social media, such as Twitter and Facebook, have in particular changed the nature of the use of information systems in crises. Traditionally, information systems for emergency management were designed for a designated set of government and non-governmental organizations that operated in a more or less "command and control" approach [Turoff et al. 2009]. Now, the general public, via social media, are directly involved in crisis information exchange at all stages [Malizia et al. 2010], and their input needs to be taken into account by official organizations [Fugate 2011]. For example, during the Eyjafjallajokull volcano crisis in Europe that affected the travel plans of nearly nine million people around the world, social media were used by citizens to organize themselves as well as by official organizations like Eurocontrol to get in touch with a huge, heterogeneous, and scattered affected population. The general public expects that if it uses social media to report a problem and request help, that somehow the official agencies will become aware of this and use the information in planning actions. The public also uses social media to inform one another about what is happening and to organize ways in which they can act during the crisis rather than waiting for official reports and directives. As Craig Fugate of the U.S. Federal Emergency Management Agency, states: "We must use social media tools to more fully engage the public as a critical partner in our efforts".

The five articles chosen for this special issue, selected from over 20 submissions, span a number of the important topics within this domain. All of these articles demonstrate the socio-technical aspect of crisis management systems, that is, the interaction of the technical and the social systems in a continuous process of adaptation. Because different organizations must communicate and cooperate in order to coordinate their actions during a crisis, inter-systems operability and compatibility is a major challenge and issue for crisis response systems. This issue is treated in two of the articles, one on Tsunami Warning Systems, and one on socio-cognitive aspects of inter-operability.

2. A CASE STUDY OF TSUNAMI WARNING SYSTEMS

Strong undersea earthquakes often result in deadly tsunamis with widespread death and destruction, as was shown by the Boxing Day tsunamis in Southeast Asia in 2004 and in the Sendai Japan region in 2011. Tsunami Warning Systems (TWS) as socio-technical systems of co-evolving technical and organizational structures are examined by Grabowski and Roberts through the lens of Adaptive Structuration Theory

[DeSanctis and Poole 1994]. TWS are an example of what the authors term "high reliability virtual organizations." As with other high reliability organizations, the consequences of failure are very severe, and reliability and safety are primary concerns. They are also virtual, in that a wide variety of organizations and groups are joined in a worldwide network by computer-based information and communication systems. These are characteristics of all crisis management systems, made very clear in this example.

The technical aspect of TWS is briefly described: warning centers manned by scientists and watchstanders around the world; network connections among them and such systems as deep sea tsunami detection buoys, seismic and satellite observation networks; and ties via a variety of media, including social media networks, to civil disaster and emergency managers as well as political leaders and public affairs officers. Social media are also used to engage and inform the public and to gather critical real-time information. An example is given of the Sendai event, where with only minutes to evacuate, it was social media that gave the public location-specific advice about where to go.

The TWS case study describes problems with adaptation of the technology as intended, based on issues of lack of interoperability and HCI weaknesses. The U.S. has two Tsunami Warning Centers, and these two centers have totally different technologies and organizational cultures. Thus, they cannot serve as backups for one another, and they sometimes issue different warnings about the same event. In addition, the messages often violate some basic HCI guidelines, such as clarity, consistency, and communicating in the user's language. The article ends by summarizing the HCI and organizational challenges that remain in the co-adaptation of technology and organizational structures to create a highly reliable TWS.

3. THE ISSUE OF INTEROPERABILITY

Definitions of interoperability include such attributes as the systems ability to exchange information or services. This is especially important during the time-critical response phase. Most Americans are aware that their "first responder" public safety organizations, such as fire and police, often have incompatible communications equipment and thus cannot easily exchange information or coordinate during an emergency. However, interoperability is not just technical; there are many social and cognitive aspects that must be taken into account if users of systems from different organizations are to be able to use the information for joint sensemaking and coordination of actions.

The exploratory study of this topic by Kwon and his colleagues is based on semi-structured interviews with members of two public safety organizations at Virginia Tech, now infamous for a mass shooting crisis. Five main themes relating to barriers to interoperability were identified and coded from the interviews: information sharing, communication readiness, operational awareness, adaptiveness, and coupledness. The issue of communication synchronicity is especially interesting and perhaps counterintuitive. The emphasis in the past has been on getting systems that are basically audio-based to allow real-time, synchronous communication among all those involved in responding to a particular crisis. However, synchronous audio communication creates overload and confusion if there are many responders involved in dealing with many different incidents. Some studies have shown that responders often turn their devices off, because they cannot concentrate on what they are doing with a constant barrage of information about all current incidents, most of which are not of their immediate concern. The responders wanted text messages, which could be stored and filtered and reviewed asynchronously. Another important issue described is willingness to share information. The police and the rescue squad (emergency medical personnel) both felt that information about victims is too private to be shared with another organization. The relationship

of these problems to the goal of enabling joint sensemaking and coordinated actions is discussed, along with implications for the improved design of future systems.

4. THE RECOVERY PHASE: USING ICT TO WORK AROUND INFRASTRUCTURE BREAKDOWNS

Semaan and Mark's study looks at how Iraqi citizens used ICTs to overcome the protracted and extensive infrastructure breakdowns of the second Iraq war. ICTs were also used to conduct the study as cell phones and Skype were the primary mode of communication for the lengthy semi-structured interviews conducted between 2007 and 2010. Infrastructure can be likened to the skeleton, blood vessels, and nervous system that are inside the human body that enable it to function; it is usually invisible to us and unnoticed unless it becomes disabled. Societal infrastructure includes not only physical entities but also the humans that keep it operating. The infrastructure problems of Iraq include transportation (roads, bridges, busses, taxis), telecommunications, electrical systems, and the educational system, and an overall breakdown of trust in the government to be able to get things working again.

This article describes how social networks connected by a variety of communication modes (cell phones, Facebook, email, SMS, etc) enable people to travel, go to work or school, and carry out their everyday activities when they "do not feel safe utilizing public transportation, do not trust that the education system will deliver, and do not trust information from official sources." The examples given are a testimony to the resilience of human social structures; people created redundancy in their tools, for instance, by equipping all family members with two or more different cell phone carriers, setting up neighborhood electrical generators, and switching among different technologies to find one that works. These communication devices supported the construction of social networks consisting of both strong ties (kin and friends) and weak ties (friends or relatives of their direct ties), and in the process, developing new collaborative practices that enabled them to obtain accurate and timely information, and thus to resolve the problems created by infrastructure breakdowns.

5. COLLABORATION ISSUES IN EMERGENCY MANAGEMENT

The next two articles address collaboration issues within the context of crisis and emergency management. Convertino et al. apply a design research approach to support efficient knowledge sharing and awareness in collaborative planning tasks and Toups et al. propose the use of zero-fidelity simulations (a simulation where reality is abstracted to support operational and functional fidelity) to improve the ability to work in a coordinated way. Both of them come back to the roots of HCI and remind us again that technology per se should not be the focus of our research on crisis management, but in Engelbart's words, the way in which technology can be used to "augment our ability to collaborate to solve problems beyond the compass of any single human mind."

In "Supporting Common Ground and Awareness in Emergency Management Planning: A Design Research Project," Convertino, Mentis, Slavkovik, Rosson and Carroll go through an exhaustive design research approach combining fieldwork and the use of different kinds of prototypes to better understand how the members of a planning team share knowledge and develop awareness. Both knowledge-sharing and activity awareness become essential in crisis planning processes that involve dealing with multiple streams of multi-perspective data and require people with different roles and backgrounds to make collaborative decisions. The article reports three different experiments involving a paper-prototype in a collocated work setting, a first software prototype in a distributed setting, and a second, enhanced software prototype in a distributed setting. The authors explain how the findings of these experiences were used to gain knowledge on the planning process and how computer systesms can support

it in an efficient way. Thus, as described in the article, empirical findings concerning common ground processes led to specific proposals to improve the implicit sharing of procedural and strategic knowledge among group members whose benefits in the planning process were tested empirically in the experiments. The authors also propose specific functions that capitalize on potential benefits that can emerge in a distributed, computer-mediated environment to enlarge the capacity of multidisciplinary teams to make collaborative plans.

The ability to coordinate the action of the members of a response team is basic in collaborative crisis response. To provide a quick and adequate response, team members have to synchronize their activity while distributed across space, for which effective communication is essential. In "The Team Coordination Game: Zero-Fidelity Simulation Abstracted from Fire Emergency Response Practice", Toups, Kerne and Hamilton describe the development and evaluation of the Team Coordination Game (TeC). TeC is a zero-fidelity simulation that is based on distributed cognition, simulation theory, and a number of design principles for teaching team coordination derived from the observation of and engagement with fire emergency response practitioners. Through their work and evaluations, the authors demonstrate that a mimesis of the environment is not required to improve coordination abilities; simple interfaces providing efficient information distribution and mixed communication modalities are enough to reach this goal. This approach poses a provocative debate on the utility of realistic simulations and moves the focus of the design from appealing and sophisticated technologies to the abilities that technology is aimed to develop in humans.

6. CHALLENGES FOR THE FUTURE

One of the major challenges for crisis management is integrating the information during disasters from citizens, using social media, with that of official responders, disseminating messages through channels such as television, radio, SMS, and Internet Web sites. Citizen responses are bottom-up; citizens may be dispersed throughout the disaster zone, and thus are reporting on experiences "from the trenches." Official responses, such as from government or large humanitarian emergency management organizations, are instead top-down as instructions are issued in what is typically a command-and-control style. In contrast to citizen response where any individual can broadcast a message immediately, official responses may be filtered and delayed. The field of HCI needs to investigate further how to integrate both formal and informal sources of information (the latter usually referred to in the literature as back-channel communication [Sutton et al. 2008]) to understand which goals such an integration will serve, both from the point-of-view of organizations and citizens (such us improving response and recovery, integrating citizens in the response phase, promoting self-organization, increasing agency transparency, etc.). Moreover, there is also a need to investigate how systems can be designed to make such an integration efficient, taking into account that these two modes of information delivery are based on different sources, perspectives, and communication styles.

Another future challenge when we consider social media use is determining the trustworthiness of the information. As social media becomes more widespread in its use for citizen response to disasters, issues concerning trust and reputation move to the forefront. Which reports should be trusted and which might be due to malicious behavior? Future research is needed to design authentication mechanisms to enable citizens during an emergency to differentiate information which is credible from that which is not reliable.

As social media becomes more recognized as a valuable source of information about a disaster, it becomes increasingly important to continue to develop and refine methods to analyze the large-scale volume of information. An analysis of the aggregate of citizen

reports in real time can present officials with valuable data, for example, on the state of the disaster in different geographic regions, which areas are in need of aid, and who needs to be evacuated. Such large-scale analysis can also provide policymakers with a rough indicator of the "mood" of the people in a disaster zone.

Other significant challenges exist as well, such as the technical but also social interoperability of information systems and organizations. Understanding how to rapidly coordinate organizations, which have different cultures, goals, and structures, at a disaster site will involve considerable research into the interplay of organizations, social media use, and communication. We can expect to see the rise of hastily formed networks [Denning 2006] as social media proliferates. Importantly for the future, as social media becomes the *modus vivendi* by citizens, we need to reframe our thinking from regional to global response for crises.

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