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InNEED: Managing Natural Disasters Through Community Self-Organization Using Mobile Technology

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Abstract. With recent frequency of natural disasters, a global ethos of pre- emptive crisis management and the development of resilient communities has become essential. Research in disaster sociology describes an organic process of community collaboration and resource sharing that occurs during and after disaster situations. InNEED is a survivor-driven system that functions through community mobilization. The design leverages mobile technology as a medium to build connectivity at a time when network infrastructure is not reliable.

Introduction

"Disasters will continue to occur. But their damage can be mitigated by relief efforts that are well-planned and executed in concert with the local population. Digital media technologies offer a unique opportunity to advance these goals with the right on-the-ground coordination." [1]

The surge of major natural disasters over the last decade have put into question existing natural disaster management systems and infrastructures worldwide. Current UN-led efforts seek to define comprehensive eco-systems that would enable resiliency through a combination of community and government

collaboration and technological innovation. The 2004 Asian tsunami, 2005 hurricane Katrina, 2005 Pakistan earthquake and 2010 floods and most recently the 2011 Japan earthquake make clear the need for advances in the theory, process and technology of natural disaster management.

This position paper presents InNEED, a design solution that approaches disaster management through the lens of disaster sociology [2]. Highlighting the potential of community collaboration as a tool for building resiliency, and with a focus on pre-emptive thinking, the system considers mobile technology as a tool to engage and empower the public to become part of the solution. This paper outlines the theory underlying InNEED, presents the research questions and design process, describes the current manifestation of the design, and our current questions.

Background

We considered multiple natural disaster case studies, particularly Hurricane Katrina and the 2010 Haiti Earthquake, in tandem with the technological innovations that surfaced during these times. We extensively looked at the Ushahidi platform [3], CrisisCommons [4] and Guarldy [5] amongst others. We analyzed these case studies through the lens of disaster sociology and attempted to identify the pros and cons of the systems. Our research made evident a gap in the relationship and coordination between the technologies used to mitigate disaster management, the institutions (governmental / non-profit) and the citizens. This realization led us to consider specific theories and case studies grappling to bridge the gap between the various players of disaster management.

Research in disaster sociology shows that ad-hoc organic processes of community building and resource sharing emerge at times of crisis [6]. In her recent book A Paradise Built in Hell, Rebecca Solnit describes at length how in the aftermath of natural and man-made disasters, individuals and communities band together to help each other [7]. This stands in contradiction with the commonly held belief of crowd panic, chaos and looting that is perpetuated by top-down organizations. Solnit, gives the example of the spontaneous cooperation and successful evacuation of Lower Manhattan during the September 11 attacks where nearly half a million people fled Manhattan on boats emphasizing the self-organizational ability of the community. Solnit argues for the recognition and nurturing of altruistic human behavior to create more resilient communities.

We were also inspired by current global discourses in disaster management and resiliency, particularly the UN's 2010 global awareness and implementation campaign *Making Cities Resilient*, which aims to raise consciousness and

commitment towards sustainable development practices to reduce disaster risk and increase the wellbeing and safety of citizens [8].

We therefore argue for a pre-emptive solution that enables bottom-up community collaboration using readily accessible technologies and infrastructure. Current disaster management systems place little emphasis on the engagement and empowerment of survivors even though research validates their contribution during times of disaster. Our design work was focused on addressing this lack of community involvement and resulted in a system that facilitates and leverages an organic process of survivor engagement post-disaster.

Design process

InNEED's 5-month design process incorporated theoretical and technical research, weekly brainstorming sessions, interviews with experts in the field and iterative prototyping. Prototypes were continually refined by reflecting on the unpredictable nature of natural disasters, the limitations of technology and current disaster management set-ups, and the uncertainty underlying community self-organization.

Our case studies and technological infrastructure scenarios highlighted the complexity and breadth of disaster management. However, we identified that basic survival, information dissemination and maintaining connectivity were among the most fundamental needs of natural disaster situations that could be supported by information technology. We therefore designed a service that would

- accelerate, facilitate and organize outreach,
- provide access to updated and pertinent information,
- mobilize a community by making it an actionable resource,
- use readily available technology, and
- be geographically pervasive

InNEED prototype

Leveraging everyday technologies, personal mobile devices are used at the point of disaster when there is little or no connectivity to the outside world. Reflecting on our design requirements, InNEED therefore consists of three main features: a *survival toolkit*, a *community profile directory*, and a *community message board*. During periods of limited or no internet connectivity, the system functions through the use of community base-stations comprised of a generator, router and server (e.g. a desktop or laptop computer). As Figure 1 illustrates, survivors use their mobile phones to access the key resources of InNEED. They use a map to locate base-stations in order to access network features like the message board. The

system piggy-backs on the mobility of persons between base-stations in order to share data across a wider area.

Figure 1. The InNEED system is comprised of strategically-placed base stations and a mobile application.

We elicited feedback from subject matter experts on both the conceptual and technical elements of the design, including researchers in human-centric computing systems, academics and practitioners in disaster and emergency managements and volunteers in disaster management non-profit organizations.

From these discussions, the following questions and opportunities for refinement emerged:

- How might we evaluate the robustness and utility of the concept as a disaster management system?

- What is the definition of 'community'? Is 'community the right word to use in this context? How is 'local' defined?

- What are the parameters of grassroots collaboration – what is the level of support and contributions envisioned? Outside of a disaster situation, what is the incentive for community members to participate in such a system?

- Will people really be using their cellphones during a disaster situation? How can we prove or rationalize this?

- Who is managing the application? If it is a grassroots initiative – who owns it? What are the privacy concerns in such a concept?

Understanding that the system would need to meet a certain level of robustness in order to be perceived as a legitimate preparedness system, we carefully considered these questions of functionality and reliability. We outline relevant details of InNEED's design here.

InNEED's System Functionality

Centralized information storage and dissemination. Despite the primary emphasis on a survivor-driven system, we envision that InNEED would require formal organizational support, to manage and coordinate logistics and infrastructure for most communities before a crisis occurs. This is to address fundamental differences between communities pre-crisis vs. in-crisis. An organization (likely governmental) consisting of personnel with disaster response and emergency training would be responsible for holding and protecting personal information provided by community members through a voluntary opt-in mechanism. This organization would work in close collaboration with local and international emergency organizations to determine what information should be released to the public (depending on the disaster type), and at what point of the occurrence of the disaster.

Predetermined base stations. In order to ensure substantial network coverage, the locations and provisioning of network nodes or base-stations would be determined in advance, and likely housed in strategic locations such as community centers, schools, etc.

Mobile interface. InNEED's system leverages the ubiquity of cell- phone devices and their potential versatility at times of crisis. Therefore, the system's mobile application would be pre- downloaded and installed on neighborhood member's cell-phones devices. In order to make the system accessible to people who may not have subscribed before the occurrence of a disaster, a web-based mechanism will be available to users.

Robustness and Usability

To assess robustness, usability and privacy questions we implemented a functional prototype. The outline below walks through two hypothetical scenarios outlining the multi-layered functionality of the system and its application in a disaster situation.

InNEED Hypothetical Scenario #1

Consider two fictional characters John, who works in neighborhood X and Mike who works in neighborhood Y. Both John and Mike are members' of InNEEDs'

system and have pre- downloaded and installed the mobile application on their cell- phone devices. Since InNEEDs' base stations have been pre- determined and set-up in various locations through the city, when an earthquake or any disaster situation occurs, through organizational efforts and community collaboration, the system goes online.

In order to maintain privacy, the system has been designed such that it sends a key code to its members only when a disaster situation has been declared. When entered into the application, the key code enables John and Mike to access the previously locked database of member profiles and community message board.

Figure 2. A key code is sent to the members to unlock the system.

InNEED's system leverages the brief moment of connectivity that is available during disaster situations before infrastructure collapse. Through GPS technology, the application is able to gather and provide key information to its users including member locations and their online / offline status. At this point, John and Mike get an aerial snapshot of the nearby community and are able to benefit from and provide multiple levels of information.

Figure 3. Levels of information include online / offline status of members, map of base stations and up-to-date GPS location of members at time of disaster.

In our hypothetical scenario, John is anxious to get back home to his family and is looking for a ride. Once he is logged into the system, he accesses the community message board and posts a message requesting for a ride in the direction of his house. His message is stored in the database of neighborhood X where he works.

Figure 4. John posts a message on Neighborhood X's message board.

While he is waiting for a response, John starts to look for alternative help. As he walking through the city, he enters into the vicinity of neighborhood Y and is able to connect to their base- station network. The data that he is carrying from neighborhood X's community message board gets transferred to neighborhood Y's network. This allows Mike to see John's message. Mike is able to send a direct ping to John, letting him know that he can give him a ride.

Figure 5. Using the community message board, Mike sends a direct message to John.

InNEED Hypothetical Scenario #2

InNEED's mobile application can be used and accessed in multiple ways; the following scenario considers Patrick, a chef by occupation who lives in neighborhood M. After the earthquake, Patrick realizes that he has both the ability and the resources to open a soup kitchen for his neighborhood. At this point, Patrick does two things: updates his member profile by listing himself as a food provider and posts a message on Neighborhood M's community board announcing that the is serving food at a certain time and location.

Figure 6. Patrick updates his member profile.

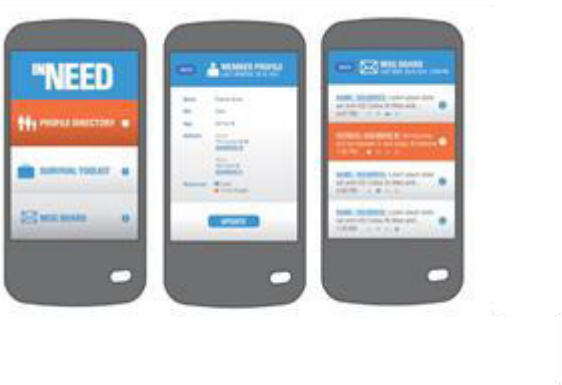

Figure 7. Patrick posts a public message about his soup kitchen.

Prototyping through multiple scenarios allowed us to clearly identify the subtleties in the levels and types of personal data that would be useful in disaster situations. It also made evident the malleability of the data based on the type disaster at hand. For example, Patrick is perhaps only able to set up a soup kitchen in / nearby his house because the road infrastructure is still intact. In the case of a flood, the opportunity may not have been there. Or for example, John was able to post a message on the community board shortly after the occurrence of the disaster only because the severity of the earthquake did not damage the base station near his office building. If the disaster would have damaged the network node near his location, he would have had to go look for a working network in the city to get connectivity.

Workshop Questions

Our refined design was presented to two panels of design experts, the first in the Design Exchange in Toronto, Ontario in April 2011 and the second at the annual Microsoft Research Design Expo in Redmond, Washington in July 2011. The project was well- received. Feedback largely reflected three areas we identify as discussion points for the workshop, *robustness* and *privacy*.

Robustness. Suggestions were made to integrate other networking approaches such as ham radios and ad-hoc mesh networks to expand the networking potential during times of collapsed infrastructure, and to further consider how the system might gracefully degrade, for example as generator power becomes unavailable. Robustness is a concern in a more general sense as well, in terms of the range and severity of disasters a system like inNEED can help to address, and adapting to varying levels of community involvement and preparedness in different areas.

Privacy. The issue of personal privacy before, during, and after a crisis was acknowledged as needing further research. While our design emphasizes controlled and localized access to another person's personal data only when it is contextually relevant to a crisis, it introduces privacy concerns and a potential risk

to personal security. Related to this is how to encourage opt-in before a crisis occurs, and how to permit opt-in after one has occurred.

Conclusion

In conclusion, we envision InNEED as a bottom-up, collaborative solution rooted in disaster sociology research. The system finds a niche within the ethos of self-organization and resilience and bridges the gap between pre-crisis and post-crisis disaster operations. Through calculated and timely technological innovation, the design solution aims to build a pre-emptive system that aids in natural disaster management through community led initiatives.

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