Understanding the role of mobile technologies for humanitarian relief

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ABSTRACT

Smartphones are becoming increasingly useful in disaster management both to provide useful information to victims and to coordinate relief operations. However, a lack of technological expertise as well as considerable amount of time and cost required to build mobile applications prevents the rapid deployment of useful applications by humanitarian organizations for different crises. In this paper, we describe a participatory design workshop that we conducted at the International Committee of Red Cross to identify challenges of adopting mobile technologies within relief organizations. Through this workshop, we identified major challenges associated with developing mobile applications: lengthy development and deployment cycle, costly budget, and frequent requirement changes. We then introduced our framework that enables non-programmers to quickly develop and deploy mobile applications in these situations. The workshop participants identified three areas where our framework improved upon existing mobile solutions: reducing data integration overhead, fast prototyping for app development, and customization of apps.

Keywords

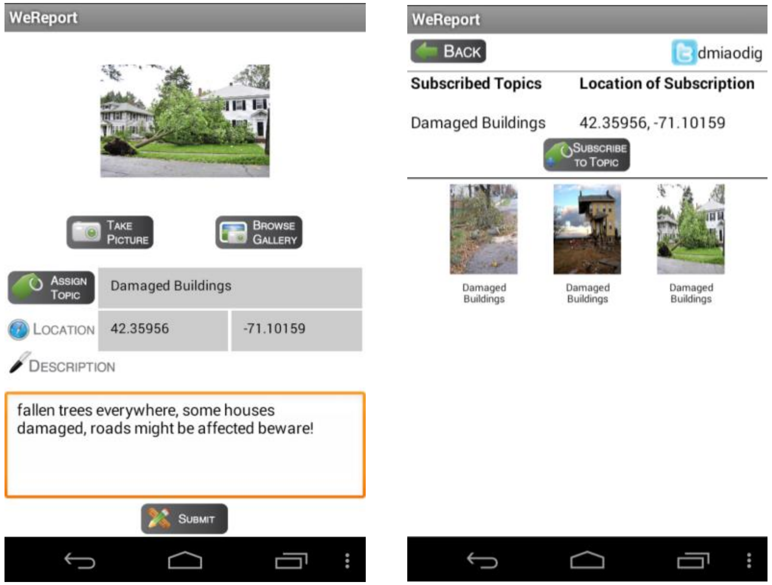
Disaster management, mobile applications, relief operations, smartphones

INTRODUCTION

The ubiquity of handheld computing technology has been found to be useful in disaster management and relief operations (Monares, Ochoa, Pino, Herskovic, Rodriguez-Covili and Neyem, 2011). However, the lack of technological expertise, the considerable amount of time, and cost associated with building mobile applications prevents the widespread use and adoption of mobile applications to automate real time notifications, damage assessment, and co-ordinate relief operations (Kluckner, Heintze and Wendt, 2014). We have developed a framework, called Punya. The framework enables users to develop mobile applications leveraging advanced features, such as push notification, production and consumption of structured data, visualizations, as well as wearable device support. The goal of the framework is to enable non-programmers, like volunteers and first responders, to quickly acquire the capability to develop and deploy mobile applications that can be leveraged in humanitarian relief operations. The framework is an extension to the App Inventor[1] that serves to provide a web-based environment for easy development of Android Applications (Shih, Seneviratne, Miao, Liccardi, Kagal, Patton, Meier and Castillo, 2013). Though the framework's capabilities can be leveraged in a much broader context, here we focus on its application to disaster settings.

We present an example application that was developed through the platform to demonstrate the functional capabilities. WeReport, shown in Figure 1, is an incident crowdsourcing application that allows individuals to easily report disaster incidents through pictures and videos using their Android devices (Shih et al., 2013). In addition, individuals can also easily follow various kinds of incidents that occur in their vicinity. The WeReport application demonstrates how information from smartphone sensors, and other sources can be easily integrated for use in an application. The ease of the use-modify-create mechanism that the framework allows for enables other individuals to develop additional capabilities on top of the WeReport application. The WeReport application can be extended to report power outages as well as other disaster incidents. The ability to quickly develop and deploy an application like WeReport presents a unique opportunity for crisis managers and others to more easily leverage mobile technology during disaster scenarios.

The focus of this paper is a participatory design workshop that we conducted with the International Committee of Red Cross (ICRC) staff and managers to identify challenges of adopting mobile technologies in their current projects within the organization. We received overwhelming positive feedback on our framework and were told that it could lead to savings in time, and money through fast prototyping mobile development for humanitarian work. Finally, we had various in depth interviews that were aimed at introducing better practices for future mobile application development and deployment process.



Damaged Buildings

42.35956 -71.10159

fallen trees everywhere, some houses damaged, roads might be affected beware!

Subscribed Topics	Location of Subscription
Damaged Buildings	42.35956, -71.10159

Figure 1. User Interface (UI) for the reporting and subscription

WeReport allows users to submit disaster reports to the cloud. Users can subscribe to reports close to a certain location on a topic such as `Fallen Trees', and results are received in real-time to subscribers of these topics.

MOTIVATION

Mobile phones are being leveraged for use in disaster management applications due to the presence of sophisticated sensors that enable real-time monitoring of the environment as well as individuals more easily (Radianti, Dugdale, Gonzalez and Granmo, 2014). Mobile applications and platforms often enable aid workers to get and store data regarding the real-time impact of the disaster, monitor overall

[1] http://appinventor.mit.edu

population movements in order to better assess real-time distribution channels (Montoya, 2003). Mobile phones and associated platforms can further complement on ground communication infrastructure in case of disaster (Shih et al., 2013).

Increasingly, mobile application development platforms targeted at crisis or disaster workers are being developed. One such system is the Kobotoolbox, a data collection platform developed by researchers at Harvard Humanitarian Initiative (Harvard Humanitarian Initiative, 2014). Kobotoolbox works across multiple platforms including mobile and desktop computing environments in order to enable quick and seamless data collection in the field during the onset of an environmental disaster. Through Kobotoolbox, on ground workers can more easily collect survey information as well as other necessary data regarding an emerging situation (Harvard Humanitarian Initiative, 2014). Further, Researchers at the University of Agder in Norway developed, SmartRescue, a mobile-based computing and visualization platform that seeks to process and present mobile data to aid decision making for crisis managers (Radianti et al., 2014). By leveraging mobile phones as sensors, SmartRescue can also apply machine-learning algorithms to crowdsourced data in order to determine relevant information for crisis managers (Radianti et al., 2014). As mobile phones gain more computing power, platforms that enable quick and agile deployment of crisis management software would be critical for field practitioners in crisis management (Fajardo and Oppus, 2010).

There are several challenges that aid agencies face in the development of mobile applications for in-field use. To begin, several aid organizations are usually not equipped with software development teams; so mobile application development is often outsourced to outside teams (Radianti et al., 2014). Furthermore, the software development process is often lengthy and isolated from critical on-ground response needs. This gap leads to development of expensive mobile platforms that might not meet the desired needs and requirements for infield use in disaster response situations (Radianti et al., 2014). Additionally, significant technology capacity is often lacking in aid and humanitarian organizations, so these mobile applications can also suffer from lack of use (Radianti et al., 2014). To address these challenges, an agile disaster management platform that encourages humanitarian workers to easily develop and deploy, on the fly, humanitarian-focused mobile applications would be most useful (Radianti et al., 2014; Shih et al., 2013).

PARTICIPATORY DESIGN WORKSHOP AND INTERVIEW

The framework is at the public beta testing stage now. To test the feasibility of the app-building framework in a humanitarian organization, we conducted a participatory design workshop and semi-structured interviews with the International Committee of Red Cross staffs and managers. It was a two-day event that took place in the ICRC office in Geneva, Switzerland. Participants represented a range of teams within ICRC at the workshop. Two graduate students, who are also the core-developers of the framework, oversaw the workshop.

Participants were excited because the framework allowed them to quickly express their ideas into mobile apps. Attendees were trained in the use of the framework to build and deploy humanitarian-focused apps. During the interviews, the participants reported some problems associated with developing and deploying mobile apps in their projects within the organization, reactions of using the framework, potential mobile apps for their projects, and the improvements needed for framework. The main findings throughout the two days were the following and the reasons will be given later.

- Mobile apps can help the organization to increase its impact.
- Time commitment and cost investment necessary to build and deploy mobile apps is unnecessarily high.
- Using the framework, participants were able to create apps that they had planned long time ago.
- The participants want to have a template app, which has the reporting and subscribing news features.
- Data encryption, protection, and offline tolerance are the needed features for the app-building framework.

Day 1: Workshop

Through the workshop, we found several barriers to develop and deploy mobile apps in their projects within the organization. One of the participants reported that it is too costly and time-consuming to build and deploy mobile applications. Several participants reported it costs several hundred thousand dollars to build and maintain a mobile app and the development and deployment cycle generally takes one or two years to complete. On top of the cost and time barriers, the developed mobile app might not function adequately at the end because there might be requirement changes halfway through or near the end of the project.

We gave the participants comprehensive training in use of the framework on the first day of the workshop. We started with a presentation of the overview of the framework, the functionalities of the framework, the technologies that power the framework, and some demo apps, which were developed using the framework. After the presentation, the participants went through six tutorials ranging from basic to advanced. These tutorials were related to one of the participants' projects, Restoring Family Links2. The project is about using information technology to reconnect families separated internationally. The tutorials asked the participants to develop and modify mobile apps to query missing people and to report missing people if they were found.

The participants were surprised at how easily they could build a mobile app using the framework. Three out of eight participants had basic to intermediate programming experience and the rest didn't have any. They were new to mobile app development and they finished all six tutorials within six hours. Despite the overwhelming positive experience, two participants pointed out that it could be difficult to locate specific logic/programming blocks in a large project.

We identified one potential mobile app and gathered all the requirements of that mobile app. The project includes looking for family members, restoring contact, reuniting families, and seeking to clarify the fate of those who remain missing during natural disasters, or conflicts. They listed the following functional requirements for the app:

- Broadcast mobile app user's status (alive, in danger) to the central server and to the predefined emergency contacts
- Submit a found or missing person report that has picture, name, and the geo-location to the central server
- Subscribe to a specific report type (found / missing) and the reports can be filtered based on geo-location
- Receive real-time updates based on the subscription on the previous step

Day 2

The workshop started on the second day with a demonstration of a working mobile version of the Restoring Family Links project as shown in Figure 2 and 3. We developed the application on day 1 night. The whole development and deployment process took four hours. Each functional requirement of the application was demonstrated to the participants. All the participants were surprised and satisfied with the application.

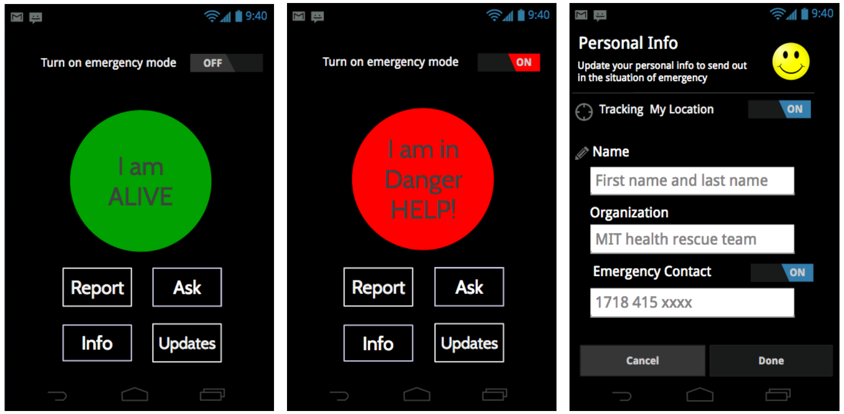
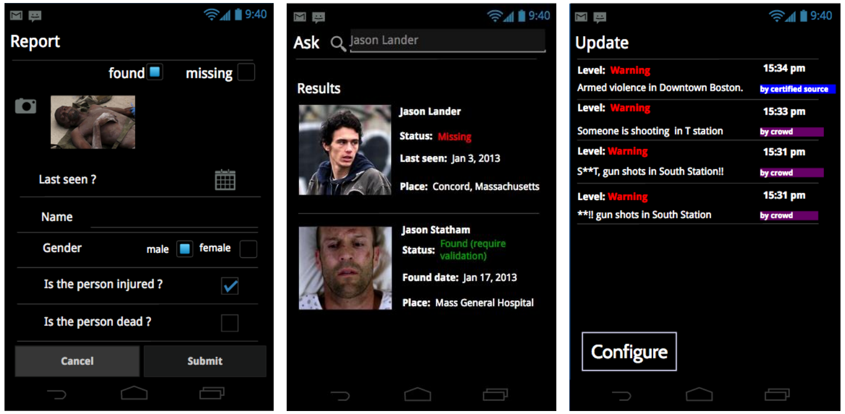


Figure 2. Restoring Family App UI
left: safe mode. center: emergency mode. right: personal information

[2] http://familylinks.icrc.org/en/Pages/home.aspx



found ☑ missing □

Last seen ?

Name

Gender male ☑ female □

Is the person injured ? ☑

Is the person dead ? □

Cancel Submit

Jason Lander

Results

Jason Lander
Status: Missing
Last seen: Jan 3, 2013
Place: Concord, Massachusetts

Jason Statham
Status: Found (require validation)
Found date: Jan 17, 2013
Place: Mass General Hospital

Level: Warning 15:34 pm
Armed violence in Downtown Boston. by certified source

Level: Warning 15:33 pm
Someone is shooting in T station by crowd

Level: Warning 15:31 pm
S**T, gun shots in South Station!! by crowd

Level: Warning 15:31 pm
**!! gun shots in South Station by crowd

Configure

Figure 3.Restoring Family App UI
left: report found/missing people. center: subscribe to found/missing people report. right: real-time updates

We found that by using the app-building framework, participants were able to create fully functional apps that they had planned to build for some time. One of the participants brought up a mock-up mobile app, which has very similar functionalities as the demo app. He explained that the mockup app is needed in the first responder community, but was never developed due to many barriers, such as money, time, etc. As remarked by one of the participants:

> "This tool can really save our time, money, and even lives."

We had discussion on how to improve this demo app. There were 15 suggestions and the top three on the list are:

- Add the ability to notify the ICRC workers in a predefined area
- Provide information about nearby ICRC offices
- Update volunteers or first responders based on their location

Interview with non-workshop participants

The first interview was conducted with the managers from the Digital Communications, Data Protection Services, Innovation Unit, Climate Center, Population Protection Unit, and Restoring Family Links within the ICRC. The goal was to identify some necessary improvements for the app-building framework. The interview began with and introduction of the framework, and a quick demo of the restoring family link mobile app that was built during the workshop. We then discussed the additional requirements needed for the framework in order for it to be used in ICRC, or other ICRC like humanitarian organizations. Data encryption and protection, and offline tolerance were identified as needed features to improve the framework. In particular, for the offline tolerance, they told us we should focus on the features for offline storage, offline communication, and offline app functionality.

Data encryption and protection are ICRC's primary concerns. They want to minimize the risk that a foreign regime would be able to break into any of the infrastructures and identify individuals to target and attack. Offline tolerance is another critical feature needed for the framework. Humanitarian-focused mobile apps could benefit from working without an Internet connection. A classic scenario is a first responder that wants to enter data while visiting the shelters, and then have that data automatically synced with a server when they get back to the office. Apps that continue to work while "offline" are a very important piece of functionality that the framework must support.

Mobile apps can help the organization to increase its impact. We conducted the second interview with the staffs from the Innovation Unit, Weapons and Decontamination Unit, Forensics, Security, and ICRC work in Africa. The goal was to identify more use cases for ICRC. We identified two more use cases from this meeting and we are in the process of implementing the mobile applications:

- Dead Bodies Identification Form: an ICRC worker or another authorized person needs to record the discovery of human remains, so that these can be documented and later possibly crosschecked for identification.

- Missing Persons Form: an ICRC worker or another authorized person needs to conduct an interview with someone reporting a missing person (friend, relative, etc.), documenting the missing person's details.

At the end of the workshop, all the participants wanted to develop a set of the template mobile apps for crisis response and management. The idea being that this set of template apps could be easily modified and deployed by the first responders from the ICRC's subsidiary institutions, such as American Red Cross, African Red Cross, etc. The participants agreed that our app-building framework was an ideal solution meets their mobile development needs. It would help their projects reach more people thereby greatly increasing their impact. Their belief was that humanitarian organizations should use our app-building framework for future mobile app development and deployment.

DISCUSSION

The core complexity in deploying technologies for crisis management exists in the integrating information from various sources. Further, as described in the previous section, agility and flexibility for developing prototypes of software for rapid testing are key factors to successfully adopting the technology in cases of disaster relief. In this section, we summarize how the app-building framework and its supported technologies address these challenges. Specifically, we highlight the use of the framework to (a) resolve issues in data integration, (b) support agility in app development and collaboration between entities, and (c) allow customization of apps tailored to local needs. The discussion aims to introduce better practice for future mobile app development and deployment processes.

Data integration

The app-building framework provides solutions for generating and consuming linked data on mobile devices. Currently, data collected by different apps are not interoperable because these apps are created by different organizations using backend databases that store data in different schemas. For example, one app that is created by organization X for collecting refugee information cannot be integrated directly with data for disaster relief held by another organization Y. Because these two apps and their backend systems were developed in silo and data hosted in relational databases lack the global identifier supported by the Resource Description Framework (RDF[3]) data model and linked data technologies for data interoperability.

In contrast, apps created with the framework can generate "RDF-ready" data that can be easily integrated with other data represented with the RDF model. For example, a data-reporting app can use the Linked Data Form component to create surveys for collecting user input. The Linked Data Form component turns user input into RDF data described in common ontologies such Humanitarian eXchange Language[4] and Management Of A Crisis[5] that are specified by the app developers. Two apps that use the same ontology for describing its data can query datasets in different RDF stores.

Fast prototyping for app development

The capability to quickly create an app and modify rapidly is critical to crisis response projects. From the workshop experience as described in the previous section, we identified the main challenges for developing mobile apps in crisis response or humanitarian projects. The potential challenges include: (a) requirements gathering, (b) validate critical features, (c) budget estimation, (d) changes of requirements, and (e) rapid testing. In many cases, a new project in Non-Governmental Organization or Non-Profit Organization is a direct response to the ongoing crisis around the world. While the needs for crisis relief might be obvious (eg. saving human lives, restoring damages, coordination of crisis resources), transferring them to requirements for a potential app will require discussions with multiple stakeholders.

The discussions have to identify critical features that leverage existing resources and address the problems at hand. For example, in the ICRC case, the potential

[3] http://www.w3.org/RDF/

[4] http://demo.hxlstandard.org/tag

[5] http://observedchange.com/moac/ns/

app for the Restoring Family Link project needs to fetch the current GPS location of the person who report the status of a missing or found person. Also, decision makers for the Restoring Family Link project may want to receive real-time notifications when the status of certain monitored area has changed, e.g. increasing number of missing people. Allowing quick prototyping and rapid testing of an app helps to refine the requirements that might not be obvious at the beginning when designing the app. For example, a new requirement for automatically tagging all reports created by the app with cached locations might emerge after finding that it takes too long to renew the GPS location.

Customization of apps

Throughout the workshop, we found that the feature to reuse and modify an existing app is greatly favored by our participants in ICRC. One scenario is for the international organization like ICRC to use the app for training its local branches, but still reserve the flexibility to customize the app to meet the needs in each local branch. For example, the master app can be an e-book app that instructs volunteers on how to participate disaster relief efforts. However, there might be emergent needs locally that require quick changes of the app. The app-building framework allows its users to upload an existing app, modify the app, and create a new app on the fly. Such use-modify-create mechanism allows different entities to take apps created by others and collaboratively improve or customize the app according to their own needs.

CONCLUSION / OUTLOOK

Mobile devices play a very important role in disaster management and relief operations. Our app-building framework can be used to help humanitarian workers to quickly develop and deploy mobile application for humanitarian relief operations. To study the potential utility and impact of our framework to humanitarian relief, we collaborated with ICRC to identify, develop, and deploy practical in-house projects using the framework. With our app-building framework, we envision more and more core-members of the humanitarian organizations, such as ICRC, getting involved early in the full mobile app development cycle, instead of only participating in requirements gathering or mock-up sessions. Along with expanding our partners, we are also working to introduce better practices for future mobile app development and deployment process in the humanitarian community.

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