LOST-Map: A Victim-Sourced Rescue Map of Disaster Areas

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Abstract. In the aftermath of natural disasters, members of the affected communities are often the *de facto* first responders. Local volunteers can respond quickly, are strongly motivated, and have the necessary ground knowledge. However, their search and rescue efforts may be misdirected in the absence of information about the location and status of victims. We propose LOST, a system that gathers data from smartphones in affected areas, even when the regular communication infrastructure fails, and aggregates it in a web interface for visualization. For each individual, LOST-Map shows location traces and activity indicators. The information can be explored by selecting time-frames and/or applying filters over activity indicators. This paper briefly describes the design of LOST, introduces the visualization tool LOST-Map, and reports on a study (n=10) that suggests that it can be effectively used by untrained volunteers.

Keywords: Disaster management, Emergency response, Location services.

1 Introduction

When disasters (like earthquakes, hurricanes or tsunamis) hit populated areas, members of the affected communities often offer themselves to help in the field. While they may not have the necessary knowledge to provide first aid to victims in every situation, these volunteers know the geography and have a better sense of which people are missing. They can be valuable actors in emergency operations, providing immediate response and collecting information useful to other stake-holders, like civil defence efforts. They can report changes in the field, which people need help, etc. In areas that become isolated, local volunteers are sometimes the primary emergency responders for extended periods of time. However, when information flows are chaotic, it is difficult, even for locals, to have an accurate account of the location and status of potential victims. Often the communication infrastructure fails or is overloaded, hindering the dissemination of information.

Technology plays a crucial role in emergency response. Yet, tools that empower local volunteers aren't still common. LOST is a system that tackles the challenge of providing a source of actionable information to volunteer responders. With LOST,

N. Baloian et al. (eds.): CRIWG 2014, LNCS 8658, pp. 319–326, 2014.

location and activity information is collected automatically from people's smartphones and then disseminated from peer to peer. When it finally finds its way to an internet connection, it is posted to an online service. Additionally, LOST allows users to write text messages and safe reports, which are also propagated through the network. The service that runs on smartphones can be locally activated by the user or remotely triggered by a central authority while there is still communication infrastructure. LOST also includes an online visualization map, LOST-Map, where volunteers can easily navigate and explore this data.

In recent years, several social computing approaches have been applied to disaster management. Agarwal et al. [1] proposes a system which allows people to agree on a secure path to exit a disaster scene, communicating through a Wi-Fi ad-hoc network. Ramesh et al. [6] propose a Bluetooth ad-hoc network formed by the victims' smartphones that allows exchange of short text messages and location pointers. Although LOST also relies on an peer-to-peer dissemination of information, the approach to communication is different: LOST is targeted at commodity smartphones operating in realistic conditions, and thus cannot rely on Bluetooth (which does not have the necessary range) or Wi-Fi ad-hoc mode (which is not available on most off-the-shelf devices). Furthermore, in LOST, when it finds its way to internet, it is made available to support the rescuers' work.

The availability of online maps has also been leveraged in many recent proposals for rescue tools: COORDINATORS [10] aids first responders to coordinate themselves and share information; WIISARD [2] consists on a mesh network to promote communication and situation updates between first rescuers and command centre; TravelThrough [3] is a system developed for victims and information centres to share and develop a secure path to exit the disaster area. These systems, however, even when they take into account information produced by victims, rely on the existence of an institutional response. LOST is designed to gather information about victims and make it accessible to the local community, as a complement to the institutional response, or as a substitute when it is not present

Recently, it has also been observed that local, unofficial efforts, are already taking advantage of online collaborative tools. During the Haiti earthquake in 2010 people collaborated to create a local map [4], later used for rescue and planning purposes. LOST-Map displays automatically gathered specific information about battery level, local activity (measured by the accelerometer and number of screen activations), distance travelled (measured by GPS), besides explicit messages. These indicators provide context, helping a rescuer to get a better sense of the situation.

This paper focuses on LOST-Map and its ability to provide information to volunteers. Filters are available that allow users to select a time-frame, to exclude individuals who have been reported safe, and to color markers according to activity information. As a preliminary validation a user study (n=10) was conducted, too assess if it can be effectively used by people with no prior knowledge of rescue operations. Findings suggest that users understood the interface and successfully identify potential victims, spending a reasonable amount of time and effort.

2 The LOST Project: Empowering Community Rescuers

The LOST project comprises two main components: LOST-OppNet and LOST-Map. LOST-Map is a web application consisting of a map to display collected data and designed to run in tablet devices and desktop/laptop computers with a standard web browser. LOST-OppNet is responsible for gathering data from the victims using a non-obstructive approach. It consists of an Android application that activates a set of predefined sensors. A dynamic mesh is created with the devices in the area, acting as nodes in an opportunistic network [5]. While the application is intended to be activated by a central remote authority, victims can also manually activate it.

To operate on commodity devices, LOST-OppNet takes advantage of the ability smartphones have to act as Wi-Fi access points. For messages to be disseminated, the devices cycle through: 1) acting as access points, and; 2) trying to connect to access points; 3) trying internet connections. Messages are disseminated for all nodes it can connect. Duplicates are prevented based on authorship and timestamp. Remaining operational details are outside the scope of this paper, but the approach is similar to WiFiOpp [8], except from the internet connection attempts and some optimization parameters.

LOST-OppNet also provides a minimal user interface to victims, allowing them to see system status and send text messages. These allow victims to describe their condition or the status of surroundings with free text. Victims can also mark themselves as safe, if they managed to escape from the disaster.

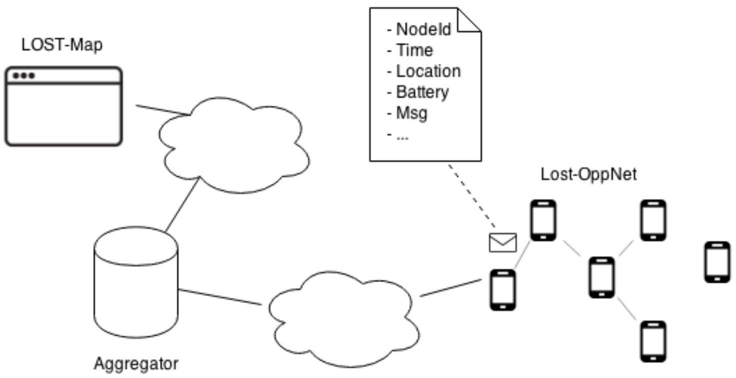

Fig. 1. The LOST architecture, including LOST-Map, LOST-OppNet and the aggregator

LOST-OppNet is a content producer while LOST-Map is a content consumer. Between them, an online repository acts as an aggregator. A LOST-OppNet node that finds itself with an available internet connection deposits in the repository not only its own tracks, but the ones that reached it in the opportunistic network. The LOST-Map webapp is, in essence, a visualization of the data in the aggregator. Fig. 1 summarizes the architecture of LOST.

3 LOST-Map: Visualizing Human Activity

LOST-Map is a web application capable of providing real-time and historical information about a disaster scene. It assumes a target audience that has some knowledge about the rescuing location. It is designed to volunteers as a complement of the rescue operation. LOST-Map allows the visual exploration of:

- Time/location of nodes: the building blocks of location tracks;
- Battery level: if low, we can infer that victim will stop producing data;
- Steps: an indicator of mobility, estimated from accelerometer readings;
- Screen activations: an indicator that an individual is active;
- Text messages: victims can explicitly send messages, readable from the web app;
- Safety status: victims with mobile app can also mark themselves as being safe.

Time and geographical location are used not only to show the last known location, but also a track, which can be an indicator of movement. The remaining information can also inform on victim status, but the inferential step is left to the volunteers.

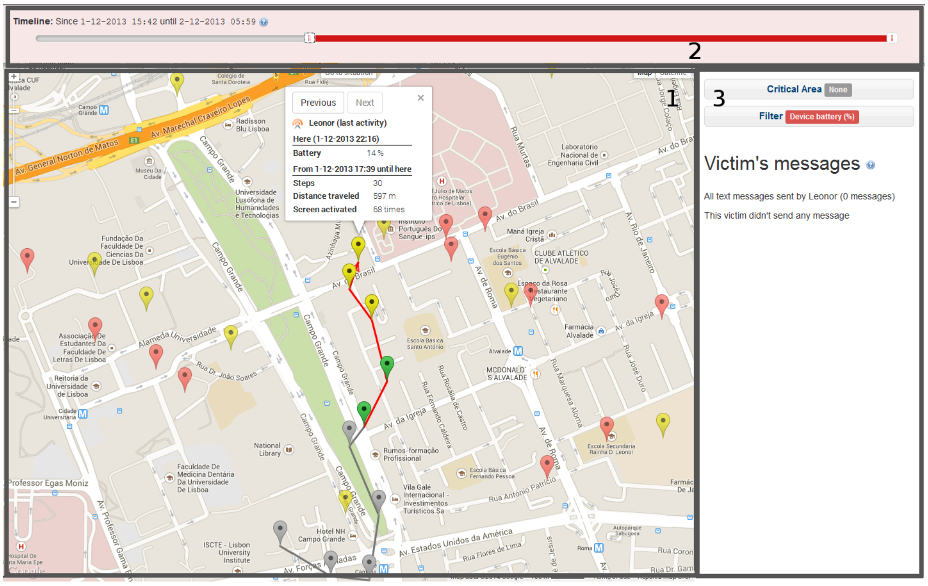

Fig. 2. The user interface split in 3 areas, with all controls applied simultaneously (path for a single victim, timeline and indicators filter)

Figure 2 shows the actual LOST-Map interface. It is divided in three areas. The most prominent is the map, which relies on the Google Maps API[1]. Each marker represents the last known location of a victim. It is possible to show the path for a single victim by clicking the marker (in the figure towards a safe area). Information

[1] Google Developers: Maps API – `https://developers.google.com/maps/`

gathered by smartphone sensors is displayed as a balloon, by clicking any marker in the path (Figure 3). The second area at the top is the time-frame master control. It is possible to select a period of time by adjusting the slider. This acts as a filter to the information shown on the map, removing markers for devices that did not produce information within the interval. The third area on the right is the toolbox. It contains access to filters, shows any posted messages when a marker is selected, and provides space for other tools still being developed.

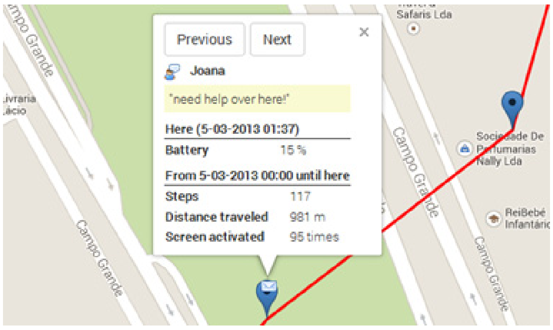

Fig. 3. Detail of the balloon that is shown when a marker is selected. It displays human activity indicators as well as messages posted by the victim through the smartphone app.

It is also possible to apply a color to markers in order to categorize them. Markers may be colored red, yellow and green according to activity indicator ranges set by the volunteer, using a semaphore analogy. Each indicator has a default scale associated on which a volunteer can control the levels using a slider.

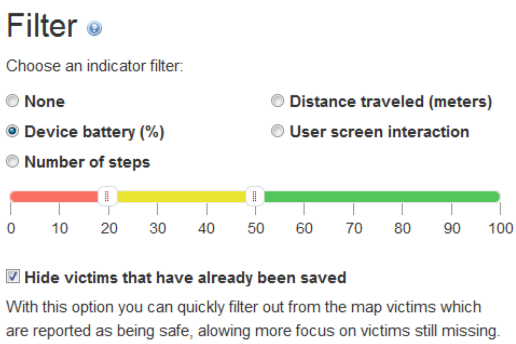

Fig. 4. Detail of the panel to choose an indicator filter and hide victims already safe

As an example, Figure 4 illustrates the selection of a filter over the battery level. In this example, three ranges are selected, from left to right in the scale:

- Lower than 20% is the critical level and is marked with red color;
- From 20% to 50% is the alert level and is marked with yellow color;
- Above 50% is the secure level and is marked with green color.

These levels can be changed by volunteers. Upon applying this filter, markers on the map are colored according to the defined ranges. This filter provides a visual cue to help volunteers to find victims according to a certain criteria. There is also a filter to completely hide individuals that had reported as being safe. This allows the removal of visual clutter on map and helps to pinpoint people in need of assistance.

4 Preliminary Evaluation

To assess if LOST-Map can be a useful and usable tool for untrained volunteers, we conducted a user study. It comprised a number of tasks that simulated the typical use cases that LOST addresses. We recruited 10 volunteers, all being students or research staff. Ages ranged from 22 to 51 (mean=27.3, SD=8.6). All participants had some experience with using Google Maps and good knowledge of the scenario areas.

Participants were given a script containing an introductory explanation about LOST-Map and its relation to LOST. They were asked to complete three. Each task concerned a different disaster scenario. Datasets for each task were generated by computer simulation in advance. Tasks, scenarios details and resulting data are available online[2]. The moderator was responsible for measuring completion times for each task. After each task, participants were asked some questions to understand their comprehension regarding the interface and functionalities. After that, they were asked to answer a between-task survey with a single question. After all tasks were completed, participants were administered a final questionnaire, to assess their overall perception of LOST-Map. All tasks were accomplished using LOST-Map.

We acquired the following measures for each task: 1) Total amount of time to conclude the task; 2) Whether the participant concluded the task without giving up; 3) Number of questions that participants asked the moderator; 4) Ease of use as measured by the Single Ease Question (SEQ) [7], from 1 (“very difficult”) to 7 (“very easy”). SEQ is a standardized usability measure, whereby users are asked to complete the statement “Overall, this task was:” using a Likert scale. Overall perceptions were measured with the AttrakDiff [9] questionnaire of user experience, in the ten-item version AttrakDiff is a set of semantic differentials that inform on subjective perceptions of pragmatic quality, hedonic quality and attractiveness.

4.1 Results

All participants concluded successfully all tasks proposed. The mean time to conclude each task is presented in the Table 1. As expected, as tasks were completed in increasing degree of difficulty, participants needed more time to conclude task #3, which was closer to a real world situation, requiring a combination of techniques learnt from the first two tasks. Scores for the SEQ are also presented in Table 1.

[2] `http://accessible-serv.lasige.di.fc.ul.pt/~astarte/criwg2014`

Table 1. Average task completion times, SEQ scores and number of questions for each task

	Avg. task completion time	Avg. SEQ score	Avg. help requests
Task #1	1m48s (SD=37s)	5.50 (SD=1.08)	0.7 (SD=0.7)
Task #2	1m58s (SD=46s)	5.70 (SD=1.34)	0.6 (SD=0.5)
Task #3	2m43s (SD=99s)	4.50 (SD=1.58)	1.0 (SD=1.2)

The answers are in line with the task completion time: the more complex the task is, the less easy users found it. We also measured the number of questions asked by the participants to the moderator. A question to the moderator means that the participant was not able to conclude the current task. When asked, we tended to allow the participant to discover how to continue autonomously. Again, participants asked more of the moderators in the most complex task. An AttrakDiff questionnaire was used to evaluate the full experience provided by LOST-Map. Each semantic differential was given a score ranging from 1 to 7, the latter being the most positive score. The first four differentials are indicators of pragmatic quality and second four are indicators of hedonic quality. All results are between 5 and 7 in the 7 points scale.

4.2 Discussion

Overall, the results validate LOST-Map as an easy-to-use tool for untrained volunteers. All tasks took a reasonable amount of time to conclude. Even the third task which was more realistic, requiring a combination of time control and filters, was completed in less than three minutes. The SEQ scores indicate that participants didn't find the tasks difficult. This is especially encouraging taking into account that participants had no previous training, therefore having to adapt and learn how to work with the tool. From our observations, most of the difficulties were related to using the slider controls. Participants asked for help from the moderator more often than desired, but our observations suggest that these difficulties could be overcome easily.

The responses to AttrakDiff were on the positive side of the differentials, but it seems users' perceived LOST-Map to have greater pragmatic quality than hedonic quality. Our primary focus was the introduction of useful functionalities to filter and understand data gathered from LOST-OppNet. This does not necessarily mean we neglect hedonic aspect of user experience; it was a factor with a slight lower priority.

5 Conclusions

In this paper we presented LOST-Map, part of the LOST project. LOST-Map enables local volunteers in their rescue efforts by augmenting their perception of the disaster area. Volunteers have access to a map and a set of functionalities that allow them to have an overview of the situation. We reported on a study indicating that LOST-Map is usable by novices. The user study also shows that there is room to improve, namely in the filter functionality and the overall hedonic quality. The LOST project is an ongoing effort. We also plan to introduce a native Android version of LOST-Map to have better support on tablet devices. This application in particular will not rely on having an Internet connection, updating the map using data gathered directly from the opportunistic network.

Acknowledgments. This work was funded by FCT through the LaSIGE Strategic Project, ref. PEst-OE/EEI/UI0408/2014 and the EU project ASTARTE - Assessment, STrategy And Risk Reduction for Tsunamis in Europe. Grant 603839, 7th FP (ENV.2013.6.4-3 ENV.2013.6.4-3).

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