SOMAP: Network Independent Social-Offline-Map-Mashup

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ABSTRACT

Maps, showing the tactical or the administrative situation at any particular time, play a central role in disaster management. They can be realized as interactive map mashups. In addition to classical information (weather, water levels, energy network, forces), they can also be used to present a view on citizen-generated content, e.g. from social media. In this paper we offer insights into how mobile map mashups can assist citizens during infrastructure failures that often occur in large-scale emergencies. Based on a review of approaches and mobile applications from literature and especially from practice, we present SOMAP (social offline map), a mobile app we developed in Android. It offers offline map functionality in terms of (A) pro-active loading and storing of potentially needed maps of the respective area as well as (B) the possibility of exchanging information from social media using Bluetooth. The application was evaluated qualitatively, to gain insights into the potential of such applications.

Keywords

Map Mashups, Mobile Applications, Offline Maps, OpenStreetMap, Social Media

INTRODUCTION

The rapid exchange of information is highly important in crisis management to help affected people and to minimize damages. For several years, it has been observed that the use of social platforms in crisis situations has been steadily increasing; for instance during the heavy floods in Germany in June 2013 (Reuter, Ludwig, Kaufhold, et al., 2015). Situation maps and map mashups are an integral element of crisis management, which can be used for the purpose of orientation as well as for information gathering (Liu & Palen, 2010). People often make use of internet services, such as Google Maps, as well as mobile devices; subsequently they are becoming increasingly more open towards the use of interactive maps for spatially-related matters. In addition, there is a growing supply of no-cost map services by various providers (Heidmann, 2013). Hence it can be deduced that mobile map applications or mashups hold great potential. There are already a number of web- or smartphone-based map applications for use in crisis situations which have been partly developed for affected citizens and partly for the emergency services. This gives rise to the question of which functions a crisis application should comprise in order to support citizens in crisis situations, especially taking the frequently recurring problem of network breakdowns into consideration. Moreover, there are grounds for an examination regarding how crisis applications should be designed in order to be perceived as beneficial by potential users.

In this contribution, we will compare Google Maps with OpenStreetMap and look into map-mashups in crisis management. Our focus is not on research approaches in particular but on applications actually used by citizens in such scenarios. Building on this, we will present a concept and the implementation of SOMAP (social offline map) - a mobile, network-independent map application in Android which displays crisis information and offers offline functionality in terms of (A) pro-active loading of potentially needed maps of the respective area as well as (B) the possibility to exchange information from social media using Bluetooth. We have evaluated SOMAP with particular focus on its offline availability during network disturbances by providing offline map materials;

on the data-exchange possibility it offers; and also on the integration of citizen-generated information from social media.

BACKGROUND AND RELATED WORK: MAP MASHUPS IN CRISIS MANAGEMENT

Map-mashups can be suitable for crisis applications because interactive maps offer various possibilities to visualize geo-referenced data. According to Alby (2007), the term "mashup" originates from the field of music and refers to a remix composed of two different musical pieces, e.g. music from A with vocals from B. In Web 2.0, mashup refers to a new application which has emerged from the connection of two other applications. For the development of mashups, so-called APIs (Application Programming Interfaces) are used by web-applications. Content from third party applications can be linked with the application via APIs to create new applications (Alby, 2007). In the following, we will first outline the differences between Google Maps and OpenStreetMap as important representatives of map mashup services. Afterwards we will take a look at already existing web-mashups and mobile applications in crisis management, which have also been considered in literature (Liu & Palen, 2010; Schulz & Paulheim, 2013).

Google Maps and OpenStreetMap

Google Maps and OpenStreetMap are the most prominent map providers. According to a statistic from programmableweb.com, the Google Maps API is generally the most popular API for mashups. A direct comparison reveals several differences. Table 1 illustrates the major differences between Google Maps and OpenStreetMap.

	Google Maps	OpenStreetMap
Provider	commercial (Google Inc.)	open-source project
Distribution	high popularity, usually pre-installed on Android smartphones, formerly also on iOS	rather low popularity, not pre-installed on smartphones
Availability of map materials	offline availability only to a limited extent	can be downloaded legally and can be used offline
Map renderer	pre-defined	different options or user can create it himself
Visualization	road map view, physical map, satellite view, hybrid map	dependent on renderer, usually road map view; additionally different layers
Editing map materials by users	errors and suggestions can be forwarded to Google, otherwise no editing	completely effected by the community
Costs	usually free for private use; fee charged for company use	free by stating the source
Humanitarian Projects	Google Public Alerts, Google Crisis Map, Google Person Finder	Humanitarian OpenStreetMap Team (HOT)

Table 1. Comparison Google Maps und OpenStreetMap

Google Maps: The popularity of Google maps is its greatest advantage; users can operate it more easily; and the pre-existing satellite map materials are of value. With the aid of satellite images, users can form a better picture of an area than would be possible with static maps. However, Google`s satellite images are often not up-to-date and, as a result, might distort the situation – especially in regions affected by a crisis. In order to avoid this problem, Google Crisis Map offers multiple up-to-date satellite images for certain regions which can be directly compared with images of the damages being provided by citizens. In the standard map such images cannot be found. Optionally, you can activate a view which includes altitudes.

OpenStreetMap: In contrast, OpenStreetMap's big advantage is a very large and continuously growing community through which the maps are increasingly becoming better and more precise. The Humanitarian OpenStreetMap Team maintains and improves maps for the poor regions of the world. In crisis situations, the affected regions are digitized extremely quickly to support the emergency responders. **Error! Reference source not found.** demonstrates how completely and precisely a region in the Philippines was captured during typhoon Haiyan in 2013. A very important – and for many users crucial – advantage lies in the fact that the map data are freely available for everyone and, additionally, the entire material can be downloaded, which means it is available offline. Google Maps are only free to a limited extent and only parts of it are downloadable.

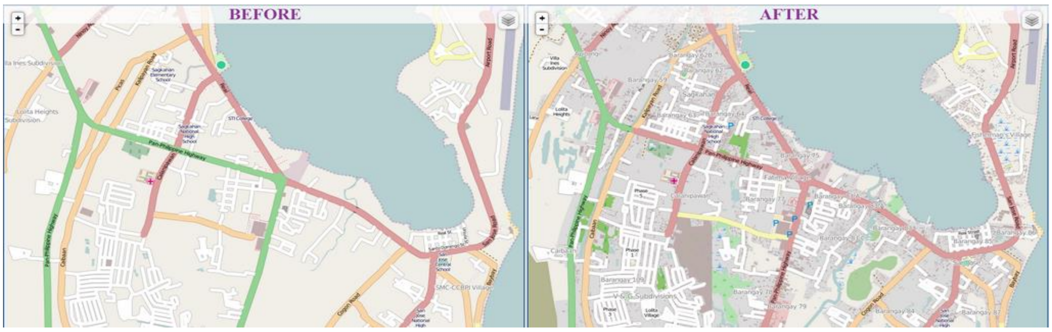

Figure 1: Before/After of an OpenStreetMap (https://twitter.com/RBanick/status/400055778435809280)

Existing Web-Mashups and Mobile Applications

Today several web-mashups and mobile applications for the purpose of crisis management can be found, which are based either on Google Maps or OpenStreetMap (e.g. Figure 2). In order to examine and compare these applications, we practically examined an exemplary selection, since many of them only differ in detail. The mobile applications, which seemed to have a focus similar to our research, were obtained from Google's PlayStore[1] and were tested for many hours; whereas many approaches from research have only been deployed for evaluation purposes and are not openly available. The latter were therefore examined by reference to their paper[2]. In the following, we will present the most important insights of our examination, which are structured in four aspects: integration of social media, basic map provider, offline availability and popularity.

Integration of Social Media: Hochwasser 2013 is the only application from our selection which does not make use of a map. It exclusively serves the purpose of summarizing information from news platforms, social networks or various weather services. The application was kept very simple, because its developers created it in a short space of time to supply affected citizens with information as quickly as possible during the heavy floods in Germany in 2013. The integration of posts from social media was not part of other mobile applications we examined. However, some web-mashups based on Google Maps – known, inter alia, from a Google ad campaign – consisted in large part information from social media (Mildner, 2013).

Basic Map Providers and Distribution: Regarding maps, the applications hardly differ from each other, as all providers offer maps using Google material. Most of them offer the option of choosing between the standard map and satellite maps. Only in *Hurricane Hound* and *Ushahidi* the user can change to OpenStreetMap. Concerning the distribution, the earthquake-information-app *Earthquake Alert!* has the highest number of downloads in Google's PlayStore (approx. 1 million, including updates; counted before 2013). Most of the other applications have less downloads (<100,000). From these relatively small numbers we deduce that crisis-related applications are barely used by citizens and its distribution in general is rather low.

Offline-Availability: Our specific focus is offline availability. The majority of applications we examined depend on constant Internet access - otherwise neither the map nor messages are shown. Merely the applications *Elerts* and *Ushahidi* permanently and locally store messages after entering the map for the first time and, in addition, offer a world map with a maximum altitude view, from which the geographical reference of the messages can at least be roughly identified. *EQInfo* and *Real Time Warning* store messages but not the map. *Disaster Alert*, *Earthquake Alert!*, and *Outbreaks Near Me* only offer a rudimental map but do not store any messages. The other applications do not store any data at all. As a consequence, none of the applications we tested can be used effectively during network breakdowns. Only *MobileMap*, which is based on Microsoft Windows and has been developed for firefighters in South America, offers complete offline functionality. This is made possible by pre-installed map materials of the deployment region and a method of network-independent communication among the devices with the aid of ad-hoc-networks (MANET) via Wi-Fi (Al-Akkad et al., 2014; Monares et al., 2011).

[1] Applications from stores: Disaster Alert (https://play.google.com/store/apps/details?id=disasterAlert.PDC), Real Time Warning (com.horizon.android.rtw), Earthquake Altert! (com.joshclemm.android.quake), Hurricane Hound (com.stkiconcepts.hurricaneHound), Outbreaks Near Me (com.duethealth.healthmap). EQInfo (de.gempa.android.eqinfo), Hochwasser 2013 (de.se.hochwasser), Elerts (com.elerts.elerts), Ushahidi (com.ushahidi.android.app&hl=de),

[2] Approaches from literature: MobileMap (Monares et al., 2011), MyDisasterDroid (Fajardo & Oppus, 2009), Augmented Reality App (Schöning et al., 2009)

Summary: The approaches we examined indicate that mobile crisis applications have the potential to offer added value to crisis management. They reveal different strategies in deploying maps; sometimes maps only play a minor role (Fajardo & Oppus, 2009) or are used indirectly on a mobile device (Schöning et al., 2009). Moreover, the applications and approaches almost exclusively focus on online usage and do not offer any offline map materials. In our contribution, we aim to place the emphasis on the usage and availability of maps on smartphones. Until now, social media have been integrated into crisis maps by non-automated methods; more precisely by administrators who select the relevant messages (Mildner, 2013). So far, considering mobile crisis apps, citizen-generated information has not been displayed on maps with explicit geo-reference, but has merely been published as reports in lists. In contrast to this, we wish to combine (A) the integration of social media content with geo-reference into maps with (B) offline functionality, such as the map's availability during breakdowns of infrastructure.

Disaster Alert | Real Time Warning | Earthquake Alert! List | Hurricane Hound | Elerts | ubAlert

Figure 2: Excerpt of Existing Web-Mashups and Mobile Applications

SOMAP: CONCEPTION OF A MOBILE NETWORK INDEPENDENT MAP MASHUP

The examination of map-mashups revealed several common advantages and disadvantages as well as some which varied. All of these have to be considered for the concept of a new mobile application. In research, different approaches for supporting emergency services in crisis situations already exist (Fajardo & Oppus, 2009; Ludwig et al., 2013; Monares et al., 2011; Reuter et al., 2014; Schöning et al., 2009). However, the target group "citizens" has been subordinated. In contrast, many examples show that citizen-generated information can be very useful in crises (Reuter et al., 2012) and contributes towards improving the situation (Mildner, 2013). For that reason, the concept for our application SOMAP aims to focus on the personal information management for citizen and the information exchange between citizens. This could be used for various purposes, such as orientation, navigation, or information assessment. Citizens are often the first ones at the scene of the incident and therefore often have in their possession relevant information and data, such as pictures. Furthermore, crisis information is visualized on a map, similar to most of the other mobile or browser-based applications we have examined. It is mandatory to keep the licensing rights of the respective map provider in mind, especially for the purpose of offline-usage. In order to support citizens in a mobile and local context, the application has been developed for use on smartphones.

Moreover, our app review exposed that cellular network breakdowns - which can (and do) occur during crisis situations (Reuter, 2014) - have hardly been considered in the applications, thus rendering the usage severely limited. Only one of the applications designed for emergency services included offline functionality (Monares et al., 2011), which has proven to be useful. Our application should as well offer functionalities which do not require Internet access, including the availability of offline maps for citizens. One major consideration here is that offline maps should require as little memory space as possible since they are to be used on smartphones. In order to achieve wide distribution, we strive for high user acceptance through simple usability without technical intricacies. We also intend to integrate information from social media, such as Facebook and Twitter, as doing so promises high potential for the exchange of crisis information (Reuter et al., 2012) and, until now, there is no mobile map application which has such a focus.

IMPLEMENTATION OF SOMAP – SOCIAL OFFLINE MAP

To evaluate our concept we implemented the Social Offline Map (SOMAP) for exchanging information from social media services during crisis situations. The map mashup concept has been implemented by combining map data with social media data and geolocation information. In the following, we will present its specifics and most important functions.

Program Library

Map applications, its program libraries - such as Google Maps - and all apps based on them usually make use of map materials from online "tile servers". Generally, on request, these servers only provide the map section, which is currently being viewed, as a series of picture files (256x256 pixels) or map tiles in the zoom level adjusted previously. As long as an application only requests the current section and downloads these picture files temporarily or permanently, the amount of data remains small (Ramm & Topf, 2009). If, however, map tiles are downloaded in advance for a large section – as for example in tools such as *Mobile Atlas Creator*[3], an open source program which creates offline atlases for handheld GPS and cell phone applications – the amount of data will increase enormously because every section of the map, including every single zoom level, has to be stored. For low zoom levels, the share of the requested picture files is minimal. The number of pictures multiplies each time the zoom level is increased. A map of the area of the German state of North Rhine-Westphalia containing all zoom levels consists of about six million tiles and would be over 25 GB in size. Since the program library *osmdroid,* which indeed offers a wide range of functions, can only display these tiles in an application, we have additionally included *Mapsforge*[4]. It provides a free, open-source, offline vector map library for Android and Java-based applications to easily create new OpenStreetMap-based applications. In its format, a map for the area of North Rhine-Westphalia is only 264 MB in size. The combination of osmdroid and Mapsforge make it possible to keep the amount of data small, even for maps with offline availability.

General Map Functionality (Figure 3, Figure 4)

On the map, the current position is marked by a yellow icon (Figure 3). The user can place a flag on a self-chosen point of the map. The flag's purpose is to obtain additional information from an area, in which you are currently not located, in the course of a subsequent data transmission. This flag can be repositioned any time via the menu item "Set flag" in the main menu. Moreover, we have integrated a so-called "MiniMap" in the lower-right corner. With this small additional map, the user can choose a map with other optics. Especially for users, who have to find orientation in rural areas, we have added satellite map materials from *Mapquest Open Aerials.* In its free version, it does not provide material for high zoom levels, so that it can only create a rough overview. The MiniMap can be deactivated any time via the general settings' menu, as can be seen in Figure 6. Furthermore it is possible to add information from third parties, such as KML layers (Figure 4)

Offline Availability (Figure 5)

Even when the cellular network breaks down, the application is usable if the user has previously downloaded offline maps. Via a button in the main menu, the user can switch between the online and offline map. The screenshot exhibits both views. The icon on top changes correspondingly. If the device in use does not have internet access when the application is started, the offline map will be selected automatically. So that a user does not have to search for suitable map materials via a browser by themselves, they can make use of the menu item "Download", through which they can access the map download server of MapsForge where the user can select maps of the entire world. Before users can download a map, they are again informed about the file size and are asked whether they really wish to download the map. If the user confirms, the download is started by the Android download function of the device. The file will be directly stored in the application's folder on the SD card, so that it can be activated immediately after the download has ended. After being accessed initially, the information from social media is stored locally in a SQLite database which renders it available without requiring internet access. Furthermore, the app utilizes the Android share function to share stored messages with other users of the app. Data are shared via the Android share function only after the user has initiated this function or some kind of auto syncing is possible. With this share-function, users can transfer various files via different interfaces, such as Bluetooth or NFC, e-mail or other applications installed on the device.

[3] http://mobac.sourceforge.net/
[4] http://wiki.openstreetmap.org/wiki/Mapsforge

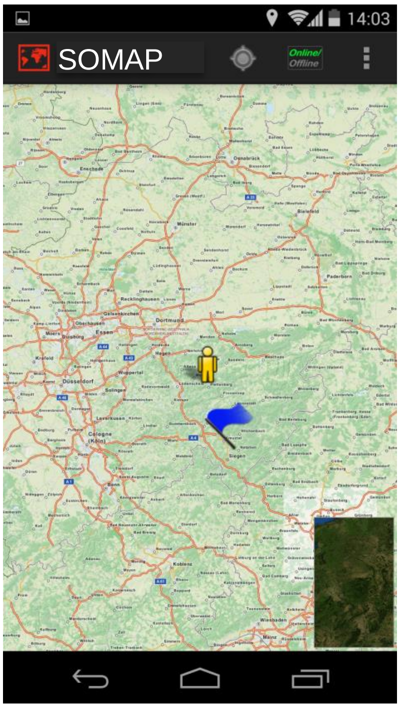

Figure 3: General map functionality: map, flag, minimap

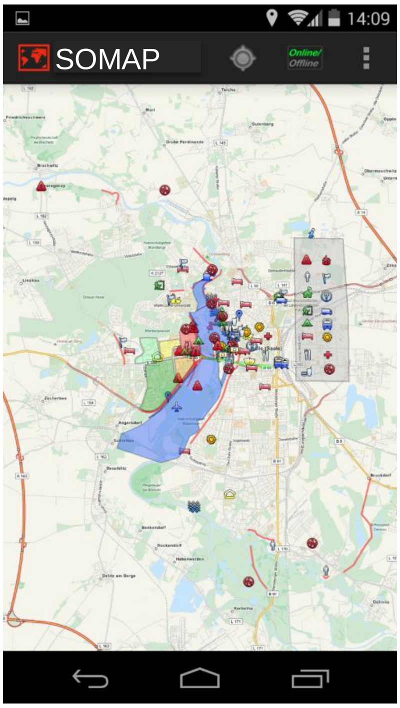

Figure 4: Additional map layer: KML during the European Floods

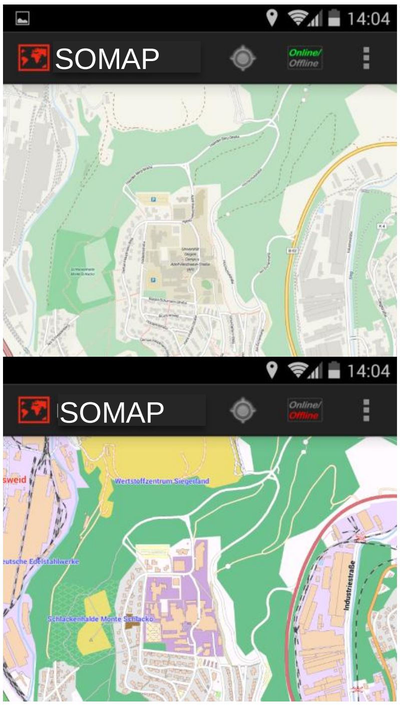

Figure 5: Online (top) and offline (bottom) view of a particular area

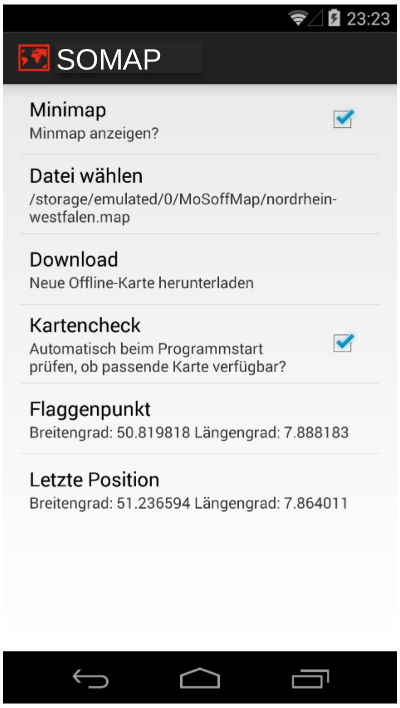

Figure 6: Settings: minimap, file, download, automatic proactive map check, and positions

Figure 7: Search for social media: keyword, time, area, GPS and platform

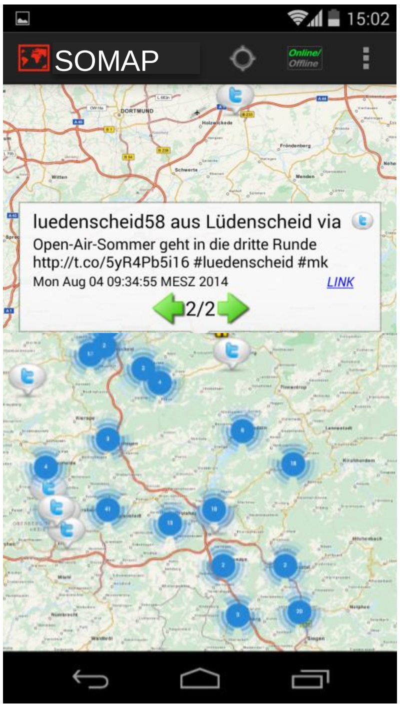

Figure 8: Integration of social media: information window and cluster marker

Automatic Proactive Map Check (Figure 6)

While the application is being started up, automatic checks take place to ascertain whether a network connection exists. If the user is in an area without network coverage, the application starts with an offline map. Assuming no map of the ".map" file format of Mapsforge was chosen previously, the application automatically navigates to the settings windows of Figure 6 to choose a map. If there is a network connection on the applications startup, the last known position of the device is calculated by using the "getLastKnownLocation" function of Android; a GPS geolocation is not required for this purpose. Using an online geocoder, the coordinates thus identified are transformed into a detailed address, comprising country, state, district and town. The application subsequently creates a list of all the maps installed within the SOMAP folder to determine whether the identified address data matches a particular map. If no appropriate map is found, the user automatically receives a message regarding the missing map. Following this, he has the opportunity to navigate to the settings view where he can choose a suitable map to download. This function could be optimized by automatically suggesting a suitable map. The absence of the possibility to automatically download a map or social media data introduces a limitation to the potential of the application; and this needs to be addressed. This, however, would require having a file server that is both directly integrated into the application and also provides maps of the ".map" file format.

Integration of Social Media (Figure 7, Figure 8)

The application allows social media messages to be queried by a quality assessment service for social media (Reuter, Ludwig, Ritzkatis, et al., 2015) which uses API to various social media services. The geo-referenced results are then displayed on a map. Within the search settings displayed on Figure 7, the user can change the search keyword, a time period in hours and a search radius in kilometers. For both the radius and the time period, sliders are provided to speed up adjustments. As the application is aligned on local and current information, both search parameters have a maximum value: information may only be a maximum of ten days old, and has to be within a radius of 50 kilometers from the user's last position, or a from a manually-positioned flag; the user can decide the latter with the help of two radio buttons. Underneath the buttons, the user can select which social media platforms are to be searched; this requires at least one to be selected.

Concerning social media messages, it is possible that numerous messages are geo-referenced to exactly the same spot. The application automatically recognizes messages with either identical geo-coordinates or geo-coordinates which are close at low zoom levels, consolidating them into clusters. These clusters are displayed as blue circles with a white number representing the quantity of consolidated messages. As soon as the user zooms into the map, cluster markers are dissolved into their single markers. Individual Tweets are displayed with a "t" and Facebook posts with an "f" in a speech bubble. Multiple information windows may be opened at the same time. Figure 8 illustrates the map view with cluster markers and information windows. To display information from individual messages, the user can click on both individual and cluster markers, which trigger the related information windows and automatically center them. Each information window always contains information about the author's name and his residence; the platform represented via Twitter or Facebook symbol; the date the message was created and the message itself. The size of the window adapts to the quantity of message text. If a cluster marker was selected, the information window provides arrow buttons to navigate through the individual markers, and if the marker contains a hyperlink, the information window presents a link button. If the hyperlink points to an image, it is displayed automatically within the information window; however, images will not be saved on the device.

It is also possible to search for data if other SOMAP users have allowed the application to use and share their data, and if they are in the proximity of the application, so that Bluetooth can be used to exchange information.

QUALITATIVE EVALUATION OF SOMAP

The developed application SOMAP was evaluated qualitatively to verify the concept's requirements and to identify potentials of subsequent areas for improvement (Figure 10). Additionally, it was examined whether the application provides added value towards known methods of using social media in local contexts. The general usability was evaluated to determine if the application can be used effectively and will be accepted by users. During the entire evaluation, alongside answering guiding questions, the Thinking-Aloud-Protocol (Nielsen, 1993) was applied: the participants were asked to express aloud their thoughts and way of proceeding throughout the evaluation. To simulate the data exchange during the evaluation, groups were formed with two representatives of a target audience in each case, testing the application cooperatively and simultaneously. The Constructive-Interaction-Method (Kahler et al., 2000) was applied, which required the users to accomplish both their own and joint tasks; and to maintain a mutual dialogue besides replying to guiding questions. The application of these methods should achieve plentiful and detailed results.

The evaluation guideline was separated into five sections, each consisting of practical steps or guiding questions. The introductory section aimed to determine each participant's technical expertise; the results are summarized in Table 2. An example scenario was given in section two, in which protesters occupied rooms and buildings in a university complex. The participants were asked about their general approach to obtaining social media information about the incident and how they would orientate themselves using smartphones, as well as possible benefits and drawbacks of their proceeding. Moreover, they were asked to express their experience with applications that process geo data. The third section addressed the usage of the developed application; the participants were asked to start a search with self-selected keywords and to acquire information, aiming at the evaluation of the general usability of the application independently of any scenario. Section four enhances the presented scenario with the breakdown of mobile communication and WLAN infrastructure, requiring the participants to solve a prescribed task collaboratively: Using information from social media, the participants were supposed to find an open door since the building had been locked by protesters. After accomplishing the task, the participants had to assess the operability in general and also the problems of using the application without network infrastructure and data exchange. Afterwards they were asked to express potentials of functional enhancement. The last section of the guideline required the participants to assess whether the benefits and drawbacks, named in section two, apply to the presented application; or respectively if the drawbacks identified could possibly be solved.

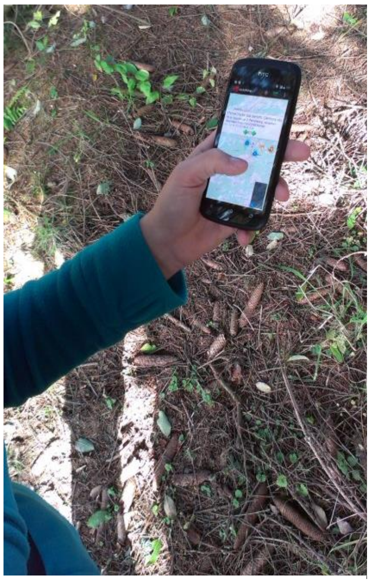

Figure 9: SOMAP in Use

Person	Age	Profession	Smartphone Experience
1	< 25	Web-Developer & Student Information Systems	Very high
2	25-30	Tradeswoman & Student Information Systems	High
3	< 25	Student Information Systems	Low
4	< 25	Student Information Systems	High
5	25-30	Tradeswoman & Student Business Administration	High
6	25-30	Student Physics	Low
7	> 60	Tailor	No
8	> 60	Retired Officer	Very low

Table 2: Participants in the Evaluation

Results of the Evaluation

After the completion of evaluation, the statements of the participants were transcribed and analyzed regarding (1) usability, (2) offline maps, and (3) suitability of the application. As the evaluation emphasized the pivotal role of the quality of the messages, this aspect was included in the evaluation. The follow paragraphs present the results of the analysis.

Usability: Although a small number of use problems were observed during the evaluation, the participants appropriated the application quickly, due to the handling of the map being known from widespread applications like Google Maps. Even participants that did not own or rarely used a smartphone had few problems: *"Anyway, I'm no touchscreen (smartphone) user and I've only heard it from friends or when I use a tablet, which I do from time to time, but there it is anyway […]. You can zoom in, this is how it works. And you can drag the map around"* (P6). Due to the insights gained regarding the users' acceptance of the application, we can conclude that the application might be suitable for various target audiences and is easy to comprehend.

Offline Maps: Few participants knew the OpenStreetMap project in advance; however, they were positively surprised at the map layers used and thought them to be a good alternative to Google map layers, with which they were already familiar. The great degree of detail regarding marked buildings and street numbers was especially emphasized: *"I actually wrote that I am rather familiar with the Google Maps application, but I must admit that it is self-explanatory in OpenStreetMap, and OpenStreetMap is more appealing"* (P5). Since a number of participants were not aware that it is not possible to use Google maps without an internet connection *"I didn't expect that I wouldn't be able to use Google Maps offline"* (P6), the availability of offline maps additionally convinced the participants in favor of the application. These results show that the detailed

OpenStreetMap maps provide enough benefits to be deployed actively in an application.

Quality of Messages: Although the majority of participants presently use, and have used Facebook in the past, they were skeptical about shared information from strangers and would generally not trust this information: *"When information is old, then you certainly question if you can trust them or not"* (P3). This problem could be countered with a stronger incorporation of a module for quality assessment for social media, providing diverse settings and additional search criteria. Further settings of the application could enable the user to filter important and unimportant messages more easily: *"It would certainly be interesting to have a rating of Tweets and Facebook postings, which is highlighted accordingly"* (P1). The implementation of this should visually separate important messages from others. Despite the participants' skeptical attitude towards social media, they still saw benefits regarding messages with a geographic location.

Suitability: In conclusion, SOMAP has the potential to support users in emergencies both with offline maps and information from social media. To ensure such support, the application must be downloaded initially and used in an emergency. The relatively low distribution of mobile applications in reference to emergencies and the low motivation to prepare for such situations in advance is problematic. It is therefore to be expected that people do not make provision for emergency applications before an emergency actually occurs (Lorenz, 2010). However, during the evaluation participants expressed that they would be more likely to download the application if it did not only serve for emergencies, but also had a bearing on everyday life: *"I could imagine, if there is some event or something […], a music festival with multiple stages […]; then someone could pass on the message that the area in front of the stage is full"* (P6). *"That the intended function, i.e. emergency management, is provided, but that is only a minor matter in everyday life. But this is the way I can imagine the application will be used"* (P4). Such an approach could leverage the application to be noticed and used by a much larger audience.

CONCLUSION

This paper has studied mobile map mashup applications to support citizens in crisis situations with a specific focus on offline functionality. The analysis of different mobile and browser-based mashups in the context of disasters outlines that most applications are rather similar and utilize maps which can only be used with an existing wireless network. Only one approach – MobileMap (Monares et al., 2011), which was specifically designed for the support of firefighters - offers extensive offline functionalities. Although citizen-generated information from social media can be of value in crisis management (Mildner, 2013; Reuter, Ludwig, Kaufhold, et al., 2015), an integration of this information in the application MobileMap is not given.

The results of our analysis were used as a basis for the development of a mobile map application in Android. The developed application SOMAP (Social Offline Map) supports the search for information as well as its display and the exchange of information for citizens in crisis situations, and it also enhances existing mobile applications with important aspects: Unlike existing approaches in literature (Fajardo & Oppus, 2009; Monares et al., 2011; Schöning et al., 2009) and current smartphone applications available in the different mobile stores, SOMAP uses OpenStreetMap maps and implements the offline availability of the maps as well as a built-in function for the retrieval of Twitter and Facebook messages. The automated testing on available offline maps at the given location during application startup ensures that users have maps available when needed. This helps especially in mobile use cases.

The evaluation with potential end users has shown that SOMAP meets the most important needs of offline availability: information from social media and user acceptance. The automatic availability of maps was especially highlighted by the participants. Further, the OpenStreetMap data was found to be particularly detailed and therefore also suitable for such an approach. With regard to the general use of mobile applications, the participants generally found added value in such an application. However, they would probably only download it in normal circumstances (outside of a crisis), if it would also provide additional benefits for their daily lives. The participants saw a benefit of SOMAP as a guide for larger events.

Since SOMAP, unlike other applications, also provides offline maps, the concept could also be relevant for infrastructure operators. In contrast to the known methods for mobile orientation and use of citizen-generated information, which cause a partial increase in data traffic over the wireless network, the application can help to reduce the traffic. On the one hand this covers the information and guidance needs of citizens in crisis situations (Reuter, 2014), while no resources of the infrastructure provider are unnecessarily dissipated on the other hand.

ACKNOWLEDGEMENTS

The research project EmerGent' was funded by a grant of the European Union (FP7 No. 608352).

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