Communication between Power Blackout and Mobile Network Overload

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ABSTRACT

In cases of power outages the communication of organizations responsible for recovery work (emergency services, public administration, energy network operators) to the public poses several challenges, primarily the breakdowns of many communication infrastructures and therefore the limitations of the use of classical communication media. This paper surveys technical concepts to support crisis communication during blackouts. Therefore it first investigates the perception and information demands of citizens and communication infrastructures in different scenarios. Furthermore, it analyzes communication infrastructures and their availability in different scenarios. Finally it proposes 'BlaCom', an ICT-based concept for blackout communication, which addresses the time span between the occurrence of the energy blackout and the possible overload of the mobile phone network. It combines general information with location-specific and setting-specific information, was implemented as a prototype smartphone application and evaluated with 12 potential end users.

Keywords: Blackout, Citizen, Communication Infrastructures, Crisis Communication, Mobile Network Overload, Power Outage

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1. INTRODUCTION

The 2012 blackout in India (670 million affected), the 2009 blackout in Brazil and Paraguay (87 million), the 2006 European blackout (10 million) and the 2003 Northeast blackout in the United States and Canada (55 million) show that big power outages still occur all over the world. The constant electricity supply became increasingly important over the recent decades because large parts of our infrastructure only function with electricity. Therefore the occurrence of power outages is a growing problem

(Birkmann et al., 2010). This does not only concern the economy or private households, but all basic (critical) infrastructures like water and food or information and communication technology in general (Lorenz, 2010). The dependency on a functioning electricity supply is very high, so that a long outage is highly problematic (Deutscher Bundestag, 2011; Holenstein & Küng, 2008). Even though the probability for power outages is relatively low and the average duration of such blackouts e.g. in Western Europe only amounts to few minutes, the general preparation for potential crisis situ-

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Figure 1. Focus of the study using the "crisis communication matrix" (Modified) (Reuter et al., 2012)
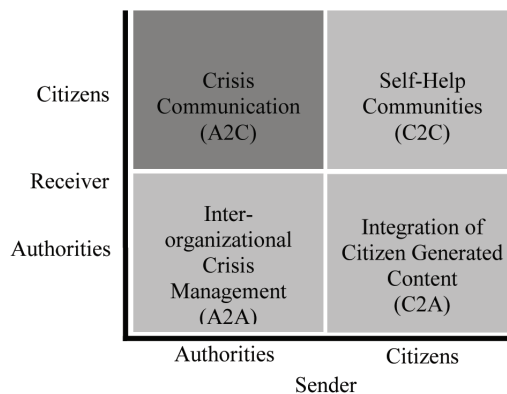
ations is rather poor (Birkmann et al., 2010). If a power outage takes place, communication tools, and almost all further infrastructures, will fail after a certain time, which can entail serious consequences especially in the case of long outages (Deutscher Bundestag, 2011; Hiete et al., 2010). Such long blackouts do not only mean a physical, but also a psychological burden for the affected people (Volgger et al., 2006). Uncertainty and feelings of anxiety, as well as the need for information emerge.

In terms of the communication matrix for social software in crisis management (Reuter et al., 2012), four different cases for information and communication in such a situation can be distinguished (Figure 1) depending on a distinction of (a) organizations and the (b) public as the (i) sender and the (ii) receiver of information. On the inter-organizational level organizations of crisis response communicate with each other often using radio communication, which is less affected by working electricity due to emergency power units (bottom left). On the public level, citizens and volunteers communicate with each other in the real or via social media such as Twitter or Facebook (top right). This citizen-generated content is also being analyzed by crisis response organizations (bottom left). Besides the communication among the citizen, it is also

very important that organizations responsible for recovery work inform the public (top left)

This work focuses on crisis communication between authorities/organizations and the people affected by a power outage (citizens), as marked in Figure 1. It focuses on which and how crisis-related information should be provided to the public.

Based on a previous short paper (Reuter, 2013) this paper outlines the perception of the population, their demands for information as well as relevant communication media and their availability during power outages. Furthermore it presents an ICT-based prototypically implemented concept for crisis communication and the results of its evaluation. This paper reports from a project focusing on coping and recovery work during big to medium power outages (Wiedenhoefer et al., 2011). Therefore organizations responsible for recovery work and crisis communication, such as emergency services like the police and fire department and infrastructure suppliers, such as energy network operators, are part of the collaborative project aiming to improve both information sharing (Ley et al., 2014) as well as mobile collaboration (Reuter et al., 2014). However, the aim of this work is also to research how to provide the citizens with information about emergencies during power breakdowns, focusing on the time span between

the occurrence of the power blackout and the breakdown of communication infrastructures due to mobile network overload.

2. INFORMATION NEEDS IN POWER OUTAGES BY CITIZEN

Because electricity has become indispensable in everyday life, there is a strong dependency on an intact supply infrastructure (Birkmann et al., 2010). Typically, citizens only notice the underlying infrastructure when the electricity supply fails and only then become aware of their dependency on electricity in their daily lives (Lorenz, 2010). Power outages are seen as annoying, but not as threatening. Furthermore, a functioning electricity supply is taken for granted – the possibility of a long power outage is not considered (Holenstein & Küng, 2008, 14). By putting an emphasize on a functioning electricity supply and by not taking possible consequences into consideration, the potential threat is underestimated (Birkmann et al., 2010, 82). Reflecting on such situations is seen as less important than dealing with daily problems (Quarantelli, 1999, 27). Moreover, the population's self-help capacity decreases because of its growing dependence on the electricity supply (Lorenz, 2010, 40). According to the German Federal Administration Office (Bundesverwaltungsamt, 2001) it can be assumed that self-protection will stagnate at the current low level.

From the citizen's perspective, the responsibility for civil protection lies with other actors, especially with the federal state. Those citizens who had to repeatedly deal with crisis situations are the only exception for practiced self-protection (Bundesverwaltungsamt, 2001). As a consequence, existing concepts for risk communication are widely unknown within the population (Helsloot & Beerens, 2009, 31; Lorenz, 2010, 38; Menski & Gardemann, 2008, 65). Memories of events, in which people were affected only slightly or for a short period of time, are often forgotten, so that no arrangements for better self-protection in the future are made

(Holenstein & Küng, 2008, 22; Menski & Gardemann, 2008, 5). Additionally, power outages are seen as unique incidents with the result that a repetition of such an incident is mentally out ruled by those affected (Lorenz, 2010, 31). The availability of groceries and drinking water in private households has decreased noticeably because of the permanent availability of these goods in stores. Keeping large quantities of food has become rare, especially in cities (Menski & Gardemann, 2008, 39). This can in part be explained by the absence of shortages in supply over recent decades. To sum up, it can be said that power outages seldom happen in Western Europe, so that the population is not aware of the risk of a long power outage and is not well prepared for such an incident.

Information is of great importance in such uncertain situations. Before and during power outages there are different information demands on behalf of the population. Before a crisis, information is necessary for sensitizing and crisis preparation. The awareness of a threat is essential for implementing prevention measures (Genen, 2009, 64). At first, citizens have to be informed about existing hazard potentials and their probabilities, and – if foreseeable – possible consequences. This makes a better preparation possible because citizens then have a rough idea of what to do when a crisis occurs (Volgger et al., 2006, 8). Especially recommendations regarding the preparation and assessment of the emerging threat are useful (Volgger et al., 2006, 16). The distribution of such information can take place in many different ways. Basic plans and instructions, including best practices, are a simple solution for emergencies. For this kind of information, Coombs (2009, 105) uses the term "instructing information". This is information that shows the people affected how to protect themselves. It is imperative that warnings are issued before a crisis occurs (Geenen, 2009, 64; Volgger et al., 2006, 16). For predictable crises, detailed warnings have to be announced on every channel available as early as possible. Thus, the citizens are given a time frame large enough for individual preparations.

During the crisis a demand for orientation information generally exists, so that those affected can comprehend the crisis situation. According to a network operator (Nilges et al., 2009) and an empirical study (Klauser et al., 2008, 3) a consistent and transparent provision of information to the population is necessary. The duration of the power outage is undoubtedly the most urgently needed piece of information. If this information is not available, at least an estimation of the time frame will be required in order to be able to better adjust to the new situation. If no information is passed on, the feeling of uncertainty – of being left alone – will intensify, especially in longer outages. If communication is generally possible but fails because of problem with the information transmission (e.g. hotline overload so that callers are redirected to unspecific recorded messages), those affected will quickly feel as if they are not being taken seriously (Klauser et al., 2008, 4). This is also the case when confronting affected citizens with standardized, unspecific information (Holenstein & Küng, 2008, 5). Because of failures in the pre-crisis communication, those affected will additionally also need all the information which should have been communicated in the context of risk communication. Thus, "instructing information" is required, which is adapted to the current crisis situation (Klauser et al., 2008, 5). According to Lorenz (2010, 29), the need of information should optimally correspond to the specific demand, as well as the existing fears and hardships of the population and also be as precise and detailed as possible. In case of longer power outages, there also exists an information demand for how to deal with scarce resources and how and where mutual help is necessary and possible. This information exchange requires dialogic forms of communication. However, this seems to be hardly realizable – especially for widespread and long power outages. Moreover, Coombs (2009, 106) mentions "adjusting information", which helps those affected to deal with the crisis situation psychologically. He also mentions the "golden hour", the response time of 60 minutes or less for first adjusting information. Klafft (2014) highlights current issues in crisis communication and alerting, such as strategies for the implementation of individualization in the alerting system as well as adaptive multi-channel alerting.

To sum it up, the most information demands exist: (1) Warnings: Once a crisis is predictable for the crisis management, the affected population must be informed of possible damages and threats. (2) Crisis-related information: information about the duration, the area affected (i.e. the dimension of the crisis), as well as the cause (only conditional) in order to adjust to the crisis at best. (3) Communication channels: information about which communication channels can be used. Particularly in longer crises it is important to minimize the information deficit. Additionally, the citizens are told where precise information can be found (Geenen, 2009, 86).

3. COMMUNICATION INFRASTRUCTURES AND THEIR AVAILABILITY DURING POWER OUTAGES

The use of communication infrastructures is necessary to cover the citizens' information demands. The German Federal Parliament (Deutscher Bundestag, 2011, 4-6) analyzed the risks for modern societies in a widespread and long power outage, with the result that the consequences can be summed up to damages of severe quality because of the almost total dissemination of the living and working environment by electric driven devices. The consequences for information technology and telecommunication are expected to be dramatic. Regarding communication technology, a power outage can be divided into different scenarios broken down by duration (Deutscher Bundestag, 2011; Hiete et al., 2010). Here, a transceiver needs to be available.

Table 1 shows that major parts of the communication system are currently not suitable for long and widespread power outages. For short power outages, communication can be

Table 1. Availability of media in different scenarios (Deutscher Bundestag, 2011)

#	Medium	Scenario A (<8h)	Scenario 2 (8-24h)	Scenario 3 (>24h)
1	Telephony	Yes, but maybe overloaded	No	No
2	Cell phone	Yes, but maybe overloaded	No	No
3	Internet (via cell phone)	Yes, but maybe overloaded	No	No
1-3	(if telephone switch central office / base station is not affected)	Yes, but maybe overloaded	Yes	Yes
4	Television	No	No	No
5	Radio (battery-powered receiver unit provided)	Yes	Yes	Yes

ensured with the aid of analog telephony as well as battery-driven devices as long as the communication infrastructure is not damaged or overloaded. For locally restricted power outages, under certain circumstances, mobile telephony and mobile Internet connections can be maintained by surrounding base stations that are not affected by the outage. In every other scenario it can be assumed that technical dia-logic communication is not possible (Deutscher Bundestag, 2011, 104).

In the area of *fixed-line telephony,* the digital devices will immediately stop working. The same is true for the base stations of *mobile networks*, whereas the mobile devices may still work for a few days, if they are fully charged. Nevertheless, a mobile network overload will most likely occur because of the increased traffic volume. Cell broadcast, a mobile technology allowing messages to be broadcasted to all mobile devices within the cell, is used by Wire-less Emergency Alerts (WEA), a "public safety system that allows customers who own certain wireless phone models and other enabled mobile devices to receive geographically-targeted, text-like messages alerting them of imminent threats to safety in their area" (Federal Commu-nications Commission, 2013). It is an initiative of the Federal Communications Commission (FCC), along with the Federal Emergency Management Agency (FEMA) and the wireless industry. However, in Germany cell broadcast is currently not provided by telecommunication companies caused by the lack of appropriate business models[1].

Mass media are available due to emergency power capacities (e.g. newspaper publishers); particularly radio, because it can also be re-ceived by battery-driven devices. According to Andersen and Spitzberg (2009, p.221), communication has to be redundant, both in the selection of the transmission media, as well as regarding the sources of information. Therefore, as many information channels as possible should be covered. Communication should also not only be run as a one-way com-munication. The *Radio Data System* (RDS), a data stream, which offers the standard functions of automatic program search and alternate frequencies through Traffic Message Channel (TMC), is used by navigation devices for traffic messages and is also broadcasted via radio. In the USA, such concepts already exist when us-ing RDS for weather alerts and other potential emergencies. RDS can be extended by further services – the radio text can be transmitted, which consists of up to 64 characters, and can also be used for rudimental information. Over the years, however, the distribution of battery-operable devices (transistor radios or corded telephones) has decreased; a fact which is often only realized during a power outage (Holenstein & Küng, 2008).

Further capabilities to warn the population were decreased throughout the 1990s (Geenen, 2009, 98; Menski & Gardemann, 2008, 28). *Sirens* were taken out of service or were handed over to the communities and not all siren warning systems are equipped with an emergency power supply. Only about one third can be used for warning the population (Menski & Gardemann, 2008, 28). Additionally, Helsloot and Beerens (2009) present non-technical communication concepts, which could be utilized during power outages: vans equipped with speakers, flyers, information points and meetings. This is all necessary in order to be able to reach a high percentage of people.

Due to the *Internet* and its mobile use, a variety of different ways of communication are now available. Classic services, such as websites and e-mail exist and more recent social services available in a mobile version, are chats, microblogging services and social networking services, all of which are used in a crisis (Palen & Liu, 2007). Social media services are being implemented by individuals in a self-organizing activity (Reuter et al., 2013); however crisis management organizations can "take advantage […] for their crisis response as long as they take precautions to maintain their proprietary data" (Jennex, 2010). Latonero & Shklovski (2011) present an example, where the Los Angeles Fire Department using Twitter for emergency management. By doing this, one way communication (broadcasting) as well as dialogic communication (e.g. answering questions) is realized. A journey with about 500 students researched the availability of social media during the 2011 San Diego/Southwest Blackout: "Contrary to expectations, the cell phone system did not have the expected availability, and as a result, users had a difficult time using social media to status/contact family and friends" (Jennex, 2012). Another study discusses the utilities' efforts to ensure communication in case of blackout during Y2K (Jennex, 2004): Concerning the preparations for ensuring communications a conclusion is to utilize multiple communication methods including wired and wireless networks as well as the suggestion to do not solely reliability of the Internet. In order to make such communication also available during *power outages*, Hossmann et al. (2011) present a disaster mode of Twitter, which may allow communicate to continue in case of network outages by using short radio technologies. Al-Akkad et al. (2013) "examine challenges people face in situations of disrupted network infrastructures" and found that people "often make creative use of the remains of the technological landscape". They propose architectural qualities fostering resilient technology among self-exposure (wireless hotspots), short-lived interactions, graceful degradation, self-management and viral deployment. Semaan and Mark (2011) describe resilience through technology adaptation, e.g. unintended uses, in Iraq. Panitzek et al. (2012) propose an emergency switch for privately owned wireless routers, which allows wireless routers to transition to an emergency mode creating a supportive wireless mesh network. However, none of the concepts enables the comprehensive provision of information during power outages.

The number of crisis-specific *mobile applications* for iOS (MissionMode, 2012a) as well as Android (MissionMode, 2012b) is increasing (see Table 2). Besides general crisis applications, which enable an interactive display of catastrophes on a map ('Disaster Alert', 'Disaster Radar'), sharing information ('Real Time Warning'), collecting eyewitness reports ('EarShot'), or live broadcasts of emergency services and infrastructure providers ('EmergencyRadio'), there are applications, which send push-notifications when entering a current danger area ('Katwarn'). There are also many applications for special crisis situations, such as earthquakes (e.g. 'Earthquake Alert'), storms (e.g. 'Hurricane Tracker'), floods ('Flood Watch'), wild fires ('Wildfires'), or epidemics (e.g. 'HealthMap'). Furthermore applications with 'instructing information', such as a pocket reference for first responders including crisis-checklists ('NIMS ICS Guide'), as well as for the purpose of prevention ('FEMA') exist. Google

*Table 2. Overview of mobile crisis applications for iOS and Android*

Name	iOS	Andr.	Focus	Description/Speciality
Centers for Disease Control		x	Epidemic	News, updates, extracts from social media
Disaster Alert	x	x	Catastrophe	List and interactive map for displaying catastrophes
Disaster Radar	x		Catastrophe	Interactive map for displaying catastrophes globally
EarShot	x		Eye witness	Collecting eyewitness reports including pictures
Earthquake Alert		x	Earthquakes	Real-time information
Earthquake!		x	Earthquakes	Information provided over the last 24 hours; display on a map
Emergency Radio	x		Radio	Live broadcast of emergency services and infrastructure providers in the USA
FEMA	x		Instruction	Information for prevention and crisis-checklists in crises
Flood Watch	x		Floods	Displaying floods with changing trends
HealthMap		x	Epidemic	Overview on epidemics, location-specific warnings
Hurricane Express	x		Hurricane	Data on storms in America, weather forecasts
Hurricane Hound		x	Hurricane	Marking potential development regions
Hurricane Tracker	x		Hurricane	Live videos, localized information, warnings
KATWARN		x	Danger	Notification when entering a current danger area
Latest Quakes		x	Earthquakes	Information on earthquakes including filtering option
NIMS ICS Guide	x	x	Instruction	Pocket reference for first responders, crisis-checklist
OnGuard Weather Alerts		x	Weather	Location-specific weather alerts
Outbreak Near Me	x		Epidemic	Real-time capturing of spread, submitting information
RadarScope	x		Weather	Overview on storms from 155 different radar information sites
Real time Warning		x	Warning	Crises worldwide including the option to share information
Shelter View	x		Instruction	Display of shelters (gymnasiums etc.)
Storm Shield		x	Weather	Weather information for storms
StormEye		x	Weather	Displaying storms in the surroundings
Tsunami Alert		x	Tsunami	Real-time alerts for tsunamis
Wildfires		x	Wildfires	Message option: „I'm OK"

Now and Maps forward automatic notifications for locally relevant warnings – independently from crisis-specific apps installed – for Android smartphones since the second quarter 2013. Applications, which explicitly consider the individual needs for information as well as the specifics of blackout situations, are currently not available.

4. 'BLACOM': CONCEPT FOR INTERNET-BASED BLACKOUT COMMUNICATION

Although radio is undoubtedly the most reliable medium for information transmission, it currently cannot be used to meet target-group-specific information demands (Deutscher Bundestag, 2011, 116). In addition the distribution of

Figure 2. Blackout and its consequences for mobile communication to illustrate the time frame (own illustration)
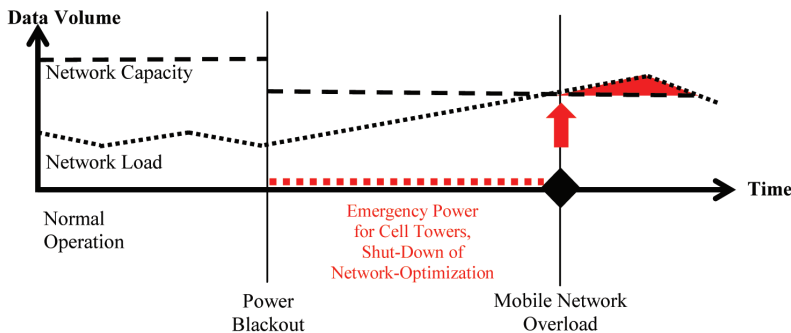
transistor radios independent from electricity is progressively decreasing (Holenstein & Küng, 2008). As depicted in the previous section, many communication media fail when power breaks down. Mobile communications are rudimentarily maintained through emergency power, whereas, however, rather unimportant base stations, which normally serve to optimize network coverage, are shut down, by which the network becomes overloaded more quickly for a large number of phone calls. Figure 2 clarifies this sequence by reference to a timeline. Because of the time span available between emergency power supply and the overload of mobile communications (punctured in Figure 2) the target-group-specific transmission of preferably small amounts of data compared to manual calls of the affected customers at power suppliers and emergency services is comprehensible and reasonable. Cell broadcast would be an additional way to inform all people, but it does not allow sending tailored information and is not available in Germany.

The aim of the concept is to cover the timespan between the occurrence of the power outage and the mobile network overload.

In order to address these points we have decided to conceptualize and implement an application for mobile-independent, battery-powered, internet-enabled smartphones and tablets. They are usually usable also after the actual comm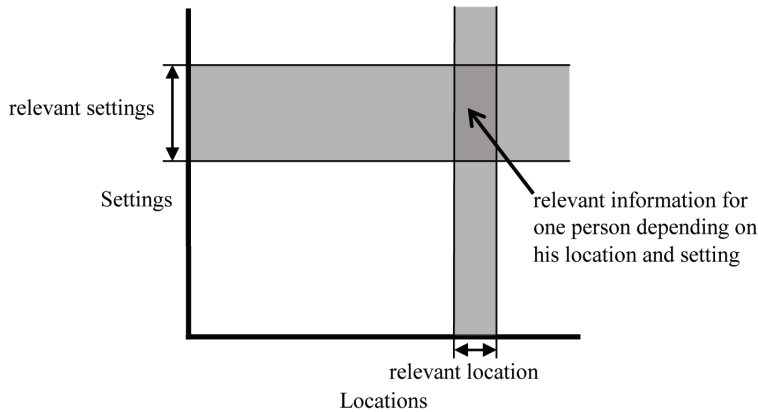unication channels fail and, at the same time, enable detailed and individual interaction. We aimed to proactively meet the information needs of the affected based on experiences of previous crises or trainings (Reuter et al., 2009) in order to reduce the amount of manual requests, which can become a quantitative problem for the respective emergency services (Ley et al., 2012). As a consequence the overload of the mobile communication network should be prolonged as long as possible by the decreased number of phone calls.

At this, the following core functionalities have to be considered:

4.1. Feature A: Location-Specific Information

Depending on the location a user needs different information. Providing him all information at any place might lead to information overload instead valuable information. As a first step, the concept intends to automatically locate the user. Of course the user has to allow the application to use the location based on sensors – if no location sensor is available it is possible to enter the location manually. Based on the location of the user location-specific crisis-related information (e.g. the duration of the outage or specific warnings, contact points in the surroundings, emergency accommodations, positions of hospitals nearby, help request) are given. The content of the messages might be

Figure 3. Information depended on the (1) locations and (2) settings of the recipient (own figure)

4.3. Feature C: General Information

Besides the characterization of location- and setting-specific information (Figure 3), which enables individual information supply, the category of general information is necessary as well. For instance, it consists of 'best practices', manuals or infrastructure information, which are permanently available in a further category.

4.4. Feature D: Handling Network Breakdowns

In order to be better prepared for blackouts the characteristics of such scenarios have to be considered. In case of energy breakdowns it is very likely that the mobile networks will also break down, at least after a certain time they are often not continuously available. A native smartphone application or an installed program has an advantage compared to a web site where information is always available once it is downloaded, even if the network breaks down. To assess the actuality, the time of the latest update (relevant for temporary power outages) should be displayed as well as the availability of new information. When the networks are available again new information should be downloaded directly and automatically prioritized.

based on standardized libraries (Niebla et al., 2012). Energy network operators are willing to provide this information instead of having thousands of calls, which cannot be answered in that amount during power outages. With such information also the amount of information that needs to be transferred can be reduced. Furthermore energy network operators are not always willing to provide all citizens an over-view about the supply rate of the whole area, but their specific situation.

4.2. Feature B: Setting-Specific Information

Information needs are not only based on the position but vary according to specific, individual requirements of each citizen. Such requirements result from, for instance, disease specifics (e.g. dialysis patient), family specifics (e.g. parents of young children) or demographic specifics (e.g. age) and implicate the necessity for targeted information supply. The concept contains an option to configure one's own profile in order to, for example, determine language, age and further parameters as well as to activate or deactivate special information types.

Figure 4. Screenshot of the prototypical application concept "BlaCom" for blackout communication

4.5. Feature E: Integration of Emergency Services and Energy Network Operators

To enable up-to-date information, a close connection to existing systems is necessary. Energy network operators might be motivated to provide information in order to relieve emergency services and overloaded hotlines from relatively uncritical problems.

5. DEVELOPMENT AND EVALUATION OF THE 'BLACOM'-PROTOTYPE

In order to test the acceptance of the concept we have implemented a clickable prototype, which represents all functionalities but, however, in the first phase, does not have access to real-time information and contains pre-defined demo data (Figure 4).

The concept, implemented as a prototype, was evaluated in a qualitative summative evaluation that included 12 participants (Table 3) (duration: ∅ 35 minutes; bandwidth: 20-40 minutes). The participants were chosen based on previous knowledge regarding power outages and risk preparation, as well as technical understanding in order to be able to assess the operability and the benefit more profoundly, and availability. In the beginning, the possible problem scenario was explained to the users. Especially those problems that are often underestimated and forgotten and mainly occur during longer blackouts (e.g. the failures of inventory control systems or water supply) were mentioned. Afterwards, the main idea of the concept – information transmission as early as possible – and its functionality were presented. The participants were then told to use the prototype by themselves using the "thinking aloud" method (Nielsen, 1993). The evaluation was recorded and the statements were then classified and analyzed.

The evaluation consisted of three parts (Table 4): First, an introduction with the description of a blackout scenario and possible reasons, second, the presentation of the concept and a walkthrough of the prototype and third, questions related to the usability, usefulness of the categories, if the information is complete, the motivation of using it and perceived problems and suggested extensions.

5.1. Results of the Evaluation

5.1.1. Why and How Long

Throughout the evaluation, the information perceived as the most relevant, was that on the current crisis situation, especially about the duration and the scale:

Table 3. Overview about the participants of the qualitative summative evaluation

Participant	Gender	Age	Profession
E1	male	56	Master craftsman
E2	female	54	Translator
E3	male	21	Student of Business Administration
E4	male	24	Student of Economics
E5	male	23	Student of Civil Engineering
E6	male	24	Student of Political Science
E7	male	20	Apprentice of cook
E8	male	23	Student of Information Systems
E9	male	23	Student of Computer Science
E10	female	25	Student of Sociology
E11	male	54	Electrician
E12	male	49	Teacher

Of course I want to know: why and how long? (E11, 35:15).

The transparent presentation of this information at any time during the use was of great importance for the participants: "*What is definitely good here is that the* [name of the] *incident is* transparent *here every time*" (E4, 22:00). It was emphasized that, particularly in the area of the behavior tips and the current information, the conciseness of the statement is vital: "*At a first glance, I want to see what it is about*" (E1). The information should be as short as possible, that is to say with little text, only highlighting the central information in the area of the behavior tips was considered good and necessary (E1, E2).

5.1.2. Local Help and Volunteer Services

Another participant introduced the aspect of self-help / volunteerism (E6, 22:45). With this, a further category for local help services driven by citizens could be added. Examples for such a service could be childcare or shelter offered by private persons. At the same time, however, it was suggested that such help services should be managed centrally: citizens could offer their help via central information points and would then be added to the system. Moreover, it should be considered if, besides the information category, the other categories could also be updated during an incident (E4, 26:00). Then it would be foreseeable if emergency shelters were occupied or if further telephone numbers were added.

5.1.3. No Motivation of Using the System before Crisis

Only a few participants were interested in using the program and in already receive information before a crisis:

Electricity comes from the socket. It has always come from there. In order to create a motivation one would have to deliberately turn off the electricity every now and again. Illusionistic indeed, but probably the only way (E11, 29:15).

Statements from several participants mirrored the tendencies mentioned in the literature, to not, or only seldom deal with a crisis before it happens:

Table 4. Concept of the evaluation

Phase	Description
1. Introduction	- Description of a blackout scenario - Description of possible problems within that scenario
2. Concept	- Presentation of the Concept - Walkthrough
3. Questions	- Usability - Usefulness of categories - Complete information - Motivation of using it - Problems / extensions

I then have this tool, so that in case of an emergency: when I click there I know how to behave optimally (E12).

In the opinion of the respondents, it does not seem possible to motivate people to deal with risk preparation. Certain incentives also need to be created to deal with such a program. The idea was expressed (E3, E9) that social networks offer an appropriate way for spreading the application because they are used by those affected by a crisis. The publication of that information on Facebook or Twitter with a link to the app download would be appropriate. At the same time, concerns regarding their reliability and trustworthiness, and the users trust in them, were expressed (E12). Two participants (E4, 29:00, E6, 30:01) had the idea that such a tool could be pre-installed on all new devices, similar to emergency numbers. A further suggestion was to combine text messages linking to the application (E3).

5.1.4. Sources of Information

There is a clear result that information about the broker of a piece of information is of great importance to the participants:

You want to know from whom the information is (E12).

In order to promote the use of the program, it was also suggested to eventually extend the problem areas so that it could be used in everyday life and the users could already get used to the program (E7, 13:30). The uncertainty regarding the availability of an Internet connection was also addressed. A respondent noted that laptops were less important than smartphones, because the use of smartphones is more widespread and they are better integrated into everyday life (E7, 14:30). Finally, the distribution of smartphones and laptops was seen negatively (E10, 37:30). Clearly, not every person affected has such a device at hand and that is why the concept can at best be a supplement to existing ways of communication.

5.1.5. Summary: When, How Long and Who

All in all, the evaluation revealed that the concept was considered useful by all participants. The design was said to be optimizable in parts, however, it was adequate and appropriate for the objective. All participants stated that either one or maybe even all information categories would be useful. Almost all participants could imagine using the suggested concept, if it was implemented adequately. But at the same time they mentioned at the beginning not to deal with such information before a power outage. Especially displaying the relevant information for those affected (when, how long), the information sources (for rating) and helping to spread the information was of high importance.

6. CONCLUSION

The aim of this paper is to discuss the use of information technology for power outage communication to the public. Based on previous work, the perception of power outages by the population, their information needs and the availability of communication infrastructures are summarized. Based on these requirements for citizen communication, the paper presents a concept of a crisis application providing relevant information, which was realized as a prototype in order to evaluate its acceptance.

The probability for power outages in Western Europe is very low. However, if a power outage occurs, a need for information on behalf of the population will emerge. At the same time, several types of communication media will not be available, so that others will then be overloaded (Birkmann et al., 2010; Deutscher Bundestag, 2011) due to increased use. In order to eliminate this dilemma, it seems to be reasonable to automatically provide relevant information for the citizens in addition to dialogic communication. This would aim to cover the information demands of the population, as well as reduce the overload of other communication media. For instance it could dramatically decrease the number of phone calls made to emergency hotlines. Mobile smartphone applications used on battery-powered devices are one possibility in order to support information management during power outages. Derived from the requirements we identified, a concept and its manifestation in a mobile application for providing relevant information has been presented and, later on, has been evaluated with potential users.

The ICT-based concept for blackout communication 'BlaCom', presented in this work, for mobile devices (laptop, smartphone, tablet computer) includes (1) general information (e.g. recommendations for action during power outages), (2) location-specific information (e.g. the duration of the outage or specific warnings, surrounding contact points, emergency accommodations, help request) and (3) setting-specific

information (people with specific needs, like dialysis patients, people with little children or older people) about the current crisis situation, in order to provide relevant information and to reduce the amount of data that needs to be transferred. The evaluation revealed that especially the reason and the expected duration of the power outage are of great interest. It also became clear that the motivation to proactively inform the population is not existent. One possibility to deal with this problem is to integrate the functions into an emergency services app that also allows people to be located in case of emergencies and therefore might provide a motivation. Another possibility is to integrate the app into smart metering applications, provided by energy network operators. But organizations responsible for infrastructures should, at any rate, make their critical information available for smartphones. Identifying the sources to establish trust in the future was seen as important. Furthermore, the availability of the Internet was mentioned as a potential problem. As a consequence it must be stated that the concept can only be used as a supplement to other communication channels.

This work has limitations: First, it focused on the situation in Western Europe. In other parts of the world the status of energy networks and the information needs of the public may be different. Second, the concept was tested with a rather small group of citizen (n=12), just in order to get some feedback about the general conceptual decisions. In future work the concept might be refined by an energy network operator and tested with a higher amount of people. Third, smartphones do not (yet) cover the entire public, so that, at present, the population can only be reached partially. As a consequence our concept cannot be seen as a comprehensive solution but as an additional form of communication, which, in a simple way, enables to make use of the time span between normal operation and overload of mobile communications in order to meet special information needs of the population and to reduce the number of phone calls at hotlines as well as their work load. To efficiently make

use of the limited infrastructure capacity for a longer time the reservation of bandwidth from mobile networks by power suppliers would be conceivable. Fourth, people are also communicating with family and friends, which has not been covered by this concept. This contribution just focuses on alert messages to the population. Despite the restrictions such a concept, in our opinion, is reasonable because, if mobile communication is possible, concepts are needed for using the network more efficiently.

Before establishing the concept for power suppliers and emergency services as well as in everyday life of the population further research is necessary, especially regarding the question on how the population can be motivated for prevention measures and to proactively use such an application. The pre-installation of warning applications (e.g. in Google Maps), the integration of the functionalities in a dedicated emergency services application, which additionally enables the localization of citizens in crisis situations, or the integration into smart-metering-applications, which are provided by power suppliers, could be possible. By integrating such concepts into applications already established in the population the obstacle for the intrinsically motivated use could be overcome more easily.

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REFERENCES

Al-Akkad, A., Ramirez, L., Denef, S., Boden, A., Wood, L., Büscher, M., & Zimmermann, A. (2013). "Reconstructing Normality": The Use of Infrastructure Leftovers in Crisis Situations As Inspiration for the Design of Resilient Technology. In *Proceedings of the Australian Computer-Human Interaction Conference* (pp. 457–466).

Andersen, P. A., & Spitzberg, B. H. (2009). Myth and Maxims of Risk and Crisis Communication. In R. L. Heath & D. O'Hair (Eds.), *Handbook of Crisis Communication* (pp. 206–226). New York: Routledge.

Birkmann, J., Bach, C., Guhl, S., Witting, M., Welle, T., & Schmude, M. (2010). *State of the Art der Forschung zur Verwundbarkeit Kritischer Infrastrukturen am Beispiel Strom / Stromausfall. Risk Management*. Berlin, Germany. Retrieved from http://www.sicherheit-forschung.de/schriftenreihe

Bundesverwaltungsamt. (2001). *Zweiter Gefahrenbericht der Schutzkommission beim Bundesminister des Inneren - Bericht über mögliche Gefahren für die Bevölkerung bei Großkatastrophen und im Verteidigungsfall* (Zivilschut.). Bundesverwaltungsamt.

Coombs, W. T. (2009). Conceptualizing Crisis Communication. In R. L. Heath & D. O'Hair (Eds.), *Handbook of Risk and Crisis Communication* (pp. 99–118). New York: Routledge.

Deutscher Bundestag. (2011). *Gefährdung und Verletzbarkeit moderner Gesellschaften – am Beispiel eines großräumigen und langandauernden Ausfalls der Stromversorgung* (T. Petermann, H. Bradke, A. Lüllmann, M. Poetzsch, & U. Riehm, Eds.).

Federal Communications Commission. (2013). Consumer Guide: Wireless Emergency Alerts (WEA). Retrieved from http://transition.fcc.gov/cgb/consumerfacts/wea.pdf

Geenen, E. M. (2009). Warnung der Beölkerung. In Schutzkommission beim Bundesminister des Inneren (Ed.), Gefahren und Warnung (pp. 61–102). Bonn.

Helsloot, I., & Beerens, R. (2009). Citizens' response to a large electrical power out-age in the Netherlands in 2007. *Journal of Contingencies and Crisis Management*, *17*(1), 64–68. doi:10.1111/j.1468-5973.2009.00561.x

Hiete, M., Merz, M., Trinks, C., Grambs, W., & Thiede, T. (2010). Krisenmanagement Stromausfall (Langfassung) - Krisenmanagement bei einer groß-flächigen Unterbrechung der Stromversorgung am Beispiel Baden-Württemberg. (Innenministerium Baden-Württemberg & Bundesamt für Bevölkerungsschutz und Katastrophenhilfe, Eds.). Stuttgart.

Holenstein, M., & Küng, L. (2008). Stromausfall - was denkt die Bevölkerung. *Sicherheit, 2008*(3), 61.

Hossmann, T., Legendre, F., Carta, P., Gunningberg, P., & Rohner, C. (2011). Twitter in Disaster Mode : Opportunistic Communication and Distribution of Sensor Data in Emergencies. In *Proceedings of ExtremeCom* (pp. 1–6). Manaus, Brazil: ACM Press. doi:10.1145/2414393.2414394

Jennex, M. E. (2004). Emergency Response Systems: The Utility Y2K Experience. [JITTA]. *Journal of Information Technology Theory and Application*, *6*(3), 85–102.

Jennex, M. E. (2010). Implementing Social Media in Crisis Response Using Knowledge Management. [IJISCRAM]. *International Journal of Information Systems for Crisis Response and Management*, *2*(4), 20–32. doi:10.4018/jiscrm.2010100102

Jennex, M. E. (2012). Social Media – Viable for Crisis Response? Experience from the Great San Diego/Southwest Blackout. [IJISCRAM]. *International Journal of Information Systems for Crisis Response and Management*, *4*(2), 54–68. doi:10.4018/jiscrm.2012040104

Klafft, M. (Ed.). (2014). *Current Issues in Crisis Communication and Alerting*. Fraunhofer Verlag.

Klauser, R., Pipek, V., & Rusch, G. (2008). *Störfall-Kommunikation*. Siegen: Interner Bericht des Instituts für Medienforschung der Universität Siegen.

Latonero, M., & Shklovski, I. (2011). Emergency Management, Twitter, and Social Media Evangelism. [IJISCRAM]. *International Journal of Information Systems for Crisis Response and Management*, *3*(4), 1–16. doi:10.4018/jiscrm.2011100101

Ley, B., Ludwig, T., Pipek, V., Randall, D., Reuter, C., & Wiedenhoefer, T. (2014). Information and Expertise Sharing in Inter-Organizational Crisis Management. [JCSCW]. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, *23*(4-6), 347–387. doi:10.1007/s10606-014-9205-2

Ley, B., Pipek, V., Reuter, C., & Wiedenhoefer, T. (2012). Supporting Improvisation Work in Inter-Organizational Crisis Management. In *Proceedings of the Conference on Human Factors in Computing Systems (CHI)* (pp. 1529–1538). Austin, USA: ACM Press. doi:10.1145/2207676.2208617

Lorenz, D. F. (2010). *Kritische Infrastrukturen aus Sicht der Bevölkerung*. Forschungsforum Öffentliche Sicherheit der FU Berlin. Retrieved from http://www.sicherheit-forschung.de/schriftenreihe/

Menski, U., & Gardemann, J. (2008). *Auswirkungen des Ausfalls Kritischer Infrastrukturen auf den Ernährungssektor am Beispiel des Stromausfalls im Münsterland im Herbst 2005*. Münster: Fachhochschule Münster. Retrieved from http://www.hb.fh-muenster.de/opus/fhms/volltexte/2011/677/pdf/Stromausfall_Muensterland.pdf

MissionMode. (2012a). 15 Disaster and Crisis Apps for iPhone and iPad. Retrieved from http://blog.missionmode.com/blog/15-disaster-and-crisis-apps-for-iphone-and-ipad.html

MissionMode. (2012b). 15 Disaster and Crisis Apps for Android. Retrieved from http://blog.missionmode.com/blog/15-disaster-and-crisis-apps-for-android.html

Niebla, C. P., Chaves, J. M., Ramirez, J., Mendes, M., & Ferrer, M. (2012). The Benefits of Alerting System Based on Standardised Libraries. In *Proceedings of the International Disaster and Risk Conference* (pp. 557–560).

Nielsen, J. (1993). *Usability Engineering*. San Francisco, USA: Morgan Kaufmann.

Nilges, J., Balduin, N., & Dierich, B. (2009). Information and Communication Platform for Crisis Management (IKK). In *Proceedings of the International Conference and Exhibition on Electricity Distribution (CIRED)*. Prague, Czech Republic. Retrieved from http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5255837&contentType=Conference+Publications&sortType=asc_p_Sequence&filter=AND(p_IS_Number:5255237)&pageNumber=24

Palen, L., & Liu, S. B. (2007). Citizen communications in crisis: anticipating a future of ICT-supported public participation. In *Proceedings of the Conference on Human Factors in Computing Systems (CHI)* (pp. 727–736). San Jose, USA: ACM Press. doi:10.1145/1240624.1240736

Panitzek, K., Schweizer, I., Schulz, A., Bönning, T., Seipel, G., & Mühlhäuser, M. (2012). Can We Use Your Router, Please? Benefits and Implications of an Emergency Switch for Wireless Routers. *International Journal of Information Systems for Crisis Response and Management*, *4*(4), 59–70. doi:10.4018/jiscrm.2012100104

Quarantelli, E. L. (1999). *Summary of 50 years of research findings disaster related social behavior*. Disaster Research Centre University of Delaware.

Reuter, C. (2013). Power Outage Communications: Survey of Needs, Infrastructures and Concepts. In ComesT.FiedrichF.FortierS.GeldermannJ.MüllerT. (Eds.), *Proceedings of the Information Systems for Crisis Response and Management (ISCRAM)* (pp. 884–889). Baden-Baden, Germany.

Reuter, C., Heger, O., & Pipek, V. (2013). Combining Real and Virtual Volunteers through Social Media. In ComesT.FiedrichF.FortierS.GeldermannJ.MüllerT. (Eds.), *Proceedings of the Information Systems for Crisis Response and Management (ISCRAM)* (pp. 780–790). Baden-Baden, Germany.

Reuter, C., & Ludwig, T. (2013). Anforderungen und technische Konzepte der Krisenkommunikation bei Stromausfall. In M. Hornbach (Ed.), Informatik 2013 - Informatik angepasst an Mensch, Organisation und Umwelt (pp. 1604–1618). Koblenz, Germany: GI-Edition-Lecture Notes in Informatics (LNI).

Reuter, C., Ludwig, T., & Pipek, V. (2014). Ad Hoc Participation in Situation Assessment: Supporting Mobile Collaboration in Emergencies. [TOCHI]. *ACM Transactions on Computer-Human Interaction*, *21*(5), 1–26. doi:10.1145/2651365

Reuter, C., Marx, A., & Pipek, V. (2012). Crisis Management 2.0: Towards a Systematization of Social Software Use in Crisis Situations. [IJISCRAM]. *International Journal of Information Systems for Crisis Response and Management*, *4*(1), 1–16. doi:10.4018/jiscrm.2012010101

Reuter, C., Pipek, V., & Mueller, C. (2009). Avoiding crisis in communication: A computer-supported training approach for emergency management. [IJEM]. *International Journal of Emergency Management*, *6*(3-4), 356–368. http://www.inderscience.com/search/index.php?action=record&rec_id=31571 doi:10.1504/IJEM.2009.031571

Semaan, B., & Mark, G. (2011). Technology-mediated social arrangements to resolve breakdowns in infrastructure during ongoing disruption. [TOCHI]. *ACM Transactions on Computer-Human Interaction*, *18*(4), 1–21. doi:10.1145/2063231.2063235

Volgger, S., Walch, S., Kumnig, M., & Penz, B. (2006). *Kommunikation vor, während und nach der Krise - Leitfaden für Kommunikationsmanagement anhand der Erfahrungen des Hochwasserereignisses Tirol 2005*. Innsbruck: Amt der Tiroler Landesregierung, Abteilung Öffentlichkeitsarbeit in Zusammenarbeit mit SVWP Kommunikationsmanagement und dem Management Center Innsbruck (MCI). Retrieved from http://www.tirol.gv.at/fileadmin/www.tirol.gv.at/themen/tirol-und-europa/downloads/Publikation_Krisen-_und_Risikokommunikation.pdf

Wiedenhoefer, T., Reuter, C., Ley, B., & Pipek, V. (2011). Inter-organizational crisis management infrastructures for electrical power breakdowns. In *Proceedings of the Information Systems for Crisis Response and Management (ISCRAM)*. Lisbon, Portugal.

ENDNOTES

[1] http://www.teltarif.de/i/cellbroadcast.html

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