Power Outage Communications: Survey of Needs, Infrastructures and Concepts

Christian Reuter
Institute for Information Systems, University of Siegen
christian.reuter@uni-siegen.de

ABSTRACT

Crisis communication during power outages poses several challenges. Frist, the causes of power outages are often events such as severe weather, which also lead to complications. Second, power outages themselves lead to limitations in everyday life. Third, communication infrastructures, that are necessary for crisis communication, are often affected. This work focuses on the communication of the organizations responsible for recovery work (emergency services, public administration, energy network operators) to the public affected by the power outage. Therefore this paper investigates the perception and the information demands of citizens and communication infrastructures in different scenarios. Taking the users' needs into consideration, an Information and Communication Technology (ICT) based concept for crisis communication, which combines general information with location-specific and setting-specific information was implemented as a prototype smartphone application and evaluated with 12 potential end users. ICT-based concepts can gain acceptance, however they should be understood as supplemental for some target groups and in some scenarios.

Keywords

Crisis Communication, Citizen, Power Outage, Communication Infrastructures, Mobile Computing

COMMUNICATION INFRASTRUCTURES AND THEIR AVAILABILITY DURING POWER OUTAGES

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). Even though the probability for power outages is relatively low and the average duration of such blackouts in Western Europe only amounts to few minutes, the general preparation for potential crisis situations 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 (Hiete et al., 2010).

The use of communication infrastructures is necessary to cover the citizens' information demands. However, not every type of infrastructure is available in all possible scenarios. 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 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 (Deutscher Bundestag, 2011, 104).

#	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 not affected)	Yes	Yes	Yes
4	Television	No	No	No
5	Radio (battery-powered receiver unit provided)	Yes	Yes	Yes

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

The German Federal Parliament (Deutscher Bundestag, 2011, 4-6) analyzed the risks for modern societies in a widespread and long power outage: The consequences for information technology and telecommunication are

expected to be dramatic. 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. *Mass media* are available due to emergency power capacities (e.g. newspaper publishers); particularly radio, because battery-driven devices can also receive it. According to Andersen & Spitzberg (2009, 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 and dialogue should also not only be run as a one-way communication.

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 broadcasted via radio. In the USA, such concepts already exist when using 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 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).

Due to the *Internet* and its mobile use, a variety of different ways of communication is now available. The use of the internet and social software in crisis management can be divided into four different cases for information and communication depending on a distinction of (a) organizations and the (b) public as the (i) sender and the (ii) receiver of information (Reuter et al., 2011). 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). Jennex (2012) made a journey with about 500 students in order to research 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". 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. 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.

APROACH FOR INTERNET-BASED POWER OUTAGE 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). This is why electricity-independent, web-enabled devices might be appropriate for locally restricted power outages (e.g. battery-driven laptops, tablet-computers or smartphones) (Reuter & Ritzkatis, 2013). Generally, these are also usable when the actual ways of communication are not available anymore and can also make a more detailed and individual interaction possible. For these reasons, we decided to conceptualize an application for laptops and smartphones based on theoretical findings. The concept's goal is to proactively meet foreseeable information demands of the affected on the basis of former crises or exercises (Reuter et al., 2009), also in order to reduce the amount of manual requests, which can become a quantitative problem in crises. The following functions are considered in this prototype:

(1) Location-specific information: Depending on the location an 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

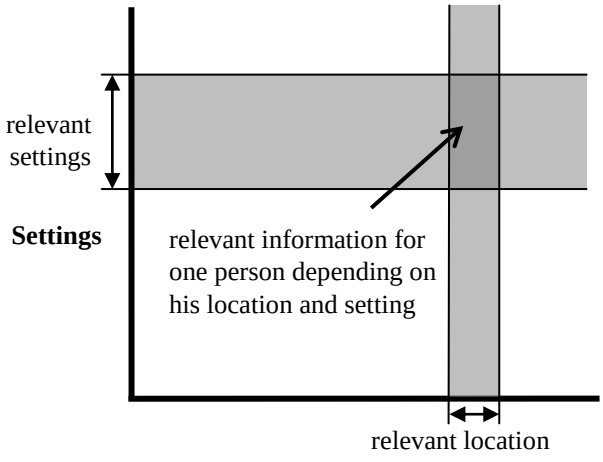

Figure 2: Information depended on the (1) locations and (2) settings of the recipient (own figure)

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, help request) are given. 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 overview about the supply rate of the whole area, but their specific situation (figure 2).

(2) Setting-specific information: Besides information that depends on the location information demands vary among the citizen related to specific needs. The concept intends to enable the user to configure his own profile and to enable or disable different types of information or to set a language. This is especially important because information demands may vary for people with specific needs, like dialysis patients, people with small children or old people, people on the countryside or in the cities. People might have different needs and should be able to receive specific information if necessary.

Besides location and setting specific information general information (e.g. recommendations for action, best practices, instructing information) should be always available, but displayed in a specific category.

Besides the different kinds of information, some other aspects also have to be taken into consideration.

Handling network breakdowns: 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.

Connection to existing social networking services: In a crisis, crisis related platforms are always used just by a rather small amount of people. Therefore, a connection to social networks, tagged with the location or setting specific key words to publish and also to receive information from specific sources, seems reasonable.

Connection to 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.

Figure 3: Screenshot of the prototype (in German)

In order to evaluate the concept it was implemented in Java as a clickable prototype, but without access to real time information (figure 3). The figure shows a screen with an advice how to behave in an emergency. The navigation furthermore shows the buttons "home", "information", "advices", and "help".

QUALITATIVE EVALUATION OF THE PROTOYPE

The concept, implemented as a prototype, was evaluated in a qualitative summative evaluation that included 12 participants (table 2) (duration: Ø 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. The evaluation was recorded and the statements were then

classified and analyzed.

The evaluation consisted of three parts: 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.

Gende	Age	Profession
male	56	Master craftsman
female	54	Translator
male	21	Student of Business Administration
male	24	Student of Economics
male	23	Student of Civil Engineering
male	24	Student of Political Science
male	20	Apprentice of cook
male	23	Student of Information Systems
male	23	Student of Computer Science
female	25	Student of Sociology
male	54	Electrician
male	49	Teacher

Table 2: Overview about the participants of the qualitative summative evaluation

Results

Throughout the evaluation, the information perceived as the most relevant, was that on the current crisis situation, especially about the duration and the scale: "*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 incident is on 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). Another participant introduced the aspect of self-help (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.

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: "*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.

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.

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.

CONCLUSION

The ICT-based concept, presented in this work for mobile devices 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 population is not motivated to proactively inform. 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, just in order to get some feedback about the general conceptual decisions.

ACKNOWLEDGEMENTS: I thank Soeren van Dongen for his contribution to this work. The project 'InfoStrom' is funded by a grant of the German Federal Ministry for Education and Research (No. 13N10712).

REFERENCES

1. 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.
2. 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*. Retrieved from http://www.sicherheit-forschung.de/schriftenreihe
3. Deutscher Bundestag. (2011). *Gefährdung und Verletzbarkeit moderner Gesellschaften – am Beispiel eines großräumigen und langandauernden Ausfalls der Stromversorgung*.
4. Geenen, E. M. (2009). Warnung der Beölkerung. In Schutzkommission beim Bundesminister des Inneren (Ed.), *Gefahren und Warnung* (pp. 61–102). Bonn.
5. Hiete, M., Merz, M., Trinks, C., Grambs, W., & Thiede, T. (2010). *Krisenmanagement Stromausfall (Langfassung) - Krisenmanagement bei einer großflächigen Unterbrechung der Stromversorgung am Beispiel Baden-Württemberg*. (Innenministerium Baden-Württemberg & Bundesamt für Bevölkerungsschutz und Katastrophenhilfe, Eds.). Stuttgart.
6. Holenstein, M., & Küng, L. (2008). Stromausfall - was denkt die Bevölkerung. *Sicherheit, 2008*(3), 61.
7. 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.
8. Jennex, M. E. (2012). Social Media – Truly Viable For Crisis Response ? In L. Rothkrantz, J. Ristvej, & Z. Franco (Eds.), *Proceedings of the Information Systems for Crisis Response and Management (ISCRAM)* (pp. 1–5). Vancouver, Canada.
9. Latonero, M., & Shklovski, I. (2011). Emergency Management, Twitter, and Social Media Evangelism. *International Journal of Information Systems for Crisis Response and Management (IJISCRAM)*, *3*(4), 1–16.
10. Lorenz, D. F. (2010). *Kritische Infrastrukturen aus Sicht der Bevölkerung*. Forschungsforum Öffentliche Sicherheit der FU Berlin. Retrieved from http://www.sicherheit-forschung.de/schriftenreihe/
11. 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
12. 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)*. San Jose, USA: ACM Press.
13. Reuter, C., Marx, A., & Pipek, V. (2011). Social Software as an Infrastructure for Crisis Management – a Case Study about Current Practice and Potential Usage. In *Proceedings of the Information Systems for Crisis Response and Management (ISCRAM)*. Lisbon.
14. Reuter, C., Pipek, V., & Müller, C. (2009). Avoiding crisis in communication: a computer-supported training approach for emergency management. *International Journal of Emergency Management (IJEM)*, *6*(3-4), 356–368. Retrieved from http://www.inderscience.com/search/index.php?action=record&rec_id=31571
15. Reuter, C., & Ritzkatis, M. (2013). Unterstützung mobiler Geo-Kollaboration zur Lageeinschätzung von Feuerwehr und Polizei. In *Proceedings of the International Conference on Wirtschaftsinformatik*. Leipzig.