Inter-Organizational Crisis Management Infrastructures for Electrical Power Breakdowns

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ABSTRACT

Major electricity breakdowns like the Northeast Blackout (USA) in 2003 or the blackout in most parts of Western Europe in 2005, have shown the fundamental role of electricity in our everyday life. The experiences of these accidents show that power suppliers, firefighters, police, county administration and citizens face multifarious challenges in inter-organizational communication, information and coordination processes during coping and recovery work. In this work-in-progress paper we describe early research dealing with inter-organizational issues in emergency management (EM). We are mainly focusing on supporting social practices in inter-organizational EM, for example collaborative interpretation of emergency situations, ad-hoc coordination or supporting citizen communication and helping routines. Identified from our experiences from related projects, discussions and literature studies, we suggest potential questions and future topics in user-driven software engineering processes for EM and domain specific problems, such as supporting citizen participation, coping with information uncertainties and quality variations or enhancing inter-organizational learning.

Keywords

Crisis management, user-centered design, inter-organizational communication and learning, citizen participation.

MOTIVATION

One of the most important infrastructures in modern industrialized societies is the electricity network. Due to its fundamental role for many aspects of our everyday life, power infrastructures manifest a strong dependence between power suppliers and customers (Birkmann et al., 2010). Customers take the infrastructure for granted and it appears mostly invisible to them as long as it works, but in the case of breakdowns in power supply customers become aware of their dependency on electricity, as was the case in 2003 in the Northeast Blackout, USA, or 2005 in Western Europe (Lorenz, 2010). We distinguish between coping work (the work to cope with the consequences of a power outage) and recovery work (the work to recover the infrastructure), which both immediately become top priority for citizens as well as many stakeholders in public administration and infrastructure providers. Cooperation among all stakeholders (maintenance workers of the power provider, police, firefighters, red cross etc.) is necessary to effectively handle the situation. These institutions encompass professionals dealing with such situations, but the people affected by a power outage also need to be considered as semi-professional actors. Our aim is to support this cooperation among all stakeholders, to foster collaboration and extend communication with an IT-based infrastructure.

RESEARCH AND APPLICATION FIELD

The aim of the project 'InfoStrom' is to develop a 'Security Arena', a communication and information platform, in regard to existing ICT, that aims at continuously improving the cooperation for coping and recovery work in

Reviewing Statement: This short paper has been fully double-blind peer reviewed for clarity, relevance and significance.

medium to large power outages among power suppliers, firefighters, police, county administration and citizens. It focuses on designing effective inter-organizational communication, information and coordination processes and on the development of new innovative technologies. Those are in the areas of situation illustration, reliability, information quality visualization, flexibility and public participation. With our approach and IT-based applications we aim at supporting both strategic and operative work in EM, and furthermore we would like to design basic technologies as a base for many activities (Figure 1). Our foci are Computer Supported Collaborative Work (CSCW) and Human Computer Interaction (HCI) related questions in designing the platform; further tasks are considered by our project partners.

Figure 1: Security Arena

In the empirical part of our research, we involve two regions in North Rhine Westphalia in Germany (counties Rhein-Erft and Siegen-Wittgenstein), which have different topographies and network structures and therefore have different kinds of dependencies in the electricity supply recovery: *Siegen-Wittgenstein* is a densely wooded, hilly county in the middle of Germany. Much of its industry is based on metalworking (e.g. mechanical engineering). The center of the region is the city of Siegen. The county lies on the border of three federal states – and therefore different structures in emergency management may interfere. *Rhein-Erft* consists of 10 growing communes in the west of Cologne with a huge number of large chemical and power plants. Many of the companies have specialized emergency plans. There are also some of Germany's most important transportation infrastructures like highways, airports, railroads and the river Rhine, which involves specific risks.

The collaboration with (and comparison of) two counties allows us to avoid generalizing from the specifics of one case. In every region we focus on several affected persons and organizations:

- Infrastructure suppliers (e.g. power supplier)
- Public strategic administration (e.g. crisis management, county administration)
- Public operative administration (e.g. police, fire fighter)
- Citizens

By our close cooperation between researchers and users/practitioners and a continuous program of evaluation phases, we interpret technology development as a process of further developing an existing infrastructure, and not developing one particular technological solution (Pipek and Wulf, 2009). The definition and negotiation of inter-organizational information chains has the same priority as the definition and formulation of technical aims.

The use of information and communication technologies should empower the actors to improve their planning, observation and management of and in crisis situations. Based on a rich technological foundation of mobile technologies, service-oriented architectures and semantic technologies, we focus on the development of socio-technical concepts, demonstrators and media concepts, which allow including existing technologies of crisis management and the infrastructure maintenance into processes of improving inter-organizational communication and collaboration in scenarios of medium to large electrical power breakdowns.

RESEARCH FOCUS AND QUESTIONS

In the realm of technology development for crisis management in our research and application field, we identified several challenges in supporting response and mitigation activities. We investigated these challenges from our experiences from former EM-Projects (e.g. Neuhaus, 2010) as well as literature studies. Basically, we can separate our research into two sections, which both have to deal with CSCW, HCI and End-User Development (EUD) issues. One section investigates the methodologies, tools and processes for the development of interactive applications. We are not addressing the interests and task of a single stakeholder in

an emergency, but the task and interests of many. Although highly professionalized in their own domains, all stakeholders face new challenges in coordinating themselves with others, particularly when we leave the public sector and integrate citizens and (industrial) infrastructure providers. When designing IT for collaboration support, a participatory approach is highly advisable at the inter-organizational level. The enhancement of end user articulations with regard to IT support and new options to tailor information infrastructures in this situation according to the needs and concerns of the stakeholders involved has been proven valuable means to develop collaboration support in other domains (Pipek, 2005). Concepts of storytelling (Bellucci et al., 2010), semi-automatic remote incident detection (Hilbert, 2000) and information exchange negotiation processes between all stakeholders may help to ensure useful and easy to use software systems.

Besides improving user-driven software engineering processes, we will focus on several domain-specific problem areas in our second section. Traditionally, a thorough understanding of the existing practice is the most important starting point for research in IS and CSCW, usually developed using ethnographic methods. Here, we have to deal with the problem that most decisions and activities of the actors in our scenario are incident-focused. They happen spontaneously, which makes it difficult for ethnographers and designers to capture them and to evaluate concepts of practice (Büscher et al., 2009). Although we can turn to observe stakeholders when they are practicing (e.g. Reuter et al. 2009), it remains a challenge for the inter-organizational case.

In the late 1950s, Lindblom (1959) already raised an important issue for cooperative work. In his contribution "The science of muddling-through", he pointed out the value of "short communication lines". Usually, work related informal activities of actors are the key factors for running a business successfully. The 'Security Arena' has to support these informal practices. Besides, the usual emergency management system follows formal work and information processes and the new concept should allow actors to make individual annotations, like map annotations. Furthermore, in cases where the crisis situation differs from routine situations and in case actors have to face new and unstructured tasks (Quarantelli, 1988), ICT needs to handle ad-hoc coordination, unique problem solving strategies and new or changed information needs (Waugh and Streib, 2006). This requires a flexible technical infrastructure, such as service-oriented architectures (SOA), which enable end users to connect and use in-situ new information resources (Morch, 2004).

Another important aspect of the 'Security Arena' will be the support of inter- and intra-organizational learning (Reuter et al., 2009). Enhancing storytelling approaches for de-briefing processes seems to be a promising way to make post-actions and decisions more accessible for inter- and intra-organizational actors. Moreover, social network concepts may be valuable to improve inter-organizational relationships and the exchange of information and experiences. Shneiderman et al. (2007) and Palen et al. (2007a) have also shown that social network platforms can bring citizens together by sharing information and experience before, during and after the crisis situation happened.

A further innovative feature of our 'Security Arena' concept is the integration of citizen-generated content for emergency management. Citizens are most commonly the first responders in emergency situations (Palen et al., 2007b) and it might be a promising idea to enhance local citizens with somehow "professional information providers", who deliver on-site information (e.g. pictures, videos or stories) for professional responders. However, in this case we need to distinguish between two different roles of citizens: Victims and witnesses. Palen et al. (2010) and Turoff et al. (2009) point out the transformational role of information and communication technologies to deal with the problem of quantity and quality as well as trustworthiness and security of information. This leads to the problem of information overload at the responder's site or less informative and uncertain material. Concepts of "Community Scouts", i.e. specially trained citizens, might help to ensure high quality information (Reuter et al., 2011). Research should be done to evaluate if semantic web technology usage can reduce the risk of information overload and unstructuredness. Information is a crucial factor for emergency management, although most of the work is comprised of decision making. It is necessary to cope with information uncertainties and quality variations. Depending on the particular case, investigation is needed on how actors deal with information uncertainties and on how information technology should be designed to help supporting the actors while handling these uncertainties, either by providing additional information or by enabling the user to interpret information all by themselves by way of providing related knowledge to them.

METHODOLOGIES

As the electricity infrastructure is an important basis for many activities of everyday private and professional life, the IT infrastructures are the basis for communication, coordination and collaboration in EM. Their failures and shortcomings create 'breakdowns' that can motivate and inform the development of IT for EM. Virtually all stakeholders involved in the scenario we address already have and use ICT in the coping and recovery work they perform. We follow the 'infrastructuring' approach (Pipek and Wulf, 2009) to IT development to maintain

a practice-oriented perspective and to let user-driven innovation emerge from IT breakdowns as well as IT innovations.

In general, the development of software for supporting collaborative work or learning requires a good (empirical) understanding of the context (Pankoke-Babatz et al., 2001, Müller and Pipek, 2009). Our research is inspired by Lewin's action research as "a comparative research on the conditions and effects of various forms of social action and research leading to social action" that uses "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action" (Lewin, 1958). In our case "action" means the design and use of suggested artifacts and a basic IT-based infrastructure. This way we follow Hevner and Chatterjee's suggestion (2010) to integrate action research with design research. A design science approach is used to create the artifacts: the design of an artifact for a relevant problem combined with rigorous evaluation methods for the design (Hevner et al., 2004).

Our research plan will start with a strong ethnography (semi-structured interviews, participatory observation, focus groups) among the four sets of stakeholders (administrative bodies, police/firefighters, infrastructure maintenance and citizens) to capture the existing practices of coping and recovery work during medium to large power outages. We will identify information needs that cannot be covered by the stakeholders themselves, but which require an inter-organizational information exchange. The 'Security Arena' in its first instance will use process representations and organizational charts to increase the transparency of the work practices and will suggest tools as well as procedures to negotiate new information chains. We will then evaluate this socio-technical infrastructure in the practice of the counties associated with our project in order to find out strengths and weaknesses. A second iteration will follow.

One of the most important aspects of the 'Security Arena' is its role as an integrating and complementing, but not replacing infrastructure. Rather than providing a solution that fits all problems of all stakeholders, it builds upon and connects the existing infrastructures of the stakeholders. We consider it as well a basis for situational coordination as a basis for further development of IT infrastructures for EM. Depending on the stakeholder practice we aim to support, we anticipate different problem foci with regard to the design and technological implementation of new tools. The operative stakeholders (police/firefighter/infrastructure maintenance) already rely on existing IT infrastructures, here we anticipate that an integration of these infrastructures with an inter-organizational concept like the 'Security Arena' will provide some challenges with regard to access rights and information quality. The administrative bodies that further develop the crisis preparedness of the counties have some general IT systems, but the 'Security Arena' will provide them with additional tools that target the briefing and debriefing processes more specifically. The citizens as the final stakeholder group have no specific IT tools, but may have established patterns of media usages in the case of emergencies that the 'Security Arena' interfaces need to be in line with.

SUMMARY

We have introduced a research project which aims at establishing an infrastructure to continuously improve the information exchange and collaboration of stakeholders that have to react to a power outage. Generally, the 'Security Arena' will provide technological as well as organizational/media-related concepts and solutions to enhance inter-organizational collaboration, coordination and learning. Here we presented HCI and CSCW related research objectives. By the fact that each crisis situation differs from the routine situation and that actors have to cope with new and unstructured tasks and actions, the 'Security Arena' also has to deal with ad-hoc coordination and communication. Informal communication and actions are common practices in coping and recovery work, so that supporting 'muddling-through' practices and 'short communication lines' are key requirements.

We focus on innovations in (a) high-flexible and adaptable technical infrastructures, (b) concepts and tools for integrating citizen-generated content for situation illustration with a social software infrastructure and (c) creating prototypes to cope with information uncertainties in emergency management. Methodologically, we will follow an action research and design science approach. To ensure useful and usable software tools we try to achieve this goal by a high level of user participation, an interdisciplinary research team with competencies in technology development and empirical analysis and as well as strong industrial partners that can bring project results into practice.

ACKNOWLEDGEMENTS

The project 'InfoStrom' is funded by a grant of the German Federal Ministry for Education and Research (No. 13N10712).

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