Connecting Disaster Volunteers and Relief Organizations: A Design Science Approach

Research-in-Progress

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Abstract

The increasing number of man-made crises presents relief organizations with serious challenges. For one, paid relief workers are increasingly scarce, making disaster volunteers essential components of official endeavors. But there are several issues concerning communication with as well as coordination and organization of disaster volunteers that hamper their deployment. We propose a design theory for mobile crisis response systems to support the management of disaster volunteers, with a focus on the current refugee situation in Germany. We derive requirements from interviews with relief organization employees working at the national level and those operating in the field, as well as with disaster volunteers. We translate requirements into both functional and non-functional design principles and map them to adequate design features, which we implement in a mobile crisis response system. As a practical contribution of our research, we provide specifications that define the form and function of a corresponding system.

Keywords: Design science, design research, disaster volunteers, relief organizations, crisis response, mobile crisis response systems

Introduction

Disaster relief organizations increasingly find themselves confronted with the scarcity of paid relief workers (Sargisson et al. 2012) and the growing frequency of man-made crises (Coleman 2006). Disaster volunteers who participate voluntarily in disaster relief activities play an important role in coping with crisis situations. But along with the benefits comes the challenge of managing efficiently volunteers who are not officially associated with relief organizations. Several communication, coordination, and organizational issues hamper the deployment of disaster volunteers (Sargisson et al. 2012). For example, poor communication is likely to lead to counterproductive relief attempts. In addition, a lack of information about existing social structures and organizational processes interferes with and hinders the
efforts of relief organizations. Furthermore, a high degree of volatility in the availability of disaster volunteers sometimes results in work being left undone without notice. Thus, there is room to improve the status quo of cooperation between professionals and volunteers with respect to effectiveness and efficiency.

A crisis response system (CRS) is used to support handling all relevant aspects of crisis response. A mobile crisis response system (MCRS) expands the functionality of a CRS with state-of-the-art information technology distributed over a network of mobile devices (Yuan and Detlor 2005). Typically, though, CRSs and MCRSs do not accommodate including independent parties such as unaffiliated disaster volunteers. Thus, disaster volunteers and relief organizations often lack a bidirectional communication channel that could enable the exchange of relevant information, including information from various sensors embedded in mobile devices (e.g., GPS, accelerometers, microphones, magnetometers, cameras). Establishing such a communication channel could help improve information quality for all parties involved, resulting in more effective coordination of volunteers and, in turn, more efficient disaster management. This study strives to develop, in the context of the refugee crisis in Germany, a suitable design for MCRSs that will support managing disaster volunteers. We follow a design science approach (Hevner et al. 2004; Peffers et al. 2007) and employ software engineering methods to overcome the following problem: “The cooperation between relief organizations and disaster volunteers in the context of the refugee crisis suffers from poor coordination and communication between the parties involved.”

The remainder of this paper is structured as follows. The next section summarizes the study's foundations, including the theoretical background regarding disaster management and disaster volunteers. We then introduce our methodology, including our design research approach and the software engineering methods employed. The subsequent section discusses the form and function of a MCRS based on the requirements derived from our requirements elicitation process. This includes the conceptualization of generic design principles that address specified design requirements and the mapping of those principles to appropriate design features. We then delineate technical details and the appearance of the prototype system. Next, we describe the demonstration and evaluation of the artifact. The paper ends with a conclusion and an outlook for future research.

**Theoretical Background**

There are several components to consider when managing an emerging disaster. Lettieri et al. (2009) define disaster management as the body of policy and administrative decisions, operational activities, involved actors, and technologies that affect the various stages of a disaster at all levels. The traditional model of disaster management acknowledges that disastrous events evolve over the course of time (Mileti 1999). The management process can be divided into three temporal and logical phases characterized by specific goals and available resources (Hensgen et al. 2003; Robert and Lajtha 2002): pre-crisis, the period before a disaster occurs; crisis, a disaster's aftermath; and post-crisis, the period between a crisis dissolving and the return to a normal state. The reference model for the process of disaster management also describes several phases before, during, or after an event (Hensgen et al. 2003; McEntire et al. 2002; Mileti 1999; Shaluf et al. 2003). The first phase, mitigation, is particularly important before a crisis develops. It aims to minimize risk, prevent disasters, and reduce vulnerabilities by deploying assessment and risk reduction (Dai et al. 2002). Preparedness is also a critical function during the mitigation period; it involves training responders and people in general for post-disaster activities (Simpson 2002). Crisis response, the second management phase, comprises the management and control of numerous effects in the midst of a disaster to decrease the loss of life and property; its main functions are evacuation, sheltering, medical care, search and rescue, property protection, and damage control. After a disaster, in the recovery phase, steps are taken to return disrupted areas to normalcy.

Shaluf (2007) identifies three general types of disastrous events. Natural disasters are catastrophic events caused by natural events (e.g., hurricanes, earthquakes) and are therefore beyond human control. In contrast, man-made disasters result from human decision making and can emerge suddenly or after building up over a longer period, and both may persist thereafter (Shaluf 2007). A third dimension, hybrid disasters, is the combination of the previous types. Moreover, Shaluf states that natural and/or man-made disasters sometimes trigger so-called subsequent disasters. In these cases, the population suffers additionally from indirect effects of an event, which further complicates the resolution of the
original problem at hand. Shaluf (2007) accentuates moving and displaced people as an example for subsequent disasters.

Due to the increasing number of non-natural disasters (Coleman 2006), the need for paid relief workers may soon exceed the number available, making volunteers an essential component of disaster response and recovery. According to relief organization employees we consulted at an early stage in our design study, disaster volunteers appear mainly during the crisis response phase. These employees also indicated that disaster volunteers are not suitable for short-term crises due to these crises’ critical nature. Longer-term scenarios, however, offer considerable potential for using volunteers. The ongoing refugee situation in Germany is an example of a crisis with serious consequences for the affected population spread over a long period. In 2015, some 1.1 million displaced persons entered Germany across its southern borders, and nearly 500,000 have applied for asylum in the country (BAMF 2016). This confronts authorities with a heavy administrative burden (Eddy and Johannsen 2015); without the assistance of local volunteers, they would not be in a position to manage the flow of refugees.

In this study, we focus on disaster volunteers who are not directly affiliated with official disaster relief organizations and volunteer spontaneously. These individuals, autonomous and erratic in nature, form self-organized, ad-hoc groups. In addition, relief organizations involved in our study observed an increasing occurrence of this type of disaster volunteering in long-term crises.

Preceding events, however, have shown there is significant potential for conflicts between authorities and spontaneous helpers, mainly because of organizational aspects in the context of coordinating volunteer work (Sargisson et al. 2012). Spontaneous helpers are an unknown variable in this context. Therefore, it is essential to define and characterize disaster volunteers. Disaster volunteers, within the scope of the refugee crisis, are individuals who engage in volunteering tasks such as distributing food and clothing or working at refugee reception centers. St. John and Fuchs (2002, p. 400) identify several specific types of likely volunteer activities during all kinds of crises: donations of blood and money, providing professional as well as non-professional goods and services, and offering time or services to organizations helping with relief efforts. It is also important to know what motivates individuals to volunteer. Wilson (2000, p. 215) generally defines volunteering as “any activity in which time is given freely to benefit another person, group, or organization” and states that it is proactive rather than reactive. Sawtell et al. (2010) shed light on the multifaceted nature of motivation for volunteering (Dolnicar and Randle 2007; Yeung 2004). They state that motivation can be based on altruism and/or self-benefit in the form of a desire to learn new skills or fulfill obligations based on religious beliefs. Sawtell et al. (2010) also identify several complex reasons for autonomous help, including the lack of bureaucratic constraints, practical aspects of aid, friendship, and demonstrating social justice principles.

The entirety of volunteer helpers’ characteristics, activities, and motivations should be regarded when building a MCRS for the management of disaster volunteers and should help shape data-gathering efforts such as interviews.

**Methodology**

The present study strives to develop a suitable design for MCRSs that will support the management of disaster volunteers. We followed the design science approach (Hevner et al. 2004; Peffers et al. 2007) and generated a conceptual design based on knowledge drawn from theoretical and practical sources. This research-in-progress paper covers the first four phases introduced by (Peffers et al. 2007): problem identification and motivation, objectives of a solution, design and development, and demonstration (see Figure 1). Based on our design and the feedback from early prototype demonstrations, we lay the foundation for the remaining phases: a rigorous demonstration and evaluation of our design and the communication of our findings. In the following section, we briefly describe the goals and methods of each phase of our research design.

The goal of the problem identification and motivation phase is to formulate a motivation to justify the value of a solution, provide a clear definition of the problem (see page 2), and limit the study’s scope. In this phase, we primarily followed a problem-driven approach and conducted open interviews (King and Horrocks 2010) and expert workshops (Alexander and Beus-Dukic 2009) with official representatives from three of the largest relief organizations in Germany (German Red Cross, Johanniter-Unfall-Hilfe, Arbeiter-Samariter-Bund) to investigate the challenges arising in coordinating volunteer helpers in the
context of the refugee crisis in Germany. This approach has enabled us to develop a clear understanding of the problem and secure stakeholder support throughout the design process in an early stage of the research project.

In the second phase, we aim to determine the objectives of a solution for the previously specified problem to define what is necessary, possible, and feasible. To achieve this goal, we followed a theory-driven approach and thoroughly reviewed related literature. In addition, we adopted a problem-driven approach and conducted a second round of interviews with stakeholders. In our literature review, we analyzed research on existing CRS solutions to identify their limitations and potential challenges for our own approach. We used the results and findings to refine the idea of an adequate software solution.

We next conducted semi-structured telephone interviews using open-ended questions to develop the conceptual MCRS design (King and Horrocks 2010). We invited participants from three stakeholder groups. The first interviewee group consisted of four relief organization employees operating on a national level who deal mainly with management and monitoring tasks. The second group was five employees with field experience functioning as experts; they constituted the professional part of the final on-site user group. The employees in both the first and second groups are members of three of the largest relief organizations in Germany. The last group included two disaster volunteers who help at various events and therefore have specific insights from their perspective as non-employees. In the first part of the interviews, we used the same general guidelines with all participants. Each participant was questioned about the situation during a disastrous event, the functions they would expect of a MCRS, characteristic problems, communication issues, and critical factors. Questions in the second part emphasized participants’ individual roles and requirements in a crisis scenario. The interviews with the first group focused on administrative aspects. The topics for the second group also covered the organization of disaster volunteers. With the third group, other important aspects in the interviews included motivations for offering help and possible barriers that hinder volunteers’ efforts. The interviews provided us with practical expert knowledge and supplementary insights about users' motivation to adopt a corresponding software solution, and also identified potential obstacles that might prevent its use. Further, in tandem with the interview participants, we formulated user stories to describe the functionality of individual requirements and facilitate discussion about them (Cohn 2004). These results formed the basis for the next step.

The goal of the design and development phase is to derive the design requirements for an artifact to solve the problem identified as well as guide implementation of the artifact. To derive the design requirements for the artifact, we analyzed the data collected in the preceding phases in three consecutive steps. In the first step, descriptive coding, we extracted from the interview transcripts detailed requirements, challenges, and further information regarding the problem context. In the second step, interpretive coding, we aggregated the descriptive codes to higher-level concepts. The last step included defining overarching themes, that is, recurring motives; these build the basis for defining final functional and non-functional requirements (King and Horrocks 2010).

Functional requirements describe services a system should provide, how it should react to particular inputs, and how it should behave in particular situations; non-functional requirements describe constraints on services or functions and often apply to a system as a whole, not to individual features or services (Sommerville 2007, p. 119). We developed functional and non-functional requirements based on
the approach proposed by Meth et al. (2015). In the first step, design requirements are developed by integrating the identified overarching themes. Meth et al. (2015) specify design requirements as comprising generic requirements that any artifact instantiated from this design should meet; these are closely associated with the meta-requirements concept depicted by Walls et al. (1992), as well as with general requirements, which Baskerville and Pries-Heje (2010) describe. Following Meth et al. (2015), we translated these requirements into general design principles that describe the main functions of the conceptualized system in a generic and abstract manner. Design principles are related to the concept of meta-design described by Walls et al. (1992) and general components depicted by Baskerville and Pries-Heje (2010). Further, we mapped these principles to concrete design features that would eventually constitute specific ways to implement a design principle in an actual artifact. Finally, we implemented an initial prototype of the artifact based on the results of this phase.

The final phase covered by this research-in-progress paper is demonstration, in which we aim to present the artifact to a diverse audience to prove its suitability to solve one or more aspects of the problem and to gather feedback on implementation. To date, as part of a project milestone in July 2016, we have conducted one expert workshop to demonstrate the artifact to stakeholders and solicit their initial feedback. The workshop brought together three relief organization employees involved in the project and five representatives of similar research projects to discuss the current state of the prototype system. Informed by this input, we aim to improve the concept and the corresponding prototype in subsequent iterations with a more diverse audience.

Evaluation and communication are the phases of our design research approach that remain. The former includes measuring meaningful characteristics of the instantiation to determine its adequacy for the specified problem (March and Smith 1995). This component forms the basis for upcoming iterations of our research approach. The latter comprises the final presentation of the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences (Peffers et al. 2007). Both phases are excluded from this paper and constitute tasks of ongoing research (see Planned Evaluation, Experimental Design, and Ongoing Research, below).

Designing a Mobile Crisis Response System

In this section, we present the aggregated results of the first three research phases in the form of functional and non-functional design requirements. In addition, we provide user stories to illustrate each requirement; a more comprehensive presentation of the data gathered in the first two phases would exceed the space limitations of this paper.

**Functional Design Requirements, Principles, and Features**

The first functional design requirement (FDR) specifies the need to improve the registration process (FDR 1) in terms of procedure and data comprehensiveness, necessary because existing processes used by relief organizations to manage disaster volunteers need to be revised and converted into digital form. Typically today, individuals who want to help contact a responsible relief organization employee via e-mail, telephone, or sometimes even directly at an operation. This leads to inconsistent and insufficient information about spontaneous helpers, thus burdening the organization with additional chores to collect information and consolidate it in a database. The need for FDR 1 is illustrated by the following statement from a user story: “Disaster volunteers should be able to register themselves at an early stage by providing their full name and address.” The second FDR specifies the need to improve the provision of information (FDR 2) to disaster volunteers and relief organization employees. Interviewees focused on the provision of preparatory information for disaster volunteers, which helps answer common questions as well as manage their expectations. Automating this with a supporting system relieves relief organization employees from having to deal with redundant inquiries, and helps ensure volunteers have a better sense of what to expect during their involvement. At a later stage, this FDR also involves simple instructions for recurring tasks, such as helping with food distribution at a refugee accommodation. For the heads of operations of relief organizations, this requirement involves the presentation of data about volunteers. The following user story motivates the first part of FDR 2: “Relief workers should be able to provide event- and task-specific information for disaster volunteers.” The third FDR addresses the need to improve communication (FDR 3) between disaster volunteers and relief organization employees by establishing a bidirectional communication channel. In our interviews, volunteers and employees emphasized the importance of
Another FDR focuses on the need to facilitate collaboration between the actors involved by enhancing the availability of information. Consequently, the first user story follows: “Relief workers should be able to display current key performance indicators about ongoing operations.”

This FDR is, in part, based in the following user story: “A disaster volunteer should be able to apply for a specific task created by a relief worker.” The last FDR addresses the need to improve the coordination process (FDR 4) in terms of effectively and efficiently matching supply and demand. For the most part today, assigning activities as they arise, both to individuals or groups of volunteers, is done verbally. Interviewees reported that initial efforts to establish online allocation systems to match available resources with pending tasks have shown promising results. A system for managing spontaneous helpers should be coordinated on a unified and standardized platform. This involves creating new tasks, listing relevant entries for helpers, and defining an appropriate matching process. In this regard, a regulated procedure should control the sequence of necessary actions. This FDR is, in part, based in the following user story: “A disaster volunteer should be able to apply for a specific task created by a relief worker.”

The interviews revealed that current registration processes involve extremely long waiting periods. One participant reported that it took eight weeks before individuals who volunteered during times of local crisis could be engaged in work. Furthermore, independent volunteers do not want to spend time filling out numerous forms or complete a registration process, and also have privacy concerns. These barriers lead to decreased motivation and intent to collaborate on the part of volunteers. Other issues involved in this NFDR relate to insurance concerns, data privacy, responsibilities, and general legal aspects. This requirement is connected to the following user story “A system should simplify the registration process for disaster volunteers by removing common possible obstacles during the traditional process.” The second NFDR goes hand in hand with the first one. It is derived from the overarching theme demanding increased volunteer motivation (NFDR 2). As one interviewee mentioned, independent volunteers offer their time and work for free and are therefore flexible in two ways. They appear immediately when critical situations emerge, but they sometimes disappear just as quickly if they are dissatisfied. Hence, this NFDR has several elements, including reducing potential barriers, managing expectations, and optimizing the registration process. A system for managing disaster volunteers should enable the facilitation of incentives such as autonomous work, data privacy, and sufficient insurance coverage during an operation. Another way to motivate volunteers is to use adjusted speech when addressing users. Interviewees emphasized that disaster volunteers want to be appreciated for their work. Messages should therefore reflect this acknowledgment. The corresponding user story for this requirement is as follows: “A system should encourage disaster volunteers to continue...”

Non-functional Design Principles, Requirements, and Features

The first non-functional design requirement (NFDR) is based on the overarching theme concerned with reducing administrative barriers (NFDR 1). The interviews revealed that current registration processes involve extremely long waiting periods. One participant reported that it took eight weeks before individuals who volunteered during times of local crisis could be engaged in work. Furthermore, independent volunteers do not want to spend time filling out numerous forms or complete a registration process, and also have privacy concerns. These barriers lead to decreased motivation and intent to collaborate on the part of volunteers. Other issues involved in this NFDR relate to insurance concerns, data privacy, responsibilities, and general legal aspects. This requirement is connected to the following user story “A system should simplify the registration process for disaster volunteers by removing common possible obstacles during the traditional process.” The second NFDR goes hand in hand with the first one. It is derived from the overarching theme demanding increased volunteer motivation (NFDR 2). As one interviewee mentioned, independent volunteers offer their time and work for free and are therefore flexible in two ways. They appear immediately when critical situations emerge, but they sometimes disappear just as quickly if they are dissatisfied. Hence, this NFDR has several elements, including reducing potential barriers, managing expectations, and optimizing the registration process. A system for managing disaster volunteers should enable the facilitation of incentives such as autonomous work, data privacy, and sufficient insurance coverage during an operation. Another way to motivate volunteers is to use adjusted speech when addressing users. Interviewees emphasized that disaster volunteers want to be appreciated for their work. Messages should therefore reflect this acknowledgment. The corresponding user story for this requirement is as follows: “A system should encourage disaster volunteers to continue...”
NFDRs 1 and 2 are similar in that they aim to uphold volunteer commitment as they work to support disaster relief efforts. NFDR 1 contributes to this by reducing obstacles that hinder volunteer involvement in relief organization operations. NFDR 2 specifies the need for ongoing motivation, support for collaboration between the parties involved, and integration of volunteers. Both non-functional design requirements address the engagement of disaster volunteers and contribute to the collaboration of established relief organizations with individual spontaneous helpers. Hence, we derive from this the non-functional design principle (NFDP) to maintain engagement (NFDP 1) so the workforce of disaster volunteers can be utilized in an effective and efficient manner. Figure 3 shows the connections between these non-functional design requirements and this corresponding non-functional design principle, as well as derived non-functional design features that address the demands identified. As with the FDFs in figure 2, we propose in figure 3 five such NFDFs as examples to address the needs identified, but the list could be adjusted or extended. Further, these features describe characteristics of the system as a whole, as they are derived from non-functional requirements (Sommerville 2007, p.119). For instance, the interviewees described the importance of privacy as a general concept for the MCRS, which includes a sophisticated concept for access privileges, complete data control for individual users, and exclusion of data transfers to third-party systems.

Prototype System

A mobile crisis response system for disaster volunteers has to account for their independence and spontaneity. Therefore, we implemented a prototype system as “mobile first” solution by means of a responsive web application with a lightweight user management system. This system allows for ad-hoc access using mobile and other devices (e.g., desktop computers). Figure 4 shows examples of screenshots of the prototype system. The screenshot on the left displays (here, in desktop mode) information about an event observed by relief agencies. It demonstrates the provision of key performance indicators (FDF 3) in an aggregated form summarizing data from subordinate tasks (FDF 4). This screenshot also shows the implementation of general communication (FDF 8) via an event-based message board. The screenshot on the right shows the mobile version, here zoomed in on a specific task for which a disaster volunteer...
applied. Users can apply for tasks created by relief workers (FDF 5) based on their qualifications entered during the registration process (FDF 1). Collaborating users are able to communicate at a task level by writing comments (FDF 7). The details and comments connected to a task are visible only to participating users as one measure to enable data privacy (NFDF 2) and reduce complexity (NFDF 3).

Figure 3. Non-functional design requirements, principles, and features.

Figure 4. User interface of the prototype system (desktop and mobile version)
**Planned Evaluation, Experimental Design, and Ongoing Research**

We plan to conduct an additional workshop to demonstrate the artifact. Participants will include relief organization employees, experts with experience managing disaster volunteers, and members of research groups involved in similar projects. The outcomes of this workshop will be used to make additional refinements to the system we have developed. If the artifact deviates too strongly from expectations, we will go back to the design and development phase to improve the artifact based on feedback. Otherwise, the study can proceed to the evaluation phase.

The goal of the evaluation phase is to demonstrate rigorously the utility, quality, and efficacy of the designed artifact using accurate methods (Hevner et al. 2004). We will conduct a field experiment to observe and measure how well the artifact supports disaster relief efforts under simulated but realistic conditions. During a large-scale mission exercise performed by the involved disaster relief agencies, two independently operating teams will participate in a disaster scenario. The control team will use conventional methods for managing disaster volunteers, while the other team will manage volunteers employing the artifact. Participants will be drawn from available employees of the relief agencies, who will be assigned randomly to one of the groups. Two randomly formed groups of civilian participants will be assigned to each of the two teams and take on the role of the disaster volunteers. The details of the evaluation will be designed in cooperation with the relief agencies and, in part, based on their existing evaluation systems for such exercises. Both groups of participants, volunteers and employees, will include participants in our earlier expert workshops and interviews. If the results of the evaluation deviate too strongly from our expectations and the external instantiation does not appropriately address the identified problem, we will repeat the build-and-evaluate loop (Markus et al. 2002) based on the evaluation feedback.

**Conclusion**

As discussed in the introduction, the focus of this research-in-progress paper is on deriving a theoretically grounded MCRS design formulated for the specified problem. To complete the study, our ongoing research needs to evaluate an artifact based on this design. In particular, ongoing research needs to assess whether management of disaster volunteers supported by the artifact developed actually increases the effectiveness and efficiency of collaboration compared to existing manual methods. We propose a collection of functional and non-functional design principles that inform future development and instantiation of MCRSSs. This research also introduces specific design features that constitute the form and function of an appropriate system. Building on the design requirements, principles, and features, we develop an artifact and provide an experimental design for the planned evaluation.

To interpret the implications of these research results, readers should consider the following limitations of our study. Its focus is on the first half of the design science methodology introduced by Peffers et al. (2007), namely problem identification and motivation, objectives of a solution, design and development, and parts of the demonstration. The evaluation of a corresponding external instantiation is excluded. However, this paper proposes recommendations for this phase and thus provides some guidance for future research. Thorough evaluation will show whether the identified requirements are met by prototypes that will be developed based on the suggested principles and features. Furthermore, it will help in analyzing the suitability of the specified solution.

The proposed design is dedicated to volunteering in the context of the current refugee situation in Germany. Choosing a more general context could result in different or additional design requirements and principles. With few changes, however, the design could also be generalized and applied to other crisis- and disaster-related contexts. This is assured by the high degree of aggregation regarding the derived functional and non-functional design principles and features.

In addition to improvements to the recommended conceptual design, there are many possibilities for extending this research. Future studies could broaden the current design by conducting additional design cycles, each utilizing a different theoretical focus and research concept. This diversification facilitates supplementary contributions to both practitioners and scientists by approaching the topic from diverse perspectives.
References


