An Introduction for System Developers to Volunteer Roles in Crisis Response and Recovery

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ABSTRACT

Technological advances, such as software tools for citizen reporting, first responder support, and online collaborative information management and mapping, are enabling new or improved forms of volunteering in humanitarian crisis. However, the change is largely driven by the technical community and many proposed solutions are never integrated into community response efforts, indicating mismatches between designs and real world needs. This paper offers readers with a technical background insight into roles, goals and constraints of humanitarian crisis response. In particular, we present three seemingly conflicting views regarding how citizens can contribute to response activities as spontaneous volunteers. With examples from two field studies and grounded in literature review, we integrate the three viewpoints into a framework explaining how the roles of volunteers and trained professionals shift with increasing severity and scale of a crisis. Based on this framework, we also discuss high-level opportunities for supporting crisis response with new software tools.

Keywords

Crisis management, disaster response, volunteering, collaboration, system development, developer guidelines

INTRODUCTION

Volunteering is a natural part of human society that it is defined by the United Nations General Assembly as activities that are of benefit to others outside of the household, which are carried out by free will and without being motivated by financial reward [33]. In communities affected by crisis or disaster, volunteering can take many forms. Whether the crisis is a small emergency such as a car crash, or a major disaster such as an earthquake, volunteering citizens form the first line of response before trained professionals arrive at the scene to help those in need. During larger-scale events, significant parts of the recovery efforts are also often handled by volunteer organizations such as the Red Cross or people with a general desire to help who arrive from outside of the affected community [1].

Though many disaster volunteers may lack formal training in emergency response, some are highly trained in skills that may be of use in response activities, such as counseling, geographic information systems (GIS), healthcare, construction or operation of heavy machinery. They may be affiliated with a volunteer organization, either by having previously registered to receive training in advance or by enlisting with an organization during the disaster. Alternatively, they may be unaffiliated and on their own initiative attempt to help without any form of centralized coordination. Organizations can also volunteer, by offering their services, equipment or staff for use in response without financial compensation. In addition, volunteers can come both from within the affected community, in which case they bring important local knowledge to the response, or arrive from outside of the community with a general desire to help. [4, 9, 33, 36].

Stallings and Quarantelli [31] determined that there are three major activities of emergent groups during response: damage assessment, operations and coordination. In practice, this typically consists of small-scale and low-risk operational activities such as clearing debris, provision of food and supplies, driving and transportation, emotional support for victims, medical and psychological aid, building and construction, lightweight search and rescue, animal rescue, searching for lost personal items, translation, registering volunteers and matching needs with skills, and data entry [1, 4, 5]. More complex activities have also been documented, including setting up wireless communication infrastructure [40], and setting up and operating a disaster relief center as well as a new bus route for transportation [39]. Aguirre (as cited in [9]) also describes an instance of volunteers developing an

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

874

ad-hoc logistics network.

Advances in Internet and Communication Technologies (ICT) have also enabled new forms of online volunteering that are in many ways reshaping the crisis management landscape. A recent report [15] summarizes emerging approaches to disaster volunteering and provides a detailed account of how in the aftermath of the 2010 Haiti earthquake several new technologies were for the first time combined into effective systems for disaster response. Despite severely damaged local infrastructure, many victims were able to send reports of needs via SMS to Twitter. Members of the Haitian diaspora in the United States then translated the reports from the native Creole into English. Others collected and entered them into the Ushahidi [34] platform, which lets users enter reports, annotate them with basic meta-data such as location, and present the reports on a map with topic filters. Online volunteers also used the Open Street Map platform to construct new digital base maps based on high-resolution satellite imagery of the disaster area that was made available. The United Nations Office for Coordination of Humanitarian Affairs (OCHA) has credited volunteers and the tech. community with collecting more information during the first 48 hours of disasters than OCHA normally does during the first week [35].

With such rapid development of new tools and technologies, research on online disaster volunteering has mostly focused on documenting how communities have made use of different communication platforms in disaster. Examples include studies of discussion forums [26], Flickr [19], Twitter [17, 23, 32], and combinations of several platforms [25]. Some researchers have argued the need for particular new types of systems [30, 41] and several projects have produced software tools and prototypes to improve different aspects of information management in disaster [15, 11, 21, 29, 34, 38].

However, few of these proposed tools have gained widespread use in practice, indicating a mismatch between system functionality and actual needs. A recent report by OCHA [35] also highlights that research is needed to further document decision makers' needs as well as outlining suitable procedures for volunteer management. In addition, we find almost no literature that discusses how officials should interact with or support online volunteers, how online information systems in use relate to on-the-ground disaster response, or whether such volunteer-based information management is indeed beneficial during all humanitarian crises.

A rigorous understanding of user roles, goals, context, environmental and technological constraints is a prerequisite for any successful development of complex software tools. Within the disaster response community there is however a tendency for new software platforms to be developed not by experienced disaster response professionals, but by members of a growing technical community who possesses technical expertise but lacks relevant field experience as crisis responders.

The main contribution of this paper is an overview of the roles of volunteers and trained professionals in response to humanitarian crises, as well as how these roles change with variations in scale and complexity of the crisis. The overview is targeted at readers with a technical background who wish to develop systems that support effective response, information management and collaboration by any of the covered stakeholders; trained professionals, victims, community members or remote online volunteers. Such an overview is primarily helpful for developers to better select specific use cases to focus on and to design features that better match real world constraints in a domain where standard observational techniques are often expensive, difficult or even dangerous to apply.

Scope

The scope of this paper is primarily the interactions between professional disaster response organizations and unaffiliated/untrained spontaneous volunteers from within an affected community. Other forms of volunteering are significant, however. For instance, a discussion of unaffiliated external volunteers who arrive at the scene following a disaster is presented in [36]. Similarly, the integration of trained disaster volunteers affiliated with volunteer organizations or professional response organizations is discussed in [2], while a broader study of volunteering in general is presented in [33].

In addition, crisis management consists of several stages, including mitigation, preparedness, response and recovery. This paper only aims to provide guidance for developers of technical tools for empowering communities in the response and recovery phases. Use cases in the remaining phases are left for future work.

FIELD OBSERVATIONS

Two field studies are presented, covering the roles of professional response organizations and spontaneous volunteers in response to emergencies and disasters that affect the community. Both studies are from the Portuguese island of Madeira, which is an autonomous region relatively isolated from the mainland, making it suitable for holistic community studies. The studies illustrate several opportunities for how professional and

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

875

volunteer interaction can be increased and improved, and the observations particularly help us understand how information management systems targeted also at volunteers can help communities coordinate their response and better recover from disasters that overwhelm the community's official response capacity.

February 2010 Floods

The island of Madeira is exceptionally mountainous and cities and villages are typically located in valleys or along the coast, where water from the mountains forms natural or artificial rivers that pass through the centers of the populated areas. Madeira has a population of 268,000, of which half lives in or near the regional capital, Funchal. In February 2010 the island was hit by unanticipated and extremely high rainfall, resulting in water surging down from the mountains and causing flash floods that overwhelmed the riverbanks and flood protection systems in many populated areas. Funchal was hardest hit, but damage was also recorded around the island, including one village reachable only through a tunnel, which remained isolated for days until the army broke through the obstacles. According to the local Civil Defense organization, the community had very little experience with this type of event, and therefore the local resilience was relatively low. Although less than 100 people died, the floods caused significant damage to infrastructure and homes, and many people were temporarily displaced.

Approximately 12 months after the floods, reports were collected from articles in local newspapers, status updates and photo albums on social media, and online video-sharing sites. The videos proved to be particularly informative, as locals were recorded discussing events at the time and location of the recording. In-depth semi-structured interviews were held with a flood victim living in the most affected street of Funchal, a person living further from the center, and twice with a manager from the local emergency response organization. Interviews were audio recorded and selected sections were transcribed. Because the authors themselves are residents of the affected community, the conclusions are also based on informal discussions with approximately 18 victims, five spontaneous volunteers and ten professional emergency responders, and follow-up questions were asked to verify the details reported in this paper. In most cases, the subjects had first-hand experiences only from within Funchal. Together, these sources helped us piece together the "big picture" of the event, as well as the response efforts that took place by volunteers and professionals. Here we describe our findings in relation to the roles and responsibilities of officials and volunteers in the community's response to the disaster, and the interaction between these two groups.

Community Recovery through Parallel Efforts

While most non-officials perceived that officials had used their resources well and had responded rapidly to the event, the floods quickly reached a point that overwhelmed the official emergency response resources and professional responders were forced to prioritize. According to the Civil Defense organization, most resources were deployed in the hardest hit areas of Funchal, while in some remote or less affected locations no official response was present until days after the floods hit. Official efforts made use of heavy machinery for redirecting torrents of water, mud and rocks away from critical facilities, clearing canals and waterways from debris, and performing search and rescue operations for victims trapped in flooded buildings. Additional resources were incorporated into the organization, such as construction equipment with civilian operators, but these were paid for rather than volunteered.

Our data however shows that due to the large scale and mostly low severity of the damage, most of the cleanup was in fact handled through a great number of small-scale response efforts by spontaneous volunteers. Victims took care of their own property, and locals who were not first-hand victims supported those in greater need. Mostly they cleaned mud and water from affected basements belonging to relatives, friends, neighbors, acquaintances or employers. Though improvised, some of these efforts were relatively well organized. For example, one effort centered on a large office building and involved over 50 people, with equipment such as shovels, buckets and brooms being provided to volunteers on arrival.

One interviewee from Funchal described calling emergency services to request help with his flooded basement, but was informed that all resources were deployed elsewhere and no help was available. He and his family then began cleaning what they could, and soon neighbors joined. TV footage showing his affected street led some of his friends to infer that he may be in need of assistance and they too arrived to help. The interviewee described how his self-confidence increased and his perceived need for official help decreased as the results of their collaborative efforts began to materialize. This is one of several reports we have on how members of the community first became aware that no official help was available and then how groups emerged to handle localized response and to gather and distribute resources such as freshwater, tools, as well as information such as when water and electricity was expected to return.

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

876

Several victims told us how official sources including the SOS call center were unable to provide them with useful information, or were completely unreachable in the case of the local electricity company. Many reported that in the absence of better sources they had approached operational personnel on the ground to seek out contextual information and advice, but that officials too lacked sufficient situational awareness. Others told us they felt police were giving them inaccurate or outdated information and that as a consequence their trust in the official capacity decreased.

An interviewee who lived in one of the hardest hit streets described how he lacked sufficient information and situation awareness to make an informed decision regarding whether to leave home or not. Though he was in contact with several professionals on the ground and had access to local public radio and phone communication, the information he managed to collect was not specific enough to offer him or his family any guidance. What he wanted to know was "*what are they doing, is the electricity coming back, what's the dimension of this, [and] when is everything going to be alright again*". 24 hours after the flooding began, the family's situation awareness was still extremely limited and, despite fear of looting, the family finally decided to evacuate to a hotel. Only there did they became aware of the magnitude of the disaster, from watching citizen footage on YouTube and by talking to others who were better informed. The interviewee explained that in future disasters, he "*would just take [his] stuff and leave the house*" as "*it is not worth staying at home if you have zero information*". The family inferred that it was safe to return to their home after passing TV footage of their area revealed that their street was being cleared. Regarding how the officials handled the response, he explained that "*I really don't think the municipality could have done more, except for the information part. There should be preventive information, or reactive information at the time it was happening, so people would go out of their houses.*"

Despite the prevalence of spontaneous volunteerism and the general satisfaction among non-officials regarding the official response, the only evidence we have of any collaboration between spontaneous volunteers and professional responders is a single video clip in which locals assist firemen searching for survivors and retrieving a corpse. A manager from the Civil Defense reported that a group of volunteers had been in touch with him, but that he refused their assistance due to being too busy to find tasks for and supervise volunteers. One interviewee living in an unaffected area of Funchal also expressed how she wanted to do something to help, but did not know how or who to contact, and she was afraid that if she was to volunteer she might get in the way of officials. This gave her a strong feeling of inadequacy.

October 2011 Full-Scale Exercise

Our second field study is of a full-scale emergency training exercise held in Madeira in 2011 by the Civil Defense authority. This was conducted in accordance to international security norms of civil aviation and had the following emergency scenario. On the 22nd of October 2011, at 09:00 an A330 aircraft carrying 147 civilian passengers and eight crew members was approaching Madeira's airport for landing, but had a technical problem that resulted in a controlled emergency landing in the ocean (ditching) around 10 km from the airport. As the plane ditched, an alert was given by the Airport Operations and Services to the Civil Defense (SOS). Out of the 155 victims, 48 died on impact, 83 were injured and 3 were missing.

All emergency handling procedures were initiated and coordinated by the Civil Defense and one of the key goals of this exercise was to train interaction between the different entities expected to take part in response to a major emergency affecting the community; civil defense, several fire departments including volunteer sea rescue, navy, fast medical intervention, local hospitals, social security services and the Red Cross. Rescue activities took place on water, land and air and were centered on rescuing victims from the water at the crash site, transporting them to land for physical and psychological examination, and transporting injured victims to a nearby hospital.

An initial planning meeting was held with the Civil Defense and representatives from involved fire departments, sea rescue, medical team, military, and commanders at operational, tactical and strategic level, to get an understanding of the events that would take place during the exercise. Following this meeting, contextual inquiries [16] were conducted on-site during the exercise, covering the activities of the full six-hour time-window. Two researchers were located at the mobile strategic command center, which was a van in close proximity to the main exercise events. They directly observed the actions and decisions at the strategic level, and monitored communications between the strategic command and the subordinate operational command level. The observations from audio logs, photographs and paper notes were organized and the categorization was iterated by three researchers. Photographs of the operational activities were also collected to support understanding of the exercise as a whole.

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

877

Opportunities for Volunteer Integration in Full-scale Exercises

This exercise illustrates how communities allocate resources and training for handling emergencies up to a greatest expected scale, beyond which crises become disasters. Up to this scale, different official organizations have clearly defined roles and operate according to protocols that are gradually refined over time, and organizations strive to rapidly gain command and control of the situation using the resources the community has allocated to them.

Despite being a full-scale exercise designed to approach the limits of the response organization and to train interaction between all entities expected to take part in real response, we saw no presence of the spontaneous volunteer elements that were so prevalent during the 2010 floods, neither as a disruptive element, a resource, or an independent response entity. As external observers, we initially found this natural, as the emergency, while severe in nature, was well localized in time and space and trained professionals were available to respond.

However, with the flooding disaster in fresh memory we analyzed the response organization as a pipeline for transporting victims from the crash site to the hospital, and we quickly identified a clear bottleneck where incorporation of volunteer resources could have improved the capacity of the response and likely saved lives, had it been a real emergency. The location of the ditched plane was relatively far from the area where medical facilities had been set up, and travel time between the two sites was significant in comparison to loading and unloading procedures. Due to the high number of passengers and the limited capacity of the two available rescue boats, multiple trips had to be made and several hours passed before all passengers could be transported safely to shore. However, the airport is located along the seashore with two nearby harbors reachable by boat in approximately five minutes. Requesting of additional vessels from either of these harbors, or simulation of volunteers spontaneously arriving at the crash site with boats, was not part of the exercise. The Civil Defense organization confirmed in discussions that integration of volunteered transportation resources in the described manner would indeed be beneficial in a real ditching event.

This example highlights how the professional emergency response organizations did not attempt to identify resource shortages which led to bottlenecks in their response effort, nor did they make any attempts to mitigate such shortages by requesting or making use of spontaneous volunteers around them. As this was the type of exercise that is specifically designed to prepare the community's responders for the greatest crises it will face, it partly explains the low levels of communication and collaboration between officials and spontaneous volunteers that were observed during the floods.

This exercise also allowed us to study the high-level information flow between different parts of the response organization. Much of this information related to the organization's own operations and is meant for internal purposes only, such as precise location and activities of staff and vehicles. For safety reasons this information should not leave the organization, nor can it realistically be tracked or reported by independent volunteers. Other information, such as the location, type and severity of the accident, as well as the presence or non-presence of trained responders, is not confidential and could thus be shared openly with the public. Often the public is also the source, for instance through SOS calls. Such information also bears close resemblance to that information which during the floods incentivized volunteering, and helped connect potential volunteers with suitable tasks.

THE SHIFTING ROLES OF VOLUNTEERS AND PROFESSIONALS IN CRISIS MANAGEMENT

If system developers wish to support crisis response, they need a grounded understanding of the responder groups likely to be present during response activities, their desirable actions and interactions and the types of information they require. Without such understanding, it is difficult for developers to define and select realistic use cases to guide the design, and system development becomes largely based on experimentation. We therefore reviewed literature to broaden the picture of interactions between spontaneous disaster volunteers how professional responders, to better understand the two roles and the challenges they face.

What emerged was three radically different viewpoints regarding the role of volunteers in crisis response; i) unsolicited volunteers are a disturbance for professional emergency responders, ii) volunteers are a valuable resource for response organizations to achieve scalability, and iii) independent efforts by spontaneous volunteers are critical for community recovery and trained professionals are a supporting resource during such response. This section presents the three viewpoints together with concrete examples from the case studies. We then present a continuous framework for the volunteer role that explains how spontaneous volunteers increasingly shoulder the responsibilities normally handled by professional responders, as the scale of emergency increases towards and beyond the capacity of the resources the community has dedicated to crisis management.

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

878

Volunteers as a Disruptive Element

Since the 1950s, the traditional model for disaster response has assumed that emergencies are characterized by chaos and that citizens affected by disaster are seen as victims who due to traumatization and inexperience with disaster conditions are unable to respond effectively to the new situation. Successful response is therefore dependent on intervention by specialist emergency response organizations that are capable of regaining command and control in these chaotic situations [6].

From this viewpoint, Halford et al. and Wenger (as cited in [20]) describe how the convergence of volunteers can be problematic to relief efforts, and even disruptive. Furthermore, Green [13] provides accounts from over ten studies of how independent unaffiliated volunteers, even when experienced in disaster response, may cause major management problems for the response organization, reduce overall efficiency, hamper coordination, expose responders to unnecessary risks, increases death tolls, and direct resources away from secondary needs. Untrained volunteers who approach response organizations to offer their capacity may themselves require more assistance from a strained organization than they contribute to the resolution of the problem, by requiring transportation, supervision and equipment. In short, the traditional model for professional emergency response treats professional teams as efficient units that ideally operate without volunteer involvement.

The studied community's professional response organization to a great extent shares this mindset. Managers and training protocols strongly emphasize the need for control and express great concern that involvement of unsolicited volunteers increases rather than reduces official workload, for instance if citizens involved in unsupervised response efforts injure themselves or hinder situational control.

Volunteers as a Resource

The view of volunteers primarily as a disruptive element has been criticized for its lack of scalability to meet large-scale needs that go beyond the capacity of official response organizations. Therefore, several authors have argued that officials should reach out to communities in non-disaster time to recruit, train and integrate volunteers into the operational structure [2, 10, 12].

This has been proposed as a cost-effective way of greatly scaling up the traditional organizational structure in time of great need, particularly suitable for responding to recurrent large-scale crises such as wildfires and earthquakes. Australian volunteer groups are able to field over 500,000 trained members throughout the country [8] and in China over 100 million volunteers have been registered and trained for disaster response [3]. Volunteers with less training can be assigned to routine tasks, letting professionals focus on the tasks they are most qualified for. Volunteers can also handle tasks that go beyond the official capacity, such as offering comfort and encouragement to victims and helping to recover pets and personal items. We note a connection between volunteer integration and creativity, with some work arguing that creative capacity should be enhanced through planning and training [18].

Two recent handbooks in disaster management [36, 37] note that volunteers will emerge in large-scale disaster regardless of the attitude of official response organizations. The handbooks then discuss how to best maintain official control in the presence of spontaneous volunteers. They include best practices for assessing volunteer skills and matching them with needs, keeping volunteers away until it is safe for them to enter affected areas, and integrating volunteers into official response efforts. However, these handbooks maintain the view of disaster-affected citizens mostly as victims and discuss volunteers almost exclusively as locals who have gone through pre-disaster registration and training, or as non-locals who arrive at the scene to help after the disaster has taken place. Neither handbook discusses how to collaborate with or empower victims who act on their own initiative as unaffiliated volunteers after a disaster has struck. According to the handbooks, untrained and unaffiliated volunteers should not be allowed to enter the disaster area during the early response phase as the risk of personal injury is too great.

In the studied community, we saw several opportunities for how this mindset could be put in practice. After the floods, heavy machinery was requested from local construction companies to support clearing of obstacles from canals. Similarly, during the plane ditching exercise, a shortage of rubber boats used to recover victims from the water could have been mitigated through requisition of vessels from nearby harbors. Early spontaneous volunteers who approached the crash site could also have been directed to a standby area, where a pool of resources would be available once safe and suitable tasks (e.g. transportation or data entry) have been identified.

Officials as a Resource for Volunteers

Critique has been directed also at the view of volunteers as a resource, arguing that its fundamental command and control approach is not a suitable model for response to larger disasters [27]. Organizations that coordinate

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

879

primarily by plan, including police, firefighters and volunteer organizations, often "refuse" non-traditional tasks in disaster situations. Rather than increase their capabilities to meet the increased demands, such organizations tend to accept only those demands that are within their present capabilities [7]. This is in part due to the difficulties naturally associated with integrating untrained volunteers into a strict hierarchical organization.

This is in full agreement with our observations from the field, where officials train primarily to gain control in emergency situations. During the flooding disaster, which was far too large-scale for all intervention to be controlled, the organization sought to satisfy its desire for control through isolation. Second, officials train to respond to events that are within the capacity of their organizations and to rely on available professional resources, and do not involve volunteer elements in training. Consequently, managers felt during the floods that potential volunteer integration was an additional burden, even when official resources were exhausted.

A study by the Australian Red Cross [4] revealed that two thirds of volunteers who approached the organization during two large-scale natural disasters were never used by the organization in actual response. An organization that considers volunteers only as a resource may see this as a surplus or a buffer for future needs, though two thirds of these unused volunteers reported having negative feelings such as disappointment, frustration and anger. This may not be surprising, as research has shown that volunteering has therapeutic effects for the volunteers themselves because it changes their role from that of a passive victim to actively contributing to resolve problems [20]. Correspondingly, our case study of the floods revealed disappointment among volunteers who approached officials offering their help, but whose offers were turned down.

When control is a prerequisite for action, response also becomes slower and deployment of official resources typically takes hours or days for larger disasters. Together with the organizational reluctance to handle problems outside of the traditional area of responsibility, this means that many needs have to be met by volunteers when dedicated resources are not yet deployed, exhausted or for other reasons unavailable [7]. Although the dominating view among professional emergency responders has been one of citizens affected by disaster as helpless victims, many are in fact highly active participants in the response [33]. Local volunteers form the first line of response and have the greatest chance to save lives and provide support immediately after the disaster. Therefore, community coordinators with critical expertise have a responsibility to help facilitate organized response, and their focus should be on coordination and collaboration rather than control [1, 27].

Spontaneous volunteers also contributed substantially to the flooded community's recovery, by taking over operational tasks which under normal circumstances would have been handled by trained professionals, such as draining flooded basements, clearing debris-covered streets and distributing supplies. For this they required awareness of needs that fell beyond the capacity of official responders, and coordination to match available resources with needs. In controllable situations, communication follows a mass-media pattern where official sources inform the public that everything is under control, to calm victims and to deter involvement. Official communication during the floods followed the same pattern, with high-level summaries of damage and intervention being disseminated over radio, TV, Internet and newspapers. Many community members however sought information that would better support their new role as independent disaster volunteers and instead relied extensively on personal contacts and phone calls, and partially on social media and passing TV footage, where informative details could be seen in the background.

AN INTEGRATED FRAMEWORK OF DISASTER VOLUNTEERING

The three presented viewpoints are better understood if considered in the light of the scale of a crisis in relation to the community's official response capacity. Most emergencies are small enough that one or a few trained operational teams can fully respond to the needs of the situation, such as a fire in a home where a subset of the community's firefighting resources are dispatched to respond, but also localized activities during greater disasters. When further professional resources are on standby but not deployed, there is no need for volunteer involvement and volunteers should be kept away from the emergency scene to avoid risks of injury and interference with trained operational behavior.

Since no volunteer intervention is desired once professional help arrives, the opportunity for technological support tools targeted at citizen use is mainly limited to citizen reporting and first responder support, for instance smartphone applications for locating automatic electronic defibrillators (AEDs). At the same time, developers should take care not to incentivize volunteer behavior that may hinder the operations of trained responders or to take unnecessary risks that may lead to increased victim counts.

As complexity and scale of emergencies increase, needs begin to approach or partly surpass the limits of the organization's capacity, which can introduce bottlenecks. During the observed plane ditching exercise this appeared in the form of an equipment shortage, specifically rubber boats used to recover victims from the ditched aircraft. This shortage was a clear bottleneck, as additional resources assigned to any other rescue

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

880

activity would have had no or very little impact on the overall effectiveness. Similarly, personnel shortages can appear, e.g. during light search and rescue missions that need to cover extensive ground.

The command and control paradigm is however still feasible during medium-scale emergencies and software tools that encourage independent unsolicited volunteering may be seen as disruptive by officials, in particular if volunteer activities directly overlap with official activities. Instead, there is an opportunity for tools that assist in rapidly gaining initial situation awareness, which can shorten the time until response begins, as well as tools that enable quick identification of bottlenecks, or helps index and match official needs with currently available volunteered resources.

Full-scale exercises can be used to refine software tools and prepare professional responders for creative use of volunteers, where the official command structure is maintained but where shortages and holes in the organization can be patched with volunteered resources. Real world success of software tools in this space will depend greatly on their inclusion in training exercises and shifts in official policy, which both dictate officials' operational behavior in real response. It is also extremely challenging for stressed emergency response managers to in the heat of ongoing response identify safe and novel ways to approach traditional tasks using volunteers.

As Britton [2] notes, it is impractical for a community to allocate too many resources for the sole purpose of countering the consequences of disaster. This implies that all communities will eventually face situations that go beyond the capacity of the official emergency response organization, first at operational and then at management level. Although volunteer efforts may be improvised and lacking in efficiency, the many parallel efforts become critical for successful community recovery and they should be encouraged. Both in our study of the floods and in literature, we also find that community members show great understanding for officials' limitations and willingly strive to find ways to handle lower priority tasks that they see fall beyond the capacity of professional responders.

During mass disasters, no single responder group has resources to reliably monitor the situation as a whole. Different stakeholders therefore need to be able to collaborate in collection, management and interpretation of situational reports and other information. Systems like Ushahidi [22, 34] and CrisisTracker [28] have proven their ability to contribute to timely situational awareness based on citizen reports collected during large-scale complex events. However, with the exception of OpenStreetMap [24], we are not aware of any tool that has been designed or used to facilitate sharing of a single common event model both among official responders and volunteers. In particular, future systems (and policies) should be designed to provide greater incentives for official responder organizations to share insensitive datasets openly with regular citizens.

The utility of citizen reports can also be improved by including report templates, clear examples and safety guidelines into reporting software. This way, volunteers are directly able to begin contributing to collective situation awareness without further directions from officials, who will be occupied with more pressing matters.

Systems that contribute to better awareness of current needs and ongoing responses enable new responders to converge to handle unmet needs. Some interviewees reported how they greatly underestimated the scale of the destruction during the floods until long after the initial event, and subsequently they overestimated the likelihood of receiving help. If policies and systems are designed to increase transparency of how response resources are and will be used, affected community members are better able to assess the severity of their own situation and earlier and better decisions can be made regarding both evacuation and volunteering.

Systems that connect documented best practices and safety advice with relevant responders can also be of great value, both for volunteers who partake in disaster response for the first time in their lives, and for professional responders who face specific challenges that have not previously been encountered within the community. The focus of such systems should be on knowledge transfer between communities. For instance, if lessons learned in one community affected by unanticipated floods can be documented in a central online repository, then those lessons can improve recovery from similar events in other communities if systems are capable of effectively matching them with relevant responders. For instance, Wiki articles describing documented response strategies to common classes of problems could be automatically paired with problem reports provided by citizens.

Finally, discussions with members of the Civil Defense highlighted that risk of volunteer injury is a primary concern behind discouragement of independent volunteer initiatives. Official acceptance of volunteers is likely to increase if systems can encourage volunteers to report their activities, skill sets and personal contact information, as this would enable officials to monitor activities and intervene where risk of injury is high. Accessible contact information would also support responders of all types to better coordinate their efforts.

CONCLUSION

This paper aims to give readers with a technical background an overview of the roles of volunteers and trained

Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013
T. Comes, F. Fiedrich, S. Fortier, J. Geldermann and T.Müller, eds.

881

professionals in response to humanitarian crises, as well as how these roles change with variations in scale and complexity of the crisis. We first presented two field studies of real and trained disaster response within a single community. These studies illustrate the contexts in which professional responders and volunteers operate and some of the common challenges they face. We then reviewed literature related to volunteering in humanitarian crisis and highlighted three seemingly conflicting viewpoints that developers may encounter when consulting literature. These viewpoints respectively claim that i) volunteers are a disruptive element for trained responders, ii) volunteers are a resource for professional responders, and iii) officials are a resource for community volunteers.

Examples from the field were then combined with further literature to reconcile the three viewpoints into a single framework, which explains how local (or remote) volunteers in practice increasingly take over the responsibilities of a community's response organizations as the community's needs go beyond the capacity of its trained responders. These responsibilities begin with basic operational tasks such as first aid and cleanup of debris, but extend all the way up to improvised hierarchical organizations for complex information and resource management. Based on this framework, we also discussed high-level opportunities for new software tools.

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882

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883