USERS NEEDS FOR COLLABORATIVE MANAGEMENT IN EMERGENCY INFORMATION SYSTEMS

Teresa Onorati, Alessio Malizia, Paloma Díaz and Ignacio Aedo

Computer Science Department, Universidad Carlos III de Madrid
Avda. de la Universidad 30, Leganés, Madrid, Spain

Abstract: The management of an emergency is a cooperative work that involves people from different areas and different roles. In this paper, we describe an empirical study based on surveys and interviews that have been done with users to study how to improve the collaborative functionalities of an existing system used for cooperating and sharing resources among different Spanish Emergency Management governmental agencies. The goal of the study was to understand how emergency workers cooperate in real emergencies and the kind of tools they are actually using, as well to identify potential strategies and technologies to improve the level of computer-supported collaboration.

1 INTRODUCTION

Emergency management is an example of collaborative work where participants could be geographically distributed. Governmental and non-governmental agencies from various nations share resources to manage a crisis in the most efficient way. Emergency workers can be subdivided in professionals or volunteers with a specific level of responsibility or role in the solution process and a specific kind of expertise and experience.

Computer Supported Cooperative Work (CSCW) might play an important role to coordinate all the people and the resources involved in an emergency. The scope of the management of an emergency is to obtain an efficient solution of the crisis, where efficient is referred to an optimal organization of the activities to perform and the resources to employ. To do this, a collaboration system is needed to support effective information sharing, decision making and communication (Waugh, 2006).

Beyond technical characteristics, it is important to consider psychological issues. In an emergency, feelings and behaviours of involved people can be different with respect to a normal situation. They are worried about the solution process and they need to work in a real-time full operating environment. In this scenario, the efficacy of the collaboration relies greatly on the ability to cope with the different ways of thinking and acting of participants. For these reasons, it is useful to interview emergency workers to collect information about the management of an emergency (e.g. a full description of different stages). In this article, we elaborate the information gathering process on interviews and surveys with emergency workers in different Spanish agencies.

Our objective is to analyse aspects about the relation between collaboration and emergency, like tools and communication devices used and how shared resources are managed. In next sections, we start describing related works and then we present our study about a possible characterization of collaboration in emergency management. We conducted an experiment with real users involved in an emergency situation to understand their needs. From these results, we eventually identify useful collaborative tools, adapting the time/space matrix (Dix et al., 2003, pp. 664-665) to the emergency management case.

2 COLLABORATION AND EMERGENCY

In these last years, many disasters, like the Hurricane Katrina, showed the limits of existing

emergency management systems. In (Waugh, 2006) authors present an interesting analysis about phases of the emergency management process. This analysis is based on a real example in United States. In general, a process to manage a crisis has: (1) to prevent or mitigate the impact of the disaster; (2) to prepare an emergency planning and training; (3) to respond with some specific activities; (4) to restore the situation with basic services.

In the past, all commands and controls were structured in a hierarchical way with a top-down approach, where few agencies were involved. Now, authority is shared among many organizations, responsibility is dispersed and resources are scattered. This new scenario needs a more dynamic and flexible network which could improve the collaboration among emergency workers. The role of collaboration is crucial to link all emergency management agencies dealing with a crisis or a potential catastrophic event. Moreover, all levels of a management process require collaboration: for example, local agencies need to create a trusted relationship between volunteers and communities.

In literature, there are many contributions that analyse how the collaboration can be improved in case of emergency. Nevertheless, last disasters have demonstrated that the most advanced information systems are not enough to support the faster relief of the affected populations. For this reason, researchers in emergency management start to rethink the role of information technology in emergency response. The development of a system consists of the following stages: design, development, usage and evaluation (Van De Walle, 2007). Moreover, one critical point for the emergency response is the time: the access to the system must be very fast and information must be always updated.

A relevant issue in emergency domain is that individuals during an emergency situation are under pressure: to absorb information rapidly, to judge its meaning and relevance and to make effective decisions about next actions. Based on these considerations, in (Carver, 2007) authors presents five important properties for emergency management: people involved feels they are exercising control; the focus of attention has to be on the problem, ignoring all that is not relevant; the improvisation is important to evaluate information and to formulate decisions; senses of challenge, curiosity, and enjoyment are important factors; depending on the critical nature of the problem, people feel more motivated to find a solution without losing time.

Manoj and Hubenko-Baker in (Manoj, 2007) identify and discuss technological, sociological, and organizational challenges to establish an efficient communication system during a crisis. The communication is the first way to respond to a disaster. Today, all local, state and federal agencies use radios to share information: the usage of orthogonal frequencies makes the communication very difficult. Authors in their research identify three categories of communication challenges: technological, sociological and organizational. These three factors guarantee an effective system to communicate in case of emergency.

3 THE EXPERIMENT: USERS NEEDS IN EMERGENCY

In this section, we describe the empirical study that has been done with emergency workers, submitting an on-line survey and a telephonic interview to a group of emergency workers. Involved participants have different profiles and roles in the emergency management process. Moreover, collected information is about: the usage of tools both in the work place and at home, the individual worker experience in the emergency management, the collaboration among emergency workers and a real participation to a crisis.

The information gathering process is organized in two phases. In the first one, thirty-two emergency workers and managers have been asked to fill a questionnaire via web. Questionnaires were anonymous and the privacy of collected information was guaranteed. At the end of this first phase, we have obtained eleven filled questionnaires. In the second phase, the same questionnaire was used for three telephonic interviews: in this case participants had the possibility to give us additional comments to questions proposed during the interview.

3.1 Participants

Participants to surveys and interviews were fourteen; they were all emergency workers or managers of agencies of Autonomous Communities and Cities (governmental authorities of Spanish regions) and of the central government.

We have chosen both professionals and volunteers, grouped into two different categories: in charge of Emergency and in charge of Command Post. Five participants belonged to the first group with different roles: area directors, responsible of

information systems and director of coordination room. The second group had nine participants, as coordinators of operations and services, technical experts, trainers and directors of command post. These two categories group together all kinds of employment in emergency management. It is a classification related to the location: at the office or at the command post. The emergency management experience of chosen participants is greater than five years: however six of them had less than ten years of experience.

3.2 The Survey

The survey is organized into five sections as summarized in Table 1. In general, the entire questionnaire is about the relationship between technologies, collaboration and emergency. The objective is described at the beginning of the survey: *to know and to understand users' functions and roles during the resolution of an emergency, as well as the influence of these roles when determining the information each user requires and her collaboration needs*. The completion is approximately twenty-five minutes.

Table 1: Questionnaire sections.

I. Experience with tools
II. Experience in emergency management as professional and volunteer
III. Kind of tasks performed according to her role and the emergency phase she is working at
IV. Features of the working place (physical and organizational) and of the collaboration
V. Description of tasks and technology used in the last participation in a real emergency

The first section of the questionnaire was about experience with tools: the frequency of use at the work place and at home. Considered tools were web browsing, electronic mail, video conference, audio conference, interactive maps and collaborative instruments (e.g. shared database).

In the second section users answered questions about their personal experience in emergency management: type of employment, years of experience in emergency management as professional or volunteer and the emergency stage where they are employed.

The third section consisted of four questions related to functions and tasks performed during emergency management. In particular, users have to indicate job functions during an emergency situation, participation in the negotiation and in the delivery of resources of others agencies, tasks

performed during the reception and the donation of resources.

Working place and collaboration during emergency management was the topic of the fourth section. Required information was about devices and tools used to perform users' activities, like collaboration and communication to manage the delegation and the authorization process.

The last part of the survey was about the description of a real emergency participation. Users have to describe the type of participation (as affected or as supplier), the management of resources and the employed devices in a real scenario.

3.3 Results

After collecting information gathering process, results both from on-line surveys and telephonic interviews have been analysed and compared to study how technology is employed in the emergency management. In this section we present the data analysis with the questionnaire results.

The first result we present is the use of internet and communication tools. Web browsing, interactive maps and GPS have higher frequency of use than e-mail and audio conference. Comparing the frequency of interactive maps and paper maps, the second ones have a lower use than the first ones: interviewed emergency workers consider interactive maps more comfortable and useful. An example is GoogleMaps that provides detailed maps of the entire world.

Results from the second section of the survey give a classification of participants, depending on various factors. Considering the role in the emergency management process, we individuate two classes: back-end people and front-end people. Back-end people are ones directly in charge of emergency that work in the back office. Front-end people are the ones that work in the command post and are in charge of managing the emergency in the field. Depending on the number of years of experience, five different groups have been individuated. The most numerous one is composed by people with twenty or more years of emergency experience as professionals or volunteers. As shown in (Waugh, 2006), the emergency management stages are mitigation, planning, response and recuperation. Depending on the stage of the emergency management process, interviewed emergency workers are mainly involved in the third one: the emergency response.

From the third section of the questionnaire we did not get any relevant results.

Concerning the collaboration during the emergency management, we obtained an interesting result from the fourth part of the survey. Three different kinds of communications have been considered: face-to-face, by traditional devices and by electronic devices. The Figure 1 is a graphic with on the y axis the number of users that had chosen the kind of communication on the x axis. Represented values on the x axis are *No* to indicate users that do not use the selected kind of communication, *Yes* for ones that had not given a preference between *to one* and *to many*, *to one* for collaboration between two people and *to many* for collaboration among many people. Looking at this graphic we can conclude that multi-directional communications are mainly done face-to-face. Traditional devices are used both among two or more people. The use of electronic devices is in any case rare limited to sending e-mails to multiple users. Combining this information, we can conclude that collaboration among many people uses a face-to-face communication, instead communication one to one uses traditional devices.
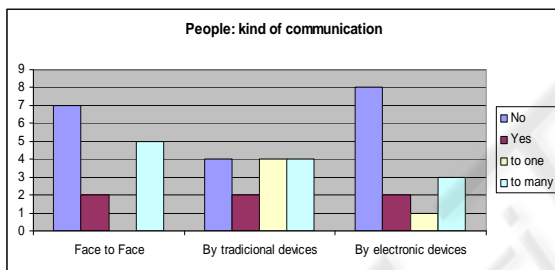

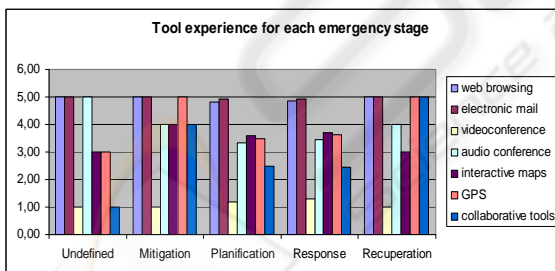Figure 1: Kind of Communication during Collaboration.

Figure 2: Combing Tool experience and Emergency stage.

In the second phase of the analysis we combined the tool experience with the emergency management phases. In Figure 2 there is the relative graphic. In this case on the y axis there is the mean frequency of use for each tool and on the x axis the emergency stage (mitigation, planning, response and recuperation). The entry *Undefined* represents users that do not indicate the stage. It is interesting to note that web browsing and electronic mail are the most

used in each stage, but in mitigation and recuperation they have the same frequency of GPS. Collaborative tools are in particular used during recuperation to coordinate all necessary operations. Moreover, video conference is the least used tool in all stages.

Table 2: Variance for results in Figure 2.

	mitigation	plan	response	recuperation
web browsing	0	0,15	0,14	0
email	0	0,08	0,08	0
video conference	0	0,33	0,56	0
audio conference	1	2,06	2,10	0
interactive maps	1	1,71	1,73	0
GPS	0	2,81	2,75	0
collaborative tools	3	2,45	2,27	0

The Table 2 presents variances for means in Figure 2 (the combination of tool experience with the emergency management phases). This further information is a way to capture the distribution degree of the presented data set. In this particular case, the lowest values are for web browsing, electronic mail and videoconference. This means that all interviewed users gave a similar evaluation to these tools: high frequency for web browsing and electronic mail, low frequency for videoconference. In case of audio conference, interactive maps, GPS and collaborative tools, there is a large gap among users' evaluation. The reason is that they are used by a small group of participants with a high frequency, in particular for GPS and collaborative tools. Looking at the variance, we can deduce that these tools can be useful in all emergency stages; nevertheless further investigation is needed in order to complete data analysis.

At the end of the combining analysis, some conclusions can be drawn. Video conference and collaborative tools have low frequency of use, due to the age of users and not to the emergency stage. Presumably, in the future people would be more available to use advanced tools in domain like the emergency management. At the same time, from a technical point view, advanced technology for collaboration system (e.g. video conference, interactive maps and shared database) needs an improvement to be most usable and easy to use.

4 CHARACTERISTICS OF A COLLABORATIVE SYSTEM FOR EMERGENCY

A collaborative system can be categorized in several ways. One of these, presented in (Dix, 2003), uses information about where and when users collaborate. To describe this approach a *Time/Space matrix* is used (Table 3). The time axis is the y (rows) and the space axis is the x (columns). For example, in case of users available to collaborate at the same time and geographically distributed (synchronous, remote), they can use devices, like a telephone or a system with an instant communication, like chat or video conference.

Table 3: Time/space matrix.

	Co-located	Remote
Synchronous	meeting rooms	video conferences
Asynchronous	argumentation tool	email

Results of the information gathering process presented in the third section have shown a set of useful tools in emergency management: combining this information with the collaboration time/space matrix, we have obtained the time/space matrix for the domain of collaboration in emergency management (see the table in Table 4).

Table 4: Time/space matrix in the emergency management.

	Co-located	Remote
Synchronous	Face-to-Face (multiple users)	Traditional Device (one to one, multiple users)
Asynchronous		Electronic Device (multiple users)

Looking at the time/space matrix for the emergency management domain and at users needs, it is possible to propose improvements to collaboration for an emergency management system. In particular, we proceeded analysing how to improve both synchronous and asynchronous communication.

In synchronous communication, users prefer traditional devices: they do not feel comfortable using new technologies, they are afraid and they do not trust these devices. In (Van De Walle, 2007), the importance of electronic devices is pinpointed: users can take advantage of these technologies by using advanced services, like video conference to communicate remotely or interactive maps to find out geographical information. The solution is to design new devices easy to use and similar to traditional ones but that can augment the capacity of response. Depending on the kind of communication, face-to-face or remote, we can identify possible solutions.

If the communication is co-located and people share the same environment, an interactive whiteboard can be useful due to various aspects. An interactive whiteboard allows workers interact with a big display where all available information is visualized and touch substitutes the mouse so that interaction might be more natural. Let's imagine a flight having problems and calling the control tower to communicate the kind of emergency; this fact will raise a procedure for managing this specific crisis. The crisis procedure will include an emergency meeting involving all the crucial professional figures collaborating in a control room to solve the crisis. The control room could be equipped with the whiteboard continuously displaying the status of the emergency, the map of the airport, aggregation points (for fire-fighters and first aids), etc. Furthermore the possibility of interacting with a touch sensitive board will help in immediately manipulating the placement of resources and aids over the airport map.

In the case of a remote and synchronous communication, an interesting idea could be to use an IP phone (integrated into a system using Voice over IP technology). An IP phone is based on IP technologies and it allows telephone calls to be made over the internet (Figure 5). It has several advantages, such as the high level of integration into digital systems and the usage of Ids like e-mail ones. An interesting utility in case of emergency management systems could be the storing of calls to extract various information with a voice recognizer (intelligent logging). By intelligent logging we mean the possibility of using data mining and natural language processing techniques to automatically analyse transcription of critical phone calls and extract relevant information.

Figure 3: The Facial Expression Recognizer.

The facial expression recognition system can provide information about the emotional state of the workers. In Figure 3 there is the output of the facial expression recognizer, presented in (Cohen et al., 2003). The output is a 7-components vector: each value is a probability for the related emotion (happy, sad, neutral, surprise, angry, disgust, fear). As shown in (Carver, 2007), the feelings of each emergency worker could influence the activities performed to solve the crisis: we propose the use of facial recognition to provide non conventional and intelligent interfaces.

For example, in a normal situation, we could assume that a manager in charge of first aids in case of big disaster (e.g. a Civil Protection Manager), would have to monitor many information. Thus, a system operating in normal status will provide her with many data about logistics (hospitals, ambulances availabilities, fire-fighters), equipments (units equipped for chemical crisis, nuclear crisis, etc), communications (governmental phonebook, faxes and relevant points of contact), etc. When a crisis occurs, all this information could overload the manager abilities. By using a face and emotion recognition module, the system could adapt the information presentation and functions to the manager's level of stress; in this way, the system could present a map locating the relevant resources (ambulances, hospitals, etc) providing a synthesised view.

5 CONCLUSIONS

The relation between collaboration and emergency management is a very interesting research area that combines principles from Computer Supported Cooperative Work (CSCW) and the domain of emergency. In these last years, the emergency management is gaining importance and relevance: in fact, big crisis like Katrina, have highlighted the lack of an effective system to prevent, manage and solve this kind of situation. For this reason, the collaboration in the emergency management is fundamental both for communication between users and for shared information and resources.

We have studied various approaches present in literature on the domain of emergency management systems that also provide information about organization of emergency processes. To obtain additional information about these main points, we have analysed the involvement of real users. The proposed questionnaire was, in particular, about the communication tools used by emergency worker to collaborate during the solution of an emergency.

From results of the conducted experiment and considering the theory of the Computer Supported Cooperative Work, we have adapted the time/space matrix at the domain of emergency management. Moreover and we have proposed possible solutions to improve the collaboration in emergency management system. Examples are the IP phone and the whiteboard as devices, the facial expression recognizer as an add-on of the system.

In conclusion, this work provides a proposal for different technologies that an emergency management system could provide to help the collaboration between its users. Future works will be to study the use of the proposed technologies in the different phases of emergency management; furthermore we believe that studying the use of non-conventional interfaces could be of great help in the systems supporting emergency control rooms.

ACKNOWLEDGEMENTS

REFERENCES

L. Carver, M. Turoff, 2007. Human-computer interaction: the human and computer as a team in emergency management information systems. *Communications of the ACM*, Vol. 50, 3, pp 33-38.

I. Cohen, N. Sebe, A. Garg, L. Chen, T. S. Huang. Facial Expression Recognition from Video Sequences: Temporal and Static Modelling. *Proceedings of VL/HCC 2004, 20-th Symposium on Visual languages and Human-Centric Computing*, pp 189-192, 27-29 September, 2004.

A. Dix, J. Finlay, G. Abowd, R. Beale, 2003. Human-Computer Interaction (Third Edition). *Prentice Hall*.

F. Fiedrich, P. Burghardt, 2007. Agent-based systems for disaster management. *Communications of the ACM*, Vol. 50, 3, pp 41-42.

B.S. Manoj, A. Hubenko Baker, 2007. Communication challenges in emergency response. *Communications of the ACM*, Vol. 50, 3, pp 51-53.

F. D. Mendonça, T. Jefferson, J. Harrald, 2007. Collaborative adhocracies and mix-and-match technologies in emergency management. *Communications of the ACM*, Vol. 50, 3, pp 44-49.

B. Van De Walle, M. Turoff, 2007. Emergency Response Information Systems: Emerging Trends and

Technologies. In *Communications of the ACM*, Vol. 50,   3, pp 29-31.

W. L. Waugh Jr., G. Streib, 2006. Collaboration and Leadership for Effective   Emergency Management. In *Public Administration Review 66,* pp 131-140.