

Shared Use of Information Technology in Emergency Response Work: Results from a Field Experiment

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ABSTRACT

This paper presents results from a field experiment of IT-use in emergency response work of a fire crew. A prototype has been developed to probe for instances of sensemaking supported by IT-use in such work. The findings have been analyzed in relation to research on design of emergency management information systems and sensemaking theory. Key findings from the field experiment suggest that there is a potential conflict between the role-based emergency management information systems and the shared use of information technology of first responders. Further it is advocated that prototypes should be used to explore the extrinsic of the work practice difficult to uncover using only direct-observation or interviews.

Keywords

Field experiment, Technology use and design, Sensemaking, Emergency response work.

INTRODUCTION

Major efforts are now being made to design various emergency management information systems that can support and improve the work on organizational levels, inter-organizational level, national levels and even global levels in case of emergencies or crisis. Independently of the scale of the emergencies or crisis the systems aim to provide improved overview of the situation and to provide ability to make competent actions in order to take control over the situation and minimize the damages to people, property and the environment. In order to accomplish such ability, information systems must both provide support for high-level coordination as well as support for the time-critical work by first responders.

A substantial body of knowledge has been established concerning the crisis phenomena (Perrow, 1984), organizational structures for emergency management (Bigley and Roberts, 2001) and the social dynamics in emergencies (Weick, 1993). In a complex society where a small accident quickly can develop into a major crisis, emergency management is no longer only of local concern but requires the efforts of several organizations to manage. Information technology is therefore fundamental in the emergency management system to mediate intra and inter-organizational communication and collaboration. Studies of information technology in an emergency management and incident response setting includes; studies of information technology as an organizing resource (Calloway and Keen, 1996), key functionality in emergency management information systems (Turoff, Chumer, Van de Walle and Yao, 2004) and information technology in relation to coordination complexity. These studies provide high-level conceptual frameworks that could be used to inform the design of information technology for emergency management.

The operative field personnel, physically responding to an emergency, have traditionally only gained limited attention. However, there are studies that have explored how to design of information technology use for field settings such as, how to improve radio communication on the fire ground (Camp, Hudson, Keldorph, Lewis and Mynatt, 2000) how ubiquitous computing could improve accountability and awareness for the fire crew (Jiang, Hong, Takayama and Landay, 2004). In these studies, interviews and observation has been the primary means for informing the design of prototypes and workshop sessions has been used to evaluate the prototypes.

There is a gap between studies of high-level design of information systems for emergency management and the applied use of information technology by first responders. Few studies have focused on how the operative use of information technology at an accident site will affect the high-level system and vice versa. Among the few is a study that explores the use of handheld computers and the design of location based service for medical first responders in relation to the somatic health-care processes (Togt, Beinart and Scholten, 2004).

If we are truly interested in understanding how to design information systems for crisis and emergency management we need to put our designs virtually in the hands of the people that we are attempting to support.

This paper presents results from a field experiment where a mobile application prototype has been used to probe for instances of sensemaking in emergency response work of a fire crew. In addition to the findings regarding the use of information technology for sensemaking, it is advocated here that field experiments are not only valuable to explore the suggested design but also to explore additional dimensions of technology use in this work domain impossible to uncover without a field experiment. The findings from the field experiment present consequences for the design of emergency management information systems.

The argumentation builds on two strands of related research, (i) structures for emergency management and (ii) information systems for emergency management. Designing information systems for crisis and emergency management is a daunting task. Part of the problem is related to the uncertainty and the dynamics of the emergency. To avoid developing structures that are too situation specific more loosely structures have been proposed, that have a certain degree of structure yet flexible to be adapted to the specific emergency. Bigley et al (2001) reports of one such structure, namely the incident command structure employed in modified forms by several fire and rescue services. One of the major strengths of this structure is its ability to both provide flexibility and structure at the same time. A crucial aspect in this ability is the concept of role switching, meaning that people in this structure can move between different roles depending on progression of the physical emergency. The concept of roles is also important to consider when designing information systems for this work domain. Turoff et al (2004) propose functionality of emergency management information systems where it is suggested that roles plays a key part of any structured group communication process. With the assigned role for a particular individual, being part of the emergency response work, a specific responsibility and access to the system is granted. Further it is suggested that the content of the information in such system determines which roles could access the information. In order to mediate information from the emergency management information system to the people on the incident location responding to the emergency, various forms of mobile information technology is needed. Turoff et al (2004) explains that their suggested system relies on the availability of PDAs, mobile phones, and laptops but a limitation factor is how to accommodate for limited screen sizes and various interaction modalities.

However, assuming that all individuals involved in emergency response work have access to mobile information technology could present some problems. If the role is determining what information can be accessed then a shared use of the mobile technology could restrict the information technologies potential. Assuming a private or role specific use of the mobile technology conflicts with the work practice of how tools, material and possibly information technology is used on the accident location. This paper will present such collaborative and shared use by presenting findings from a field experiment that aimed to probe for instances of sensemaking supported by IT-use in a fire crew's emergency response work.

THEORY

The theory of sensemaking is applied in this paper to provide a lens through which the actions of the fire crew can be understood. Sensemaking is an individual and collective process where "reality is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs."(Weick, 1993). This means that in contrast to decision making where the key question is *what shall we do*, in sensemaking the key question is: *what is going on*. A fundamental aspect in sensemaking is to understand that a person or a collective's experiences of a situation are progressively clarified, and that this clarification often works in reverse (Weick, 1995). In order for people to make sense, they must act, since it from a sensemaking perspective is understood that action precedes understanding. People actively interact to create meaning by the enlargement of small cues. The social context in which sense making takes place affect what cues will be extracted and how these cues are interpreted as well as the revision of those interpretations based on following actions and their consequences. The making of sense is oriented towards the plausible rather than the accurate due to the time criticality in many situations. Situations colored by ambiguity or unexpected events make visible people's efforts to make sense.

METHODS

This section presents the method used to conduct the field experiment. First, the prototype design process is outlined. Second, the field experiment is presented and third the data collection and analysis methods of the collected data are explained.

Participatory design of a prototype

The prototype is designed based on findings from an extensive ethnographic field study (Hammersley and Atkinson, 1995) showing how sensemaking (Weick, 1995) plays an important role in fire crews work en route to an accident (Landgren, 2004). The prototype was designed to materialize a subset of the findings from the field study. The prototype was developed to probe for instances of sensemaking of a fire crew en route to an accident and to improve their actions on the accident location. The development process was characterized by participatory design (Blomberg, Giacomi, Mosher and Swenton-Wall, 1993) where a fire crew has been deeply involved in the process to achieve a relevant transformation from the identified design implications to the materialization of the prototype. This approach shares some

ideological beliefs with the use of cultural probes where the probe or in this case the prototype “helps the designer to learn about the local culture in order to avoid the design to be irrelevant or arrogant” (Gaver, Dunne and Pacenti, 1999). As a result of the hierarchical command structure in the fire and rescue service, the intended user of the system was the incident commander but the content of the prototype was designed with the incident commander and the fire crew. Prior to the field experiment minor tests had been performed regarding the user interface and the interaction design. This was accomplished in a classroom setting at the fire station with the incident commander and the fire crew.

Field experiment

To probe for instances of sensemaking supported by IT-use and more practically, to explore the use of the prototype in as natural setting as possible, an incident scenario was constructed. The scenario was then performed as an exercise-incident having the fire crew responding on a reality-like emergency. The aim of the scenario and the incident-exercise was to provide a setting where the researcher to some extent could have control over some of the variables. A field experiment is not the same as an experiment in a laboratory setting, it is much more unpredictable and basically is it a semi-controlled context where initial design suggestions can be studied and potential design alterations can emerge.

Data collection and Analysis

To collect as rich information as possible, both non-participatory direct observation and video recording was used. A video camera was mounted in the rescue vehicle to capture the work en route to the accident location. The author was on the “accident” location and when the fire crew arrived, followed the prototype in the different use situations that emerged. A second camera was used on the accident location to record the use situations. Following the technology is a viable approach when studying mobile technology use (Weilenmann, 2003).

The data collected from the field experiment consisted of field notes and video recordings which were transcribed. In the work of analyzing the field notes, categories was formed and themes where derived. The analysis of the video recording was inspired by interaction analysis (Heath and Hindmarsh, 2002) and includes a detailed analysis of micro-events when a user is interacting with an artifact as well as managing the ongoing conversation with co-located individuals.

THE PROTOTYPE

The prototype named Rescuelab, aims to target the needs of timely and relevant information in incident response work. Fundamental requirements in such work have been reported of in Landgren (2004) and are access to information describing the incident location with contextual information. Based on these high level requirements the prototype was developed consisting of two main components: *an interactive map* of the city and *specific property information* linked to the position of specific risk objects.

The interactive map is basically a street map with functionality to zoom and scroll. Depending on the zoom level additional layers of contextual information becomes visible such as building borders, aerial-photos of buildings, fire hydrants, recreation areas, industrial areas and so forth. *Specific property information*, consist of a set of information for each particular property such as a hospital, a school, a factory, a shopping mall. Each property is described by a schematic map, showing preplanned intervention routes, hazards, ventilation shafts and other contextual details. For some of the properties building blueprints are available. Aerial-photos are available for all properties.

Interaction with the prototype is done via the touch screen no hardware buttons are used. The prototype runs on a rugged tabletpc with a weight of 2 kilograms. Macromedia flash and html has been used to develop the user interface. Map-functionality is provided using a commercial GIS-software.

The Field Experiment Scenario

The following scenario information is presented to give the reader an indication of what type of exercise incident the fire crew were dispatch to.

The exercise incident was based on a scenario where a person calling the SOS 112 explaining that; while sitting in the kitchen seeing through the window some smoke at the facade of the nearby factory. The caller is unable to see any flames and is unsure if there is a fire but feels required to contact the SOS 112. The operator sends an alarm to the local fire station, dispatching them with the following incident description “*Investigation potential fire at, Blinksfactory, Mortarstreet 17*”. En route to the factory location, the incident commander (IC) contacts the command centre. The command centre operator provides some additional information; “*The caller says he has seen some smoke from the facade of the factory, ...he calls from Landstrikstreet ... it was difficult to get anything else*”. The IC response “*okay...we will have a look when we arrive, over*”.

When the fire crew arrived to the incident location, witnesses near the factory premises informed one of the firemen that they had seen a person on the factory roof. The fireman receiving this information contacted immediately the incident commander about this report.

The scenario was constructed to include situations with ambiguity which potentially would provide instances of sensemaking and where the use of the prototype could support the ongoing work. The scenario was constructed based on more than 800 hours of field studies of operative fire crew work, and therefore based on situations that the fire crew had been experiencing.

FINDINGS

In this section findings from the field experiment will be presented. Two instances of sensemaking supported by IT-use will be presented in the following two subsections showing how the prototype supported the incident commander and the fire crew in their efforts to make sense of the incident and to form appropriate actions. In the third subsection additional findings will be outlined from the field experiment regarding the collaborative and shared use of the prototype.

Supporting en route Sensemaking

The first instance of sensemaking supported by IT-use concerns the work that is done by the fire crew enroute to the incident location. The use of the prototype en route to the incident location was focused on determining the plausible location of the potential threat to the factory, namely the façade where smoke where visible according to the caller. As presented in Landgren (2004) the use of reference points are important in order to make sense of an incident location. The following excerpt from the recorded information illustrates a conversation in the rescue vehicle concerning how to make sense of the plausible incident location at the factory premises.

[IC=Incident commander, Driver=driver of the vehicle, FM= Fire Crew Foreman]

01: IC: if one looks from the Landstrikestreet, then it should be some where here {pointing on the screen}

02: IC: take it [the tabletpc] {The IC hands over the artifact to the fire crew foreman and the two firemen in the backseat compartment}

03: Driver: It's the backside of the factory you see from up there

04: IC: yes, any other side of the factory is not visible to him [the alarm-caller]

05: FM: There is, up there...is the Landstrikestreet {leaning forward showing the screen}

06: IC: huhum {The IC turns round and looks at the screen}

07: FM: hmmm...on the backside....

Sitting in the front seat next to the driver, the IC holds the prototype with the left hand while at the same time interacting with the prototype using the right hand on the touch screen. The IC talks to the fire crew and express his understanding of which side of the factory one could possibly view from the position of the caller (01). The IC is using reference points to triangulate a plausible location to proceed to on the factory premises. Following to this, the prototype is handed over to the firemen in the backseat (02). The driver contributes to the conversation (03) and the IC emphasizes the position of the plausible location. In the backseat the fire crew foreman (FM) starts to interact with the prototype and engage the IC in the front seat in a new triangulation effort (05). The IC turns his head and looks on the screen and confirms (06). The FM says quietly "hmmm...on the backside" (07).

In the above excerpt it is shown how the location maps provide material for sensemaking by improving the ability of using reference points to determine the plausible location of the incident location. The location maps provide cues to the people in the vehicle and based on their prior knowledge about the factory surroundings, a commitment of where to proceed on the premises is formed.

Supporting sensemaking to form appropriate actions

The second instance of sensemaking supported by IT-use concerns the work on the incident location in the efforts to form appropriate actions. The prototype is not only used en route to the incident location but also to make sense of appropriate actions on the incident location. In the following excerpt it is shown how the prototype is used as an artifact to make sense and form appropriate actions. In the initial sequence a fireman and the fire crew foreman (FM) is using the prototype to locate their current position on the schematic building maps.

Prior to the following conversation the incident commander and the fire crew have been informed that witnesses near the factory premises have seen a person on the factory roof. [IC=Incident commander, FM= Fire Crew Foreman]

10: fireman: That would be this one...We are here, huh?

11: FM: yes

12: FM: one could go round here ...up here, from the opposite side...one can go through to this section

The incident commander (IC) walks up to them, expressing a concern regarding what building section is connected to the main roof of the building.

13: IC: "I don't know if it is connected to those ladders on the roof. Bill is up there right now... the question is if should take the extendable ladder and go up on the roof just behind us.

14: FM: "If you see here it looks as if it is a bypass there. {pointing his finger on a bypass on the schematic building map}

15: IC: Yes

16: FM: that's a separate building {pointing on the screen}

17: IC: and you mean that we should go up here, slant across from here {pointing with his hand across his shoulder}....take the extendable ladder it is only three meters [high]

18: fireman: Okay

What is show in the excerpt above is how the IC interrupts the FM and fireman in their discussion of the location and expresses a concern regarding which building section to use in order to bring additional people up on the roof (13). The FM uses the prototype to show contextual restrictions on the premise (14). The FM continues to explain that the nearby building section actually is a separate building, not visible from their current position (16). The IC expresses an interpretation of the FM's intention and forms appropriate action (17). The fireman standing next to the IC and FM agrees to that action (18).

The confusion regarding which building section is connected to the main roof was managed by face-to-face interaction between the FM and the IC. Rich media mediated by the prototype provided multiple cues. These cues were used by the IC to form the appropriate action and to get commitment to that action.

Collaborative and shared use

As shown in above subsections, emergency response work is a collaborative activity where sensemaking is fundamental. In this subsection additional findings from the field experiment will be presented showing collaborative and shared use of the prototype.

Before outlining this issue, let's briefly present the information technology currently in use in some fire and rescue services in Sweden. Information technology currently in operative use is designed to provide similar functionality as the prototype used in the field experiment. But, a fundamental difference between the prototype and the existing technology use available for operative rescue services in Sweden, is the stationary design. The information technology currently in use is mounted in rescue vehicles restricting it from a mobile use. In the field experiment it was shown how the mobile technology manifested in the prototype can and will be used by different roles in the fire crew and in a variety of settings. During the exercise the prototype was not only used by the IC alone or by the IC in collaboration with another role, but also by roles independently or in collaboration with other roles.

At a few occasions during the field experiment, the IC handed over the device to either the fire crew foreman or a fireman. One such hand-over occurred in the vehicle en route to the accident location, While en route to the accident location, one of the firemen in the ladder vehicle (413) contacted the IC in the rescue vehicle (411) and asked for positions regarding the location of fire hydrants. The following sequence illustrates potential problem of who is actually using the device and where such use takes place.

[IC=Incident commander]

30: Fireman in vehicle 413: 413, 411

31: IC: over

32: Fireman in vehicle 413: just want to check if you have found any water, to help us a bit

33: Just a moment...eh it [the device] is in the backseat right now so we have to call back

34: Fireman in vehicle 413: okay

35: IC: you contact 413, jonathan [referring to the fireman holding the device]

36: Fireman in the backseat of 411: Yes

The fireman asking for assistance in locating fire hydrants contacted the rescue vehicle 411 over the common en route radio channel. This channel is open during en route and used for communication between the command center and all vehicles en route to an accident, as well as between vehicles. The incident commander is responsible for handling such radio traffic in rescue vehicle 411. The radio is positioned next to the IC's seat. The IC had prior to this call for assistance handed over the prototype to the firemen in the backseat, making a respond to the request impossible. The IC handles the situation by asking to call back in a moment and asking a fireman (Jonathan) in the backseat to search for the information

and contact the ladder vehicle 413. This situation shows how the prototype is used as a common resource for the fire crew in the rescue vehicle and indirectly by firemen members of the fire crew located in other vehicles. The hand over situations and the unconstrained access to the prototype shows that the technology is shared within the group and is potentially perceived as a common resource.

DISCUSSION

In this section, the findings presented in this paper will be discussed. There are three issues that will be elaborated; instances of sensemaking supported by IT-use, technology in a collaborative practice and finally some reflections of the use of field experiments and prototypes will be presented.

Technology to support sensemaking

Sensemaking is based on the assumption that “reality is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs.”(Weick, 1993). The job for the person trying to make sense of a situation is to convert experiences to something meaningful and this is highly dependent on the social context. Situations are progressively unfolding and clarified and this clarification emerges when people in retrospect brings the pieces together to create a sensible explanation of the situation. As shown in the findings to make sense, people as actors in a social context will interact and make committed actions based on cues that help them to justify their actions in that particular social context. Findings from the field experiment show instances of sensemaking where location specific information mediated by information technology can improve the fire crew’s sensemaking ability. This claim is supported by the observation of how the information provided by the prototype was used in the conversation between the individuals in the social context of the fire crew. Further, the cues extracted based on the information presented in the prototype formed commitment for those actions. As mentioned, sensemaking is a social activity and as such the material provided to make sense is also part and forms that social context. As shown in the findings, making sense is a social activity and a collaborative effort. This is vital to understand when the artifacts used for sensemaking will be discussed next.

Technology in a collaborative practice

Information technology mediating vital information is, whether or not the intended user is a specific role, part of the collaborative practice and by such also in this work domain associated with a shared use. This has implications on how to design emergency management information systems and how information technology is introduced in the incident command structure. The typical command structure is highly hierarchical and the term chain of command, clearly illustrates that information and decision is a top-down process. However if the incident response, where a sensemaking ability is critical, is a collaborative activity and the physical tools and technology artifacts are viewed as common resources then the design of information technology to support incident response must comply to the work culture and the collaborative practice. Designing information systems for specific roles and designing functionality that requires that specific role’s immediate attention could conflict with the current work practice. The findings from the field experiment shows how sensemaking as a social activity is a collaborative effort and not an effort only managed by one role. A role-focused design of information technology and information systems as suggested by (Turoff et al., 2004) could potentially have severely negative effects of the ability of the first responders. This does not mean that a role-based design is inadequate but rather that we must extend our understanding for the social activities and context of a particular role and provide a design that can accommodate for a collaborative practice. If we overlook the social dimensions of collaborative work practice we might design information systems that not only are seen as inappropriate by the work force but also and more importantly, decrease the efficiency of a response operation.

Technology as a vehicle to understand work practice

The field experiment has highlighted at least one vital issue impossible to explore without actually moving out in the field and putting information technology in the hands of the work group. The field experiment was intended to probe for sensemaking supported by IT-use in a reality-like situation but did also provide an opportunity for the researcher to explore additional questions very hard to imagine before the field experiment. The prototype did provide knowledge about the practice that prior to the exercise was still unknown. A note of advice to individuals that are involved in exploring the use and design of information systems for crisis management and emergency response is to move out in the field and not only study the actual work but also to use the work setting to further explore this research field.

CONCLUSIONS

This paper has presented findings from a field experiment used for probing instances of sensemaking in a fire crew in emergency response work. The field experiment resulted in additional findings concerning aspects of the work practice that potentially have implications on the design of emergency management information systems. A key finding from the field experiment is that there is a potential conflict between the role-based emergency management information systems