A Study of Emergency Response Work: Patterns of Mobile Phone Interaction

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ABSTRACT
This paper presents descriptive accounts of time-critical organizing in the domain of emergency response. Patterns of mobile phone interaction in such work is analyzed showing how the dyadic exchange of mobile phone numbers between the actors plays an important role in the social interactions in the organizing and sensemaking of the emergency. Enacted sensemaking is used as an analytical framework. Implications for design of emergency response information technology are outlined and discussed.

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Ethnography, Enacted sensemaking, Mobile phones, Collaboration, Emergency Response

ACM Classification Keywords
H5 Information interfaces and presentation (e.g. HCI): H5.0 General, H.5.3 Group and Organization interfaces

INTRODUCTION

The society of today is increasingly vulnerable to disturbances or collapse of critical infrastructure caused by man-made accidents or natural disasters. Efficient responses to such events are not only important to limit the consequences in a human dimension but also from environmental and economic dimensions. Emergency response and management in relation to information and communication technology (ICT) use have in the last few years gained increased attention by researchers and visibility in the Information Systems research community.

Studies of technological risks [22], organizational reliability [23] and breakdowns in sensemaking [28] indicate that accidents will continue to be an unavoidable part of everyday life. In a complex society, crisis and emergency response is no longer just a local concern involving one dedicated organization but requires the collaboration of several organizations.

Information technology is therefore fundamental in the emergency management system to mediate intra and inter-organizational collaboration.

Since a few years, Swedish rescue services under the authority of local counties or county alliances are in the process of introducing ICT in the operative incident response organization. Vehicle navigational support, mobile access to property information and hazardous material databases are applications that have gained significant interest. Rescue services in metro areas have invested in mobile command units, mobile command and control systems and wireless connectivity to the command centre network. However, integration between stationary systems and mobile systems is lacking. On a national level, a new radio-communication network is being rolled-out involving new possibilities for improved voice communication between the rescue services, the police, customs and coast guards.

There is a tendency to be an accumulation of more and more information technology especially at the operational level in emergency response work [31]. There are many ideas of what type of information technology emergency responders should use and how such technology could make a difference, less is know about what emergency actors actually use and the role of such technology.

This paper studies time-critical emergency response work and investigates mobile phone interaction in such organizing based on empirical data from two major incidents.

RELATED WORK

Prior studies on information technology in emergency response settings include; studies of incident command structures [2], information technology as an organizing resource [3], key functionality in emergency management information systems [26], improved design of radio communication on the fire ground [4], ubiquitous computing to improve accountability and awareness for the fire crew [10].

Within the field of HCI and CSCW, a number of studies have focused on work in time and safety-critical work, including air-traffic control [9], subway crisis management [8] and emergency response centers [21, 18]. Other studies have focused on extreme or radical collaboration [16, 25] in war-room settings as a response to an organization's complex engineering problems. Studies of medical emergency response work practice have focused on design ideas based on the victim [11] as boundary object. Studies of the work practice of fire crews have explored preparation activities enroute to accident locations [12] and how temporal rhythms in small-scale incidents could be one input for improved accountability [13] and sensemaking.

It has been claimed that CSCW-system designs assume that the workers are organized into teams with clearly defined and stable roles [17]. These systems are designed to support users within one organization with a predictable structure of workplace interaction. At the same time it is clear that relationships outside the organization are critical to most organizations. These relationships, with clients, suppliers, government, and others, are often ICT mediated and computer based systems for collaboration and cooperation, and virtually extended outside the organization.

Many organizations put tight boundaries around their networks to restrain communication from leaving, and communication from entering the organization. Whereas there are many types of ICT used in organizations, there is one technology that is more reluctant to adhere to organizational borders than others; the mobile phone.

Studies of mobile phone use in professional work have shown how this technology has had impact on the temporal boundaries of the work day [20]. Further, studies of police work have shown that mobile phones allow changes in intra-organizational role relations with co-workers as well as in inter-organizational relations with the public [15]. One of the key aspects of the mobile phone is that the mobile phone number provides the only fixed address to otherwise flexible, independent and mobile individuals [1]. Studies of the relief work after the Katrina Hurricane shows that mobile phones was used for communication between ephemeral response groups and the first communication technology that became operational in the aftermath [5].

Based on empirical data from two major chemical hazard incidents, this paper will investigate mobile phone interaction in the organizing of emergency response work. Enacted sensemaking is applied as an analytical framework.

ENACTED SENSEMAKING

When professional actors such as firefighters, respond to an emergency they become part of the emergency through their actions to make sense of the situation and their actions to prevent an escalation of the emergency. From a sensemaking [29] perspective, formulated by Karl Weick, it is understood that people think by acting and that action preludes understanding. This means that when professional actors make an intervention to an emergency they also "simultaneously generate the raw material that is used for sensemaking and this affects the unfolding of the crisis itself" [27]. People construct meanings of an event when they compare what they see with what others see and interacts to form some mutually acceptable version of what exists. Based on this line of argumentation, the term enactment is powerful in explaining "when people act, they bring events and structures in to existence and set them in motion". Enactment is a social process [27] of "material and symbolic record of action" [24]. The result of this process is an enacted environment consisting of real objects such as toxic material, risks, people, cargo wagons and valves. These objects are real but their meaning and significance are subject to multiple interpretations [27].

The capacity in terms of the number of actors and the competence of those actors available to do the acting and interpretation are crucial variables. This is a collective process [29] which means that successful interaction between people in equivocal situations enable them to see more ways to intervene and decrease the escalation of the crisis [27].

The emergency response work and the accident environment are enacted through the social interaction between the key emergency organizational actors [24]. This means that organization emerges through sensemaking, not that sensemaking is a product of organization [30]. In order to study emergency responses and the effort of organizing such work, the focus must be put on the social interactions of the involved actors and specifically on the information technology used by people in such work.

RESEARCH SETTING AND METHOD

This section describes the rescue service, and briefly the police and the SOS-112 and their relationships in emergency response work. Next, the method is described. Following to this are the two incidents presented using descriptive accounts of the response work of the first day of the two major incidents involving hazardous material.

Key emergency organizations

In the event of accidents involving an immediate and substantial threat of harm to humans, property or the environment, emergency response operations are organized by the rescue services, sometimes referred to as the fire brigade.

The incidents presented in this paper took place in a region having a rescue service organization consisting of a 24/7 operational command centre, mobile command units and a range of specialized rescue units with fire crews of 4-6 firefighters in each unit. The organization has eleven full-time fire stations and additional part-time stations. The operative work conducted by the rescue services during incident response is the responsibility of an incident commander. The incident commander is a role that only exists during incident response. In small-scale incidents and

in the initial work in large-scale incidents, a fire crew commander is assigned as the incident commander, but as an incident develops, the role of incident command is transferred to higher-ranking commanders.

In addition to the rescue service, other organizations are also key actors in emergency response work such as the SOS-112 emergency call center organization and the police. When calls are made to the 112-emergency number, an SOS-operator receives the emergency calls, makes initial situation assessment and if necessary transfers the calls to the fire & rescue and police command centers, and coordinates resources of the emergency medical service. The police are organized in similar structures as the rescue services including a 24/7 command centre, mobile command units, and a number of operative patrols.

Method

Since 2002 the two authors have conducted extensive research on police patrol and fire crew work [12, 13]. Based on an ethnographic [7] approach, the two authors have made over 1900 hours of fieldwork. Participant observations have taken place as part of fire crews' and police patrols' work shifts. The rich and large amount of material from this fieldwork is used for providing a deep understanding of information technology use in such work practice.

This paper reports from two large-scale accidents happening at the same geographical location. Data has been collected through observation, interviews and document analysis. In the 2005 accident, one of the authors arrived to the accident location three hours into the incident. The observations of this incident covers seven hours of work at the accident location from around 17:00 until midnight. In the accident in 2006 the same author was doing a field work at the same rescue service organization. Observations from this incident cover 7 hours of work. The observations and recordings of verbal communication could therefore start immediately. In both accidents the observations were focused on the work of the incident commander.

The observations were documented as field notes in a paper notebook and later transcribed. By using a digital recorder, verbal communication consisting of radio-talk, mobile phone communication as well as face-to-face discussions was recorded. Episodes of this voice communication material were later transcribed. A selection of documents, artifacts and people were photographed in order to provide rich material for the following detailed analysis. The analysis started with a thematic analysis of the transcribed field notes. This analysis gave indications that mobile phones and contact information had an important impact on the organizing of the response efforts. This observation triggered a second set of data collection activities including retrospective interviews.

Semi-structured interviews [19] were conducted with key actors in the rescue services organization; the crew commander of the first arriving response units, the two incident commanders working during the first twenty-four hours of the incidents, the commander of the incident support organization. Each of these persons was asked to reflect in retrospect on the work during the first day of the incident and recollect how contacts were established and maintained as part of this work. Phone records of the commander's mobile phone use were not possible to obtain.

The interviews were made with one individual at the time and took place in meeting rooms at the rescue services. Each interview lasted between 60 and 80 minutes and was recorded and transcribed. The interviews were followed by an analysis of documentation [19] produced during the incident. The documentation consists of the rescue services command logs from the command post at the accident location and the command centre. In addition to these documents, command logs from the police authorities and evaluation reports have also been analyzed. The command logs were compiled into one event-log to provide a richer view of the critical events and the involved actors actions.

The analysis started by aligning the transcribed field notes to the timeline of the complied command log. When a mobile phone number and an actor were found in the log, the corresponding field note was used to explore the circumstances at the accident site around the same time. This was repeated for each entry in the command log for the time periods covered by the observations. The same procedure was then repeated but starting from the field notes and relating to entries in the command log. This was followed by an analysis of events and actions of the response work when additional actors or new information emerged. These events were then explored in relation to the retrospective interviews with the different commanders. The analysis of the field notes and the command log resulted in patterns showing that people and mobile phone numbers were a crucial and primary set of information in order to organize the response work.

Descriptive accounts of the two incidents

The 2005 incident

On the 28th of February 2005 at 12:50 a cargo- train with 720 tons of chlorine derailed on a field near Ledsgard, 1.5 km south of the village Anneberg on the Swedish west coast. This event triggered a massive response operation that lasted for seventeen days and involved over twenty different organizations.

Eyewitnesses to the accident called via mobile phone to the national emergency dispatch organization, SOS-112, and reported that a train had derailed. This call was re-routed to the rescue services. The rescue service command centre dispatched a first responding unit from the fire station nearby the accident location. This fire crew arrived within a few minutes to the location. The accident location was on a field with no direct roads leading towards the derailed train. There were no smoke clouds from a chlorine leakage

visible around the train and four of the firefighters in the crew including the fire crew commander started to walk across the fields towards the train, a distance of approximately 500 meters. A few minutes later, a service technician from the railway company arrived to make sure that the electricity was cut off. The fire crew commander exchanged mobile phone numbers with him. In accidents as this one, involving hazardous material, a fire engineer and an assistant operator are automatically dispatched to the incident along with a range of fire units.

"When I received the alarm here at the fire station, the information was limited, I was informed that it was a train, a cargo train with hazardous material. So we start to drive to the location. Half way to the location we were contacted and I got the information that it is a train with twelve wagons, several of the wagons have derailed, and the wagons contain chlorine. I realize that this is a really big a complex accident…It was emotionally stressful." (The Fire Engineer)

When the fire engineer arrived to the accident location, a command point was established a few hundred meters north of the train. The fire engineer was unable to get in contact with the fire crew commander over radio and instead took contact via mobile phone. Detection instruments were handed to the local fire crew to monitor for potential leakages. The instruments gave negative results. Shortly after the first police patrol arrived, followed a few minutes later by the arrival of people from the cargo company and the health authorities. At the time when media arrived, the accident location had become a bit crowded with people from several organizations. A command vehicle and a mobile command room formed the physical structures at the command post.

At the 19:15 conference at the command post on the accident location, involved a large number of actors. The conference took place in the mobile command room that basically is a rebuilt cargo container. Due to the physical limitations of this space, only one actor from each organization was invited to this meeting. The following excerpt from the incident commander, illustrates the situation:

"Do we have all the organizations here, do we miss anyone? …the wagons have derailed here, they are severely compressed and that is especially the case for the engine and the first four wagons, also the fifth wagon is affected…These wagons are squeezed together and partially derailed. We have had experts onsite to have a look and they cannot determine how safe it is."

"We have very limited information about the risks. My assessment and decision for the night is that we are not going to start any major activities here during the night because of the risks with work in darkness and associated risks for the personnel." During the night we will continue to collect information and prepare potential activities starting in the morning. That is the big picture."

"One problem we face right now is the access to the wagons, I have asked the police to have a look at the access restrictions."

The conference resulted in a situational 'freeze' of all actives to remove the train and wagons from the location. At this point it became clear that it would take several days until the cargo wagons will be removed. During the evening, the incident commander coordinated with the police how to organize an evacuation if that would become necessary. After the conference, actors from the cargo company and the chemical producer together with the incident commander discussed the necessity to bring in additional expertise to the location to provide a more qualified damage assessment of the wagons.

It took seventeen days and the involvement of over twenty different organizations to remove the derailed train and open the railroad for traffic. It was evident that the temporal dimension of the accident was far from well understood in the initial response work. The extension in time was gradually evolving as a result of the collective efforts to make sense of the situation and the possibilities for intervention.

The 2006 incident

On the 4th of August 2006 at 20:19 an almost identical alarm as the 2005 incident was sounded at the main fire station in Gothenburg. "Railroad accident, chemical material, Ledsgard, Anneberg". At this moment the night-shift fire engineer was interviewed by one of the authors regarding lessons learnt by the organization of the chemical accident in 2005. The fire engineer and the researcher looked at each other and for a moment they could not believe what they just heard, the same location, the same type of accident as last time. After a second or two the two very surprised individuals left the coffee room and went rapidly down to the command vehicle, where the command assistant met up.

Concurrently, the fire crew in the southern district was dispatched along with an operative onsite commander from another district. During the transportation phase to the accident location contact was established over mobile phone between the fire crew commander and the operative onsite commander in order to determine a safe approach route. During the next twenty minutes additional fire crews were dispatched and enroute to the accident location. The fire engineer in the command vehicle had several contacts with the command centre while enroute to the accident location. The chemical cargo of the train was proven to be ethylene oxide and communicated to all fire units.

The primary objective in the initial work on the accident location was to build up a massive water system that could be used to cool the chemical tanks as well as reduce the consequences of a potential fire. The first few hours were focused on the activities to build up a water suppression system, being both time-consuming and resource intensive. During this work arrived additional actors, such as the Cargo company, railroad-representatives, paramedics, media and county representatives to the accident location.

One of the important activities was to make a damage assessment of the derailed cargo wagon. A fire crew was equipped with sensor instruments and a digital camera in order to check for leakages as well as take pictures of any damages. The result from the sensor instruments gave

negative results, meaning no measurable leakage. But the visual inspection of the wagon indicated that there was a small leakage from a valve on the bottom side of the tank just a few drops a minute but still a leakage. This discovery resulted in ambiguity. The instruments gave no indication but the visual inspection did. The actors made sense of the situation by relying more on the visual indication than on the sensor instruments of which they had only little experience of using. This lead to the interpretation that there is a small leakage. When the chemical experts arrived two hours into the incident the situation was far from clear and the message from the expert was received with mixed feelings in the following situation brief that took place. The incident commander informed that:

"Ethylene oxide is among the worst substances…I would argue that it is even worse than chlorine…it is very toxic and highly flammable" "We have a very small leakage…and we will not make any actions at this point that can endanger the integrity of the tank…we are awaiting the arrival of a wagon expert." "We also have many citizens in this area. The police has blocked the roads and they are also helping out in cases of an evacuation"

One of the fire crew commanders (FCC) had questions to the chemical expert, asking:

FCC: "If it catches fire…how fast will it develop?"

Chemical Expert: "there are not many people that have been able to share experiences of that…a fire must be avoided."

FCC: "how large is the risk zone?"

Chemical Expert: "the safety distance is 1500 meters"

FCC: "due to a fire?"

Chemical Expert: " the explosion"

The response by the expert shows how serious the situation was understood to be. In a phone conversation, after the situation brief, the incident commander (IC) informs the regional police about the situation and the expected time frame for the response work.

IC: "In my opinion this will take several days"

During the late night an additional chemical expert arrives and the two experts conduct an inspection of the cargo wagon using very sensitive sensor instruments. After this inspection, the situation changes dramatically in a positive direction. Their instruments did not give any indications of a leakage and their explanation to the leakage is that it is water condensation from the cold toxic substance. In the following morning plans for the removal of the dislocated wagon were outlined and by late afternoon were the railroad restored to normal traffic.

This second incident shows the enacted sensemaking of the involved actors and how their collective efforts provided material to initially interpret the situation as highly dangerous. When more information became available, the capacity of the actors increased and the visibility of the situation improved. By the use of additional instruments and competences, eventually resulted in an interpretation that allowed the actors to complete the response work.

In the next section we will present findings from the analysis of these two accidents.

FINDINGS

The organizing of incident response to a large-scale and critical accident triggers activities to establish a network of affiliated persons. The structure emerging from these activities is a network of names of people with mobile phone numbers along with organizational affiliation rather than a structure of organizations and roles with anonymous or black-boxed individuals. The individual affiliated actors become nodes of expertise in the response network. The phone numbers documented in the logbook make references to individual actor's mobile phones and only in a few occasions to organizations' switchboards. The focus on actors is related to the importance of having continuity in the communication, which is especially important during the initial work in response work.

Mobile phone interactions were observed among the fire commanders and the external actors. The radio was only used to communicate with the fire crews. Overall, the conversations over radio and mobile phones were not bursty and short, as one perhaps could expect in time-critical situations. We did not observe any breakdowns in the mobile phone network or disturbances due to network overload. However, in the 2006 incident, the incident commander had significant problems with his mobile phone due to low-battery capacity.

The analysis of the incidents shows examples of three patterns of interactions in organizing a response network where the mobile phone had a fundamental role. These patterns are non excludable and to some extent overlapping. The labels signal the direction or lack of direction of the interactions. The patterns of interaction are serendipitous interaction, inbound interaction and outbound interaction.

Serendipitous interaction

The incidents presented in this study represent not only breakdowns of critical infrastructure but they are also major and severe accidents. Such events trigger multiple organizations to become involved in the direct response efforts. The initial work by the involved organizations is characterized by multiple, rapid and independent response with only limited coordination. The primary activity in the initial work is to define the location and relocate actors to the scene of the accident in order to make sense of the situation and to limit the consequences by reducing the risk for an escalating and uncontrolled situation.

When the rescue service receives an alarm regarding hazardous material from the SOS-112, they initiate a response according to a predefined plan for chemical accidents. This includes dispatch of a local first responder unit, a mobile command unit and a specialized chemical/hazmat unit. Concurrent with these activities, are the railroad company and the cargo company acting in order to send staff to the location. These three

organizations, the rescue service, the railroad company and the transport operator, became rapidly involved in these two incidents but with different perspectives. The rescue services focus on the hazardous material and potential consequences for the people in the area. In these incidents, the initial actions from the various actors focused on approaching the situation from their respective responsibility. The railroad company focused on providing a safe area around the train, cutting the electricity and exploring the possibilities to run traffic on the undamaged parallel rails. The cargo company focused on the train driver and on the status of the cargo. The three organizations have their particular share of the incident and could be seen as part-owners of the incident. The initial work is carried out with limited coordination between the actors and provides occasions for serendipitous interaction.

The concurrent and independent responses from multiple organizations affect the forming and establishment of a network of collaborating actors. Due to the time-criticality of the situation and the need to reallocate individuals to the location in order to make sense of the situation, a highly coordinated response is difficult in the initial phase of response work. The dispatching of actors to the accident location provides opportunities to connect with other actors that have part responsibility in the subsequent work. The unintentional meeting between the fire crew commander and the railroad representative is here seen as serendipitous interaction that creates connections between two important actors in the emergent network of response actors. The fire crew commander explains:

"When we were walking along the train I met the railroad guy. I didn' t order him to the location. He told me to hurry up because his organization wanted the railroad to be reopened for traffic. I told him to slow down this will take time. I also got his phone number and typed-in the number and called and hung up, making it quickly available at the time."

In this case it resulted in an exchange of phone numbers. The contact management by the fire crew commander indicates that phone numbers to other actors on the accident location are important. Neither of the actors ordered the other to be on the location or knew the location of the other up until that time. The actors had their unique task in relation to the accident and the physical co-locatedness provided the serendipitous interaction leading to an initial structuring of a network of actors for the subsequent joint-work.

Inbound Interaction

The incident commander has the overall responsibility for an emergency response operation and is highly dependent on experts from other organizations to get a sense of control over the situation. In large-scale incidents with a direct threat of toxic leak, the incident commander must act on different time-scales [6] to comply with short-term issues as well as trying to think ahead of the situation.

In addition to the directly involved organizations, within the first hours a number of organizations arrived to the accident location, such as people from the railroad company, the cargo-company as well as the media and county authorities. The establishment of the command post by the fire engineer and the role switch of the incident command role from the fire crew commander to the fire engineer form new means to manage the network of actors. The incident commander explains:

"The first on-location-contact I had was with the crew commander and it did not work well over radio so I finally called him on his mobile phone. We started to send out firefighters with indication devices to monitor for potential leaks. Pretty soon additional people from external organizations arrived and especially the railroad company was very quick, half an hour in to the work and they had five-six-seven people and it became messy, they are used to work along rails and started to move freely. An electricity-guy started to cut the power and I had to tell them quite sharply not to walk close to the train. The police did also arrive quite fast but only with a patrol with one guy"

The sheer number of people, arriving to the accident location, put pressure on the incident commander to determine what people should be at the location and who should not be there. The incident commander explains:

"People that arrive, they approach you and there is much face-to-face communication, In this situation everyone goes to the fire trucks at the command post… that is not always good if something critical would happen, but at the same time I need people close to me because of their expertise, but it is difficult to determine who should be close and who should leave [the command post.]"

The excerpt shows that people from the various organizations arriving to the accident location present difficulties to the incident commander. A problem is to make clear who are important to have close connection to and whom should be kept at a larger physical distance. An incident commander explains:

"You say to the command operator; make sure that these people stay here at the command post so I can reach them when I have time. An alternative is to take their mobile phone number. So it is a lot of phone talk"

What is seen here is inbound interaction characterized by the face-to-face communication with newly arrived actors. Inbound interaction includes a mechanism to determine the needed proximity for the actor and if the actor will become a legitimate actor in the response network. The exchange of mobile phone numbers between the external actor (P) and the command operator (CCO) form the mechanism to, on location, become part of the contact network. The following excerpt shows an example of such inbound interaction when an expert from the chemical company arrives to the command post:

P: "Malcom Larsen, ChemCo"

CCO: "Peter… command assistant, you have to wait for a few minutes for the incident commander"

P: "Okay"

CCO: "What is your phone number?"

At the time of the expert's arrival to the command post, the incident commander is unavailable for conversations due to coordination issues with a senior commander. The command operator asks the person to wait and takes his

phone number. Inbound interaction is not restricted to the physical arrival of people to the accident location. There is also inbound interaction when individuals make phone calls directly to the incident commander or contacts the command operator at the command post. The following excerpt illustrates this type of inbound interaction:

CCO: "Hey… the regional police in H-county is calling and wants to talk to you."

IC: "Take his number and tell him I will call back"

The excerpt shows that the incident commander is acknowledging the legitimacy of the interaction as such but needs to postpone the conversation with the police due to the ongoing work. The request and the subsequent exchange of phone numbers signals that the call will be made by the incident commander when an opportunity for that conversation is available to him.

The collection of phone numbers that accumulates as part of these interactions are first scribbled on paper notes and later added to a growing list of numbers and names on a paper document. A selection of these becomes available on the whiteboards on the outside of the command vehicle, but they are not explicitly handed-out to the involved actors.

Outbound Interaction

When an accident is understood as a complex incident, the rescue service activates an incident support staff organization. The structure for this organization is pre-planned but nevertheless such activation is not instrumental and immediate, but delayed due to the physical relocation of people to the command centre. Further, the work of the support staff in the initial phase is highly oriented to move ahead of the incident and get an understanding of what, where and who are currently involved in the already ongoing work. The chief of support staff explains:

"I became involved in the work quite soon. We did not get more information than, that a train has derailed and there are a few wagons with chemicals, they didn´t have more [information] and would come back."

Based on this information from the command centre, the chief of support staff and one assistant started the work of activating the incident support organization. One of their priorities became to establish a contact network. The establishing of a contact network was managed not based on a predefined sequence but more dependent on the experience of the two people working in the incident support organization:

"Based on my experience of being a former chief of command centre and the knowledge from the time as an operator, we contacted organizations that have chemical experts both in the region as well as from the national units. So it was more or less just for us to start up a contact network and inform that we have an accident. What resources do you have if we need your help."

In this work, a number of contacts were made with organizations that had chemical expertise and resources that could be sent to the accident location. Access to expertise in critical and complex incidents is necessary and fundamental for the response work. The chief of the incident support organization explains:

"A chemical accident is a tough situation where a number of actors must be involved, the rescue services would fail if we had no access to experts and the experts need to be on location and there will be a set of phone numbers."

As a result of the outbound interaction, a list of names and phone numbers is formed and documented continuously along with a time-stamp in the command log only in use at the command centre. The list of names and numbers forming the contact information includes notes regarding on when to make contact. On a few entries in the command log, include notes specifying the activities certain people were currently engaged in at the moment of contact, such as that certain persons are on their way to the accident location or that someone will attend the staff briefing. Outbound interaction is also evident in the work on the accident location. The need to bring in additional actors in the work results in a search for phone numbers that provide direct contact to such actors.

Dyadic exchange of phone numbers

The analysis of the three patterns of interactions has also identified how mobile phone numbers are exchanged on a more concrete level. The dominant form of mobile phone number exchange is that one actor, such as the command operator, acquire a phone number by asking the mundane question *"what´s your number?"* to an external actor. We view this as the number is taken by the emergency professionals, based on an understanding that this particular actors phone number is of interest for the incident command. The number is then included in the paper list forming a contact structure and made available on a whiteboard at the accident site. The acquisition of phone numbers is not just a practical solution to form a contact list but also a social mechanism to signal that a certain individual is an important actor in the response work.

A variant of the acquisition of phone numbers is provision of phone numbers. This form is used when the phone number is not intended for the individual that acquires the number but for some ´third´ individual not part of the current dyadic exchange. The excerpt show how the policeman asks for the IC phone number and declare that the number is for someone else and will be passed on to a high-ranking commander in the police organization.

Police on-site: "The phone number to you [incident commander] so I can give it to the regional police commander"

The provision of phone numbers has consequences on the communication structure and can lead to break-downs. The break-down is here conceptualized as by-passed institutionalized order. The communication and interaction between people engaged in emergency response work follows to some degree the philosophy of the hierarchical structure also known as the incident command system [2]. However, the qualities of mobile phone technology allowing a direct point-to-point communication is also

providing opportunities to explicitly and publicly by-pass the institutionalized hierarchical system. The following excerpt shows how the mobile phone number to the incident commander (IC) has become shared and later provides disturbances in the communication structure.

IC: "Yeah…hi…IC Anneberg here.."

IC: "You have to talk with your paramedics commander, the ones you have here…I have made a situation brief for them. Yes…but… you will…but you will get it via your paramedics commander here…it is unreasonable for me to have contact with the police and paramedics on-site as well as their managers."

The phone number in this excerpt was delivered to the regional ambulance commander that called the incident commander, despite the fact that the paramedics were on-site.

CONCEPTUAL DESIGN

In the previous section the descriptive findings of the analysis of the emergency response work is outlined. These findings show pattern of interactions between the various actors in order to organize the emergency response. Serendipitous, inbound and outbound interaction patterns are part of the enactment process [27] of the collective sensemaking efforts. The exchanges of mobile phone numbers are embedded in these interaction patterns and influence the ability of making a professional intervention.

Looking at mobile phone interactions in this context offers new insights into design of information technology use for time-critical organizing. The current use of mobile phones in emergency response work is to mediate verbal communication. But as the findings show the use of mobile phones also provide the ability to socially form and manage a network of actors across organizational boundaries in response work and thereby improving the capacity of enacted sensemaking [27].

These findings indicate that the mobile phone could become the infrastructure for both verbal communication as well as information sharing in emergency response work. As seen in the findings, emergency response span across organization boundaries. This means that in the event of an incident, the professional organizations would benefit of a common information channel covering the involved actors for mediation and sharing of non-verbal incident specific information. This means that symbolic record of actions, such as status reports, maps and photos produced during the intervention would become available for all the involved actors and organizations.

Implications for such system design is to avoid adding yet another system and additional artifacts for the emergency response actors but to make use of the technology that is already in use and base the design on the existing social organizing patterns. The key implications are: 1) the design entity should be the fixed address to the actor, in this case the mobile phone number, 2) the design should address the situated management of phone numbers providing both social and technical functionality. These two key issues have the potential of focusing the design of an incident specific information channel that is publicly available for all the actors that become part of the response network.

The following high-level description illustrates what such design could materialize in. When new actors are included in the response network through the exchange of mobile phone numbers they should also at that moment have access to the incident specific information channel. The incident specific information channel should be available to all actors in the rescue services via their network enabled personal communication devices such as their mobile phones. Such information channel should only be available in cases of an incident and during the response work. As long as the response is ongoing, the incident specific information channel will also be available. When the acquired phone number is added to the incident specific information channel it could result in a message that is pushed to the corresponding mobile phone and thereby provide authorization and access. The addition of a phone number should be supported at all localities where mobile phone numbers are managed; at the command centre, at the command post, and also via mobile phones of field personnel.

The incident specific information channel is envisioned to make use of technologies such as full-capacity mobile web-browsers, real simple syndication (RSS) and blogging functionality now becoming standard features in consumer mobile phone products. Information systems previously restricted by organizational boundaries will be able to publish or push information to the incident specific information channel. The information made available in the incident specific information channel could be accessed on mobile phones and when necessary, due to limitations of the handset or for actors in non-field settings, be transferred to laptops or other devices.

The suggested design contrasts solutions designed from a large-scale medical emergency management perspective [11]. The design proposed here in this paper is based on the idea that small-scale accidents can quickly escalate to large-scale crises and that the response work in the initial phases of an emergency have small-scale qualities. The focus on mundane technology such as the mobile phone and using a bottom-up perspective is targeting the issue that emergency response information technology must be both technically scalable as well as socially scalable. Further, in the study of the Katrina Hurricane relief work [5], it was shown how dyadic interaction formed the basis for information sharing and collaboration across organizational boundaries. The study also presents that introducing new technology for ephemeral response groups proved to be difficult. In contrast, our design focuses on making better use of the technology already in place among the response actors.

The formation of the response network to provide both technical as well as social connectedness is managed on the social level compared to more technical level where the

connectivity is provided on the device [14] seamlessly and automatically using for example Bluetooth. Our design does not remove the social aspect of connecting actors but rather use the social contract that the exchange of mobile phone number could be interpreted as. The design implications presented here focus on the use of mobile phones not only to maintain a social network in a symbolic meaning but also to provide a materialized information infrastructure where mobile phones mediate both network connectivity, social connectedness and information sharing which is understood as key characteristics in enacted sensemaking [27, 29]. However, the consequences of such design are difficult to project. The flow of information in the incident specific information channel will most probable put new demands on the actors. For example, expectations to be continually updated and being accountable for actions beyond their authority due to the visibility of collective actions. Further, technology pre-structures how people are able to understand their world [29] and so does also the design outlined here and the materialization of such design. Alterations of such social patterns must be done with care.

DISCUSSION

In Sweden, the regional fire and rescue service organization has the comprehensive responsibility for incident response and management. A vast number of computer systems have been designed, implemented and put to use within these organizations. These systems are used by the organizational members and serve as the backbone support for the organizational processes. However, when a more complex incident has occurred additional actors and competences have to be acquired rapidly from outside the organization. These actors are most often excluded from the organizational information systems and cooperation with these external actors has to be through other means than through these systems.

In this paper it has been shown how actors use mobile phones to interact, negotiate and establish the initial network of professionals in order to meeting the threats posed by a major incident. Emergency response organizing was analyzed from an enacted sensemaking perspective. Patterns of mobile phone interaction were presented showing how they are embedded in work of organizing socially connected actors part of the response work resulting in an increased capacity for sensemaking[27]. Three interaction patterns were outlined: serendipitous, inbound and outbound. These patterns have also been observed on other incidents but on a smaller scale.

In serendipitous interaction mobile phone numbers are exchanged face-to-face and only individually available. This was illustrated in the case where two actors independently of each other were dispatched to the incident by their respective organizations. In inbound interaction, various actors offer their expertise to the response network and if their expertise is considered as relevant in relation to the incident at hand they are accepted as a legitimate actor in the response network. The challenge here is to balance the inbound interaction to central actors as for instance the incident commander. Outbound interactions are of two kinds. First, when an actor simply is informed. Second, when a resource is called in to be a legitimate actor in relation to the incident. This can be either an actor with a specific expertise such as the chemical expert who came to the two incidents. It could also be an outbound reach to the regional police commander that analyzes evacuation plans for the incident from a distance.

The significance of this paper is discussed from two perspectives. From a practitioner perspective, i.e., fire and rescue service, is it shown that the mobile phone is of crucial importance for the process of organizing the work to meet the initial demands posed by the incident. The communication within the rescue service can be managed through the radio communication system. However, communication with other organizations has to be mediated through alternative channels such as mobile phones. From a research perspective the contribution of this paper is the detailed descriptions of the patterns of interactions of mobile phones in time-critical organizing. The ethnography may inspire design activities targeting time-critical organizing. The conceptual design illustrates contrasting views to previous studies that are related to the application domain of emergency response systems as well as technical solutions for ad-hoc connectivity. The results from this paper address on a general level, the design of information technology for ephemeral work groups. Such groups are not only found in emergency response or disaster relief work. Settings with similar characteristics include physical restoration of telecom/power infrastructures, and in general the work of field service technicians. However, additional studies are needed to further generalize these findings.

CONCLUSIONS

This paper has discussed time-critical organizing and investigated mobile phone interactions in this organizing. The analysis shows how the mobile phone not only have an important function as a communication device but also how the mobile phone numbers are used in organizing and making sense of the emergency. The analysis outlined three patterns of interactions where dyadic exchanges of mobile phone numbers could be seen as embedded in the enactment process of the collective sensemaking activities. High-level design implications have been discussed to illustrate the implications for future systems aiming to improve emergency response organizing.

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