Temporary Contact Management within Emergency Response Settings

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***Abstract*— Efficient response to emergencies is important to minimize their consequences and requires a high degree of knowledge and skill from the responders. Situation awareness and sensemaking are key cognitive processes used by emergency responders to handle these situations. Supporting these processes increases the efficiency of the response work. This study will explore how to improve these processes for an emergency response organization through visualization and information-sharing of external actor's contact information within an incident. The paper presents the development and testing of a prototype that will enable managing this data by one organization. The outcome of this study shows that providing a tool for managing temporary contact-information in large scale emergencies supports the cognitive processes required for efficient emergency response work.**

I. Introduction

Efficient response to emergencies and crisis is important not only to save human lives but also because of the need to minimize their environmental and economic impact. Modern society with its technical complexity and diversity requires an equivalent degree of knowledge and skill from the responders to be able to address the disasters and accidents that threaten it. Attention has been brought by emergency authorities to how technology can support and improve emergency response work in a local, national and global level as well as on an organizational and inter-organizational level. The challenges of designing such information systems have resulted in several proposals on what functionality emergency and crisis responders need.

Landgren addresses in his research the role of information technology in emergency response work [1]. Amongst other things he describes how technology, such as mobile phones, is used by the fire and rescue services to collaborate with external organizations within an incident setting [2]. It is particularly the more complex incidents that require inter-organizational collaboration, which in turn require a higher level of management within each organization. There have been attempts by emergency authorities to address the issue of inter-organizational collaboration by developing technologies to support it, however, little has been done in terms of research regarding this issue and the impact it has on improving efficiency in emergency response work.

In this study, focus will be on how inter-organizational communication can be supported through visualization and information-sharing of external actor's contact information, within one emergency response organization. The fire and rescue services is a key organization in large scale emergency response and will be the organization most frequently called to an incident [2], thus this study will look into how they manage contact information of external actors. It is large scale emergencies that require this type of management, typically involving incident commanders level 2 or 3. According to previous studies the type of contact information that needs to be managed are names an phone numbers of individuals affiliated with organizations (police department, coast guard etc.) or roles (building owner, residents etc.).

The contact information to be managed varies for each incident making it only relevant for that specific incident [2]. This raises an interesting phenomenon regarding temporary data vs. permanent data and the implications this brings to the management of contact information.

To be able to address this issue by developing new information technology, it is important to first understand the setting and the type of work that the fire and rescue services perform. All emergency response work relies heavily on the ability to understand complex situations and make decisions that will lead to gaining control over them. Two theories have addressed the cognitive process that is required to understand ambiguous and uncertain situations: (1) Situation awareness [3] and (2) sensemaking [4]. In emergency response work the demand for situation awareness and sensemaking is severe due to its characteristics of low probability and high consequence [4]. The connection between the two theories is made and used as an analytical framework in this study. It will also show how visualization and information-sharing are key concepts for improving the cognitive processes required in emergency response work, thus, for increasing its efficiency.

The study consists of a theoretical analysis of emergency response work together with an analysis of the work performed by the fire and rescue services in Göteborg based on interviews with key personnel within the organization. Followed by the design and implementation of a prototype that serves as a tool for the fire and rescue services' management of temporary inter-organizational contact information in level 2 and 3 command incidents. Further, the prototype will be used by incident commanders on a field experiment conducted in cooperation with the fire and rescue services in Göteborg.

A. Problem Definition

Emergency response organizations face severe problems in inter-organizational collaboration, a central issue consists in the managing, by one organization, of external actor's contact information in a given incident. Further, the contact information of the external actors is temporary, since for every incident the involved individuals to a large extent change.

II. Related work

As emergency responders begins to formulate their plans and actions for engaging in emergency response work, they do so not only on past experience but also on what actions have been taken and their consequences. This may include other fire crews arriving earlier and performing some actions or even public intervention. Providing these individuals the possibility to view abstract displays of actions and interactions, enables them to form a common operating picture (COP) which leads to improved team performance [5]. However, considerate thought has to be put into what type of data should be displayed, as more data does not mean more information. As stated by Endsley *"The problem with today's systems is not the lack of information, but finding what is needed"*[3]. Prioritizing information will be a key part of helping to avoid information overload, if data can be prioritized based on certain criteria then information can be filtered to the responders at a rate which they can process more effectively.

It is the role of the Incident Commander (IC) to both manage and prevent crisis from escalating, this can be accomplished through better management of smaller ones. [4]. One approach to better managing this type of situation is by providing a greater understanding of the situation. An IC need to be able to perform multiple tasks, while some of these tasks can be transferred to other staff members, an IC still needs to know what tasks have been allocated to others. Knowing this is one of many variables an IC must take into consideration when performing their job. Endsley describes that having the knowledge of other team members' tasks will impact on one's own goals and tasks, therefore by possessing such knowledge one can better plan in advance. As well Weick discusses, *"the more people know or see about a situation the more likely they are to see when intervention is needed"*[4]. Therefore, by having means to help managing a single task, an IC can better manage the whole situation.

Landgren and Nuldén were able to identify three types of interactions that occurred in fire rescue situations: 1) Serendipitous, 2) Inbound and 3) Outbound [2]. It was observed during these interactions that a typical protocol occurred, with one significant part being the introductions and exchanging of personal details. It was also observed that a restriction of this type of interaction was that the communication of details was limited to only the persons involved. Using Endsly's notion of shared mental models [3] it can be seen that if a network of actors and their details can be formed, a shared model of the people involved develops, which will thus aid in a greater awareness of the situation.

As one can imagine emergency response work and time criticality go hand in hand, therefore having an application that is simple and does not add further complexity to the situation would be desirable. By taking the work required of contact management and incorporating it within technology it can help achieve this goal.

III. Analytical framework

Mobilization and intervention are critical phases in emergency response work and the cognitive processes that occur during these activities are areas that have been studied by many. Two theories that can be linked to this type of research are situation awareness and sensemaking. The coupling of situation awareness and sensemaking within emergency response work will be used to show how it can improve an IC's work.

A problem that organizations like the fire rescue services face is that their sensemaking abilities are restricted to the individuals; Weick identifies this phenomena as institutional memory [4]. Part of the sensemaking process is the building of cause maps [4], which is done based on experience, knowledge and if the possibility exists through taking part of institutional memory. Therefore by having a rich map people can better understand and make sense of situations, especially when projecting further actions [3]. The knowledge that is gained by teams and individuals during emergency response work and the sharing of this knowledge are key elements in how situation awareness and sensemaking can improve an IC's work.

Each individual within a team must have a high situation awareness in order for the whole team to perform at its best. Weick discusses that it is not desirable within team work to have only one member who possess all the information [4]. Further, Endsley also states that sharing of information is critical to teams with common goals [6]. During the process of achieving these goals, firefighters must be able to share information about what they observe and sense in order to help others plan, actuate, communicate, understand and forecast decisions or actions [6]. According to Endsley *"shared mental model of a situation is believed to enhance the understanding and projections on lower level data without the need for extra communication"* [5]. Therefore by sharing data or information across a shared network, the chance increases that teams or individuals will develop a common or shared mental model thus could improve team performance.

Peoples actions are key elements in any sensemaking process, and it is through these actions that individuals develop knowledge about a situation. As discussed by Weick *"there is a delicate trade off between dangerous actions which produce understanding and safe inaction which produces confusion"* [4]. However, it is impossible to completely understand a situation especially in the work of fire fighting as the environment is ever-changing. The notion put forward by Weick suggests that in order to get feedback, learn and build an understanding of an unknown situation one must make or have actions. So by understanding how to encapsulate these actions within technology and provide them to emergency responders supports the understanding of the situation.

To visualize and share the actions taken within an incident setting, a concept application for both stationary and mobile settings will be designed and implemented. This application will provide a COP, with a focus on temporary contact management, this type of information will be used to help create a shared mental model of situations. A subsequent goal is that, if knowledge and lessons can be learnt through observations of shared information then this application should also be viewed as a training application. Where experienced can be gained by observing actions and consequences.

IV. Research Setting

Gaining an understanding of the fire and rescue services way of working and their needs will provide information about general emergency response work and conclusions will be made that could apply to other emergency response organizations.

There are two areas that are important in order to understand the work performed by the fire and rescue services: (1) the emergency response life-cycle and (2) the incident level.

A. Emergency Response Life-cycle

An emergency response can be described as having a life-cycle of 4 phases, during which the work of the fire crew varies heavily [7]:

1) **Mobilization:** The first phase is triggered by the fire station alarm and extends until the point of arrival by the fire crew to the incident site
2) **Intervention:** The second phase starts when the fire crew arrives at the incident location, an assessment of the situation is made at the same time as the first actions are taken to control the incident
3) **Situational Adjustment:** When the actions that the fire crew has taken start to give effect, the third phases has been entered. This phase is characterized by the adjustment of the actions according to predictions of the emergency. Coordination and meetings are necessary as new units arrive for assistance, as well as periodic reporting
4) **Incident Completion:** When the work of the fire crew starts reaching completion, units start being demobilized followed by a declaration of incident termination

During the emergency response life-cycle the fire crew is assisted by previous personal experience to create situation awareness and for enabling the sensemaking process. This can be knowledge about a specific geographical area, material, infrastructure, other organizations. However, the organizational structure of the fire and rescue services is changing, there are fewer fire fighters, each fire station is responsible for a larger area and we live in a more complex society with more complex technology. This means that a fire crew can no longer rely entirely on previous knowledge and experience. Fire crews can be dispatched to a location they have never been to before, or will have to deal with material they have no previous knowledge about. To be able to cope with this reality, information technology is used to help build an awareness of the situation.

B. Incident Level

There are many different settings in which the fire and rescue services have to act. The more complex incidents involve more resources and require better management. The incidents are categorized into 3 different levels:

- **Level 1:** is a small incident where a fire crew and its fire crew commander (FCC) are involved
- **Level 2:** is a complex incident that requires the assistance of at least two fire crews and their respective FCCs. In this type of incident an incident commander level 2 (IC2) is dispatched and takes the position of highest responsibility
- **Level 3:** is a complex incident that requires the involvement of several fire crews and specialist fire crews and their respective FCCs. In this type of incident an incident commander level 3 (IC3) is dispatched together with his/her staff which includes a mobile command center operator (MCCO). The IC3 takes the position of highest responsibility on site

It is particularly in the level 2 and 3 incidents that there is a high need for tools to support communication, information sharing and contact management. A lot of external actors are involved in these types of incidents, it can be people from different response organizations, property owners, victims, insurance companies etc. Information about these actors needs to be retrieved, stored and provided to the IC2/3 at different points during the incident life-cycle. However, the actors involved in one incident may not be the same in a future incident, therefore making the contact information only relevant for a specific incident.

V. Methodology

A. Research Approach and Method

The methodology used in this thesis is based on a constructivist knowledge claim, it makes the assumption that individuals construct new knowledge through experiences and the assimilation of these into an existing framework. The constructivist researcher aims to gain knowledge of the specific context in which individuals act and work, in order to understand the historical and cultural setting of the participants and the process of interaction between the individuals [8]. The existing framework of knowledge from which the research for this study took off, is presented in chapter III Analytical Framework.

The research approach used in this study is a qualitative research approach with strong inspiration from ethnographical research. The characteristics of ethnography that have formed the base of the method used in this study are:

- the goal of understanding a setting to be able to understand the individuals acting in it [9] - Understanding the characteristics of emergency response work
- the focus on a single setting or group [10] - Specifically looking into the work practices of the fire and rescue services in Göteborg
- the exploratory approach of entering the setting with an open mind [9]
- the use of conversation and interviews on different levels of formality [10]
- provide a framework where responders can express themselves openly [10]
- the flexibility and dynamics of the research which may involve being in the right place at the right time, creativity, serendipity, luck etc. [9]
- the simultaneity of the collection of data and the analysis [9]

The design process used in this study to develop the prototype is contextual design, which is a user-centered process that incorporates ethnographic methods for gathering data relevant for the product under design. Contextual design consists of the following top-level steps [11]:

1) **Contextual Inquiry:** Collection of data about user work practices through interviews, observations etc.
2) **Work Modeling:** Creation of work models representing the user work practices
3) **Consolidation:** The data is analyzed to reveal patterns
4) **Work Redesign:** The consolidated data is used to drive conversation about how to improve work practices providing a new system. The redesigned work practices are captured in a vision (a description)
5) **User Environment Design:** Captures the architecture of the new system, explaining all the parts in it
6) **Prototype and Test:** Testing is important to find problems early on and fixing them. Different types of prototypes can be developed for testing

B. Data Collection and Analysis

The gathering of data and the analysis were performed simultaneously where the team worked in an iterative mode. The data was added and assimilated into the knowledge framework, which at times created new discussions that required more interviews, information exchange and literature research to further clarify the setting.

Litterature Reviews. The data that created the initial knowledge framework was gathered through extensive reading of articles and books about research within the topic or of related topics. Two theories where identified as being relevant for understanding emergency response work: (1) Situation awareness [3] and (2) sensemaking [4], which provided key concepts and constituted the theoretical base of the study. In addition, the research conducted by Landgren and Nuldén regarding the use of mobile technology in emergency response work [2], contributed to the understanding of the setting.

Interviews. A substantial part of the data was collected through interviews, taking the form of both audio and visual data as well as notes. Interviews where held with IC level 2 and 3 as well as people with domain knowledge. The exploratory approach used in the interviews enabled the interviewees to describe their work and their needs freely. The few questions that were asked by the team were open-ended, to facilitate an open discussion.

The focus of the interviews was to understand how the work of the fire and rescue services was performed and the various technologies they use. This provided an insight into the execution of the different tasks performed during an incident. Discussions were held about issues associated with technology currently used, this enabled an understanding of work practices that had failed or succeeded in the setting. These discussions supported the creation of work models for identification of patterns in the work practice, the patterns provided a base for the the design of the prototype.

Observations. Throughout the study observations revealed different idealisms about work practices, such as habits, work culture, preferences and perspectives which contributed to the knowledge framework. These observations became a relevant part of the work models created by the team and contributed to the discussions regarding improvement of work practices through the design of the prototype.

Demonstrations. Data was collected by taking part of presentations and demonstrations of similar software used by emergency responders. During the interviews the different vehicles and technologies used by the fire and rescue services in Göteborg were presented. The team also took part of a demonstration of Daedalos, a mobile incident support system which supplies information such as maps, blueprints and address details, which provided knowledge regarding a specific mobile technology. This gave insight into the possibilities of incorporating such technologies into emergency response work and the restrictions this imposes.

Another demonstration presented RAKEL, a new radio communication infrastructure used by emergency response organizations in Sweden to coordinate inter-organizational work. A presentation of some of the applications used by the RAKEL system was provided. These applications presented a variety of ways to manage internal and external organizational activities.

Excerpts. To understand the type of information needed to be managed data was gathered through access to documents produced by the fire and rescue services in Göteborg from different incidents. These were mostly paper-based notes taken to manage contact information.

Prototype. The development and testing of a prototype was used to evaluate the accuracy of the constructed knowledge framework. The design of the prototype encapsulated the vision earlier formed regarding improved work practices in emergency response work. Throughout the development of the prototype, feedback was used to refine the concept and drive conversation about the improvement of work practices. In addition, several component tests were conducted with members of the fire and rescue services in Göteborg and people outside of the organization, which contributed to these discussions.

A system test was held with members of the fire and rescue services of Göteborg, the test setting was a simulation of an incident. Audio and visual data along with observations and notes were collected from the tests. The participants were given the opportunity to fill out a questionnaire about the prototype and the test in general. The analysis of the data produced in the system test formed the base of the evaluation of the prototype.

VI. Findings and Results

In this chapter the findings and results of the study are grouped and presented in three sections: Design, Implementation and Evaluation.

A. Design

From the work models the vision of the new system took form by the outlining of the overall design. For example, to achieve the goal of providing a common shared model of the situation there would be a requirement for abstract shared displays [4] thus also enhancing the COP. From this type of analysis high level requirements were identified and have been grouped and listed below:

Theoretical

1) The system should be able to show when a contact has been added/deleted/edited
2) The system should display basic contact information (name, number) on a shared network

Interviews

3) The user should be able to change details about a contact or a group
4) The user should be able to call a contact from the list
5) The system should be able to send and receive contact information to and from other users respectively
6) The system should be able record events (i.e adding a contact) for logging purposes

Observation

7) The system should be able to display a full contact list to users when they join a network

Demonstrations

8) The system should be able to run on both a workstation computer and mobile phone
9) The system should be able to categorize contacts into common groups or roles

From these initial requirements a general observation was that it should be a distributed system with the functionality to handle multiple users communicating independently. Each user has the possibility to view a display that shows contact information of various actors which are associated to the current emergency setting. Implementation for logging and displaying of various events that occurred during an incidents life-cycle will be designed for. These events will be tracked through the actions performed by the users using the application.

Much of the visual design choices have been inspired by existing applications that have address books or contact lists as part of their environment. Reasons for this can be attributed to allowing users in accustoming themselves with something familiar quickly thus contributing to improving the cognitive processes. To improve the portability and create platform independence the system will be developed in Java, for this reason each application can be distributed via portable storage devices (e.g USB memory sticks) which will included Java Run-time Environment (JRE) in the package.

The system consists of five main components, a general overview can be seen in figure 1:

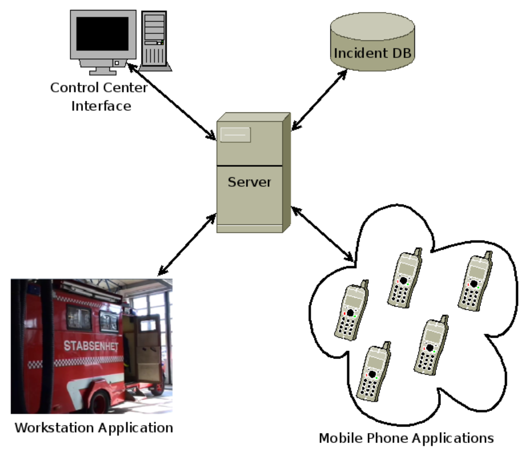

Fig. 1. System overview

1) Control Center Interface: The control center is considered to be the first entry point of information for an incident. Typically an alarm will be reported to a control center operator (CCO) through the national emergency number 112. This part of the system is a back-end to the CCO existing application, that is used to manage emergency response calls. It is envisaged that the system will retrieve the necessary data (i.e callers name and number) and create an incident report in a central database.

2) Database: The purpose of the database is to store and manage multiple incidents and to allow the sharing of information between them effectively. The database will also provide the necessary requirements for archiving data associated with each incident. Through the interviews it was found that there was a need to view a report or log file of certain events that occurred within an incident, this would also prove desirable to have when preparing post-incident reports.

3) Server: All communication will be routed through a central server to which all applications will be connected. The server will handle all requests and transmission of data to and from the various applications. At this stage there has been no design consideration for the security of data transmissions across an open network, but this will have to be addressed in later design iterations.

4) Workstation Application - WS-app: The WS-app includes the necessary functionality required to manage a "phone book". It is seen that the WS-app will be operational both within a control center (CC) and a mobile control center (MCC). The operator will perform most of the administrative tasks associated with managing a contact list (e.g entering name and number, creating different groups and altering information) therefore a user-friendly interface will have to be implemented for performing such tasks. It was found that the operators receive verbal requests for contact information and that it will be their role within this application to enter the results, thus distributing the information. It was found that the design requirements could comprise the use of the WS-app in a variety of technologies, for example the PDA used in the IC2 vehicle (see figure 2).

Fig. 2. PDA inside IC2 vehicle

5) Mobile Phone Application - MP-app: To fully encapsulate the concept of a distributed system, this application will be designed to run on mobile phones which posses Java capabilities and an internet connection. The MP-app is designed to appear in a similar way as the WS-app, this will support the creating of a COP and shared mental models. Due to the limitations imposed by mobile phones, such as smaller screens and buttons the MP-app will function in more of a passive mode where the user can view when contacts have been added and have the possibility them. While this is the main goal behind the design it is still necessary for the mobile application to contain the functionality required to manage contact information.

B. Prototype Implementation

For the purpose of investigating and evaluating the theories presented in this study the implementation of a prototype was launched. Approximately 150 hours were allocated to implementing the prototype Actor Visualization in Emergency Response (AVER 1.0) that was envisioned as a simple server-client application. The following components comprise AVER 1.0:

1) Database: No database for storing and acquiring data was implemented.

2) Server: The server, implemented in Java 2 Standard Edition (J2SE), sets up a network that all clients connect to and maintains a list of all connected clients. It manages the clients by broadcasting and sending private messages to them. The messages contain data regarding contacts and groups, from when contact/group is added, edited or deleted. When a new client joins the network, it will also provide the new client with the accumulated data of groups and contacts.

3) Client Application: The client connects to the network created by the server. It is the client that keeps track and manages the data stored in the system, it sends messages to the server whenever data is added or altered. It also handles and updates its stored data whenever it receives messages from the server. The contact list is presented in a tree-structure, the top level consists of groups where the default group is "Kontakter" ("Contacts"), the next level consists of contacts with a name and a phone number. The log was presented as a simple list with time-stamped events where the last event would be displayed at the top of the list. An easy navigation between the log and the contact-list was provided. Two separate client applications were developed:

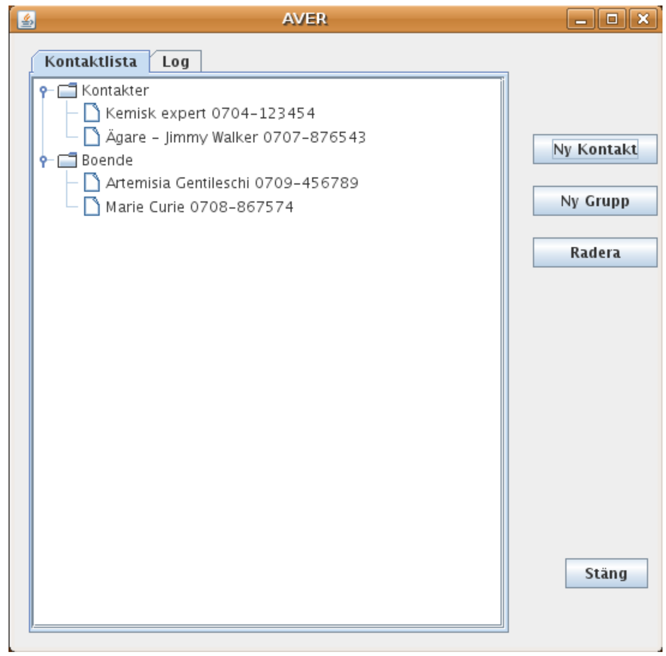

Fig. 3. WS-app - Main View

WS-app. Implemented in Java 2 Standard Edition (J2SE). The contact-list was displayed in a tree structure that would be open by default, thus giving a good overview of all the contacts (see figure 3). 4 buttons enables the user to either add a new contact, add a new group, delete an item or close the application. The items in the list can be selected for deletion or for editing by double-clicking. This way keeping the user-interface very simple. No major issues were found that diverted from the design.

MP-app. The initial phase of the MP-app development was performed with a mobile phone emulator. It was developed as a MIDlet (Mobile Information Device) program using Java 2 Micro Edition (J2ME). Major changes diverted the application from the initial design due to restrictions imposed by the hardware, however, the team was able to provide a fully functional MP-app. Focus was set on providing a good overview of the contact-list so that the user would be able to perform the most critical tasks effortless (viewing the contact-list and calling a contact). The groups are viewed as headings under which the

Fig. 4. MP-app - Contact List

contacts of that group appear. The rest of the functionality requires a higher degree of attention from the user, but they are still provided through a menu (see figure 4). The log is also made available through the menu. Another issue faced by the team during implementation was the compatibility with different types of hardware, some mobile phones can not run the prototype with full functionality.

C. Field Test - Evaluation of AVER 1.0

In the early phases of testing the discussions revolved mainly around how the contact-information was presented, the importance of quick access to the contacts with a minimal amount of interactions, was stressed by many of the testers. Further, based on previous use of applications that provided the rescue services with information, it was found to be important that the contacts were displayed in a simple list. That is, containing only crucial information, giving a good overview and not overloading the user with information (see figure 4).

Two categories of users were identified based, one being mainly passive and the other active. The passive ones were the mobile phone users who were interested in viewing the contact list, being informed when new information was added and calling a contact. The active ones were the WS-users, they would retrieve contact-information from different sources and enter it into the application. The WS-testers expressed the need of a quick overview of the entire list, rather than each branch of the tree-list being closed (see figure 5), it should be open giving a total overview of the involved contacts (see figure 6).

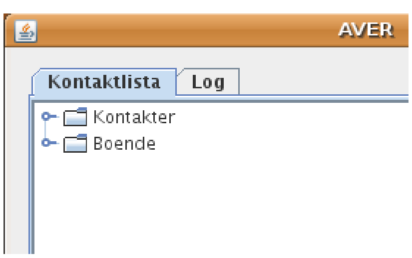

Fig. 5. WS-Display - Closed List

Testers found it valuable to have access to an initiated contact-list when arriving on site by just starting the application. Where previously each user had to gain the contact-information of an actor either by writing it down or entering

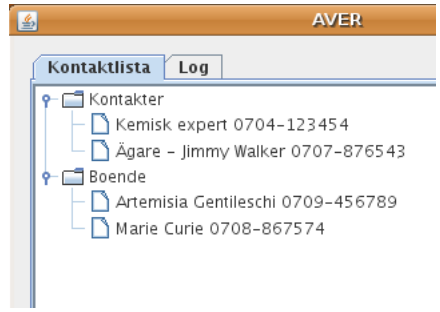

Fig. 6. WS-Display - Open List

it into their personal phone, now one user could enter it into the shared network for everybody to view. This was seen as particularly important for those who were dispatched to an ongoing incident and who would have otherwise retrieved contact-information from others manually. At the same time, it was valuable for those first-responders to get the initial contacts, added by the dispatcher (CCO), while they were being mobilized. The following conversation from the field test shows how it is seen by some members of the fire and rescue services:

IC3: *Yes, it is not easy to get a building owner like that directly...*
IC2: *...lets say that while you are driving to a site and the CCO adds it during mobilization... Here you have the contact-list from the residential company, there you go...*
IC3: *Actually, I think the CCO does the screening for you, that they will get the information that is interesting from the database and provide it to you*

General comments expressed by the testers were of the prototypes simplicity and ease of use. It was found that the testers easily and intuitively understood how to use the prototype and how it worked, making the familiarization process very short, as expressed during the field test:

CCO: *It was easy to use, you didn't need any introduction, you learned it easily by just using it*
MCCO: *I agree, it was easy for me too*

The results from the evaluation of AVER 1.0 have been grouped into four main topics:

1) Information Acquirement and Entering: The tests triggered several discussions regarding the entering of the data into the application and the workload that would imply for some of the users. For the overall team of users the workload is decreased since once the contact-information of an actor is retrieved and entered into the application it is shared with the rest of the users, as expressed by a MCCO:

MCCO: *Yes that is true, you only add it once*

Looking at each of the users however, the work effort would vary: **Mobile Phone User - IC2/3.** The workload would decrease which was seen as very valuable due to the demanding environment in which they work. Previously they managed contact-information by writing the information down on paper or into their mobile phone. The mobile phone users that were first on-site would collect information and then pass it on to new users when they arrived. Likewise, mobile users that arrived to an ongoing incident had to retrieve contact-information from the first users. All these steps are no longer needed when using the application.

WS User - MCCO. The work would be enhanced, since their main task is assisting on-site by retrieving and providing information, with the application they would still have to retrieve and enter information, but the way they distribute the information is changed. Previously the MCCO would verbally provide information to other users on-site through the radio or face-to-face, using the application they would share it visually to everybody through the shared displays.

WS User - CCO. The workload would be slightly increased. In certain occasions they would have time to retrieve and enter the data, as was done previously, but in other situations they might be handling other alarms or mobilizing units. Using the application, other users are dependant on the CCOs providing them with contact-information of involved actors, at least during mobilization, if they do not have time to provide them with it, the application would not be able to serve its cause. It was expressed that a high automation of contact-information acquirement and entering would be valuable for the CCOs, thus preventing their workload from increasing. Contact-information could be retrieved from other applications that are used in rescue work such as existing databases, the Internet, business card-scanners etc.

The following excerpts show the discussion about the workload of the CCOs during mobilization:

IC3: *The question is if you [the CCO] have time, do you?*
CCO: *It will have to be a database enquiry... it is not handled manually*

CCO: *Most of it [acquirement of data] must be automated, the systems should take care of it. If you want the information during mobilization it requires a lot of automation*

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2) Integration With Existing Systems: It was expressed by the testers that such a system should be integrated with already existing systems, not only to enable the acquirement of data, but also to ensure that the rescue work did not imply the use of several independent systems that could not communicate with each other. Having too many different systems would put pressure on the user in mastering them and also repeating the tasks when entering data into several applications. The following excerpt shows what was expressed by a CCO:

CCO: *We will have to see how many systems we work with, two systems should not be doing the same things. The different systems should be able to communicate with each other, there is were the problems usually come. Interfaces are not always simple...*

At the same time, several testers triggered discussions on how it would be possible to integrate such a system with the existing ones.

3) Synchronization: The major issue encountered when testing the prototype with several users were regarding synchronization, where more than one user was trying to edit the same contact/group. This enabled a discussion regarding the integrity of the contact information. Some users were concerned that the contact-information they were receiving might not be accurate, which would then create an uncertainty in the use of the application and in their general on-site work.

Fig. 7. WS-Display - Log

4) Post-Incident Reporting: As expressed by the testers one of the weaknesses in their work was the post-incident reporting where they usually had very little foundation about what had happened in the incident to be able to fill out a proper rapport. It was seen as valuable to have such an application assist them with that by providing not only an overview of the actors involved in an incident, but also through the application's log. Several ways in which the log could be exploited to provide foundation for the post-incident reporting were discussed (see figure 7).

VII. Discussion

In complex incidents, the fire and rescue services find themselves having to manage external actors through tasks such as retrieving, saving and distributing contact information. This paper shows that a management tool would not only facilitate in performing these tasks, but also provide another form of interactivity through a shared network. Further it is an advantage to introduce a tool that utilizes everyday technology, such as mobile phones and PCs, since it would minimize the impact on their work.

By visualizing external actors within a network the cognitive processes required to perform fire and rescue work can be improved. This is achieved by providing shared displays were all involved users have access to the information, thus forming a common operating picture. It is also achieved through providing relevant information in a timely manner, with the subsequent benefit of preventing information overload. However, there are many concerns about sharing of personal information, therefore consideration has to be given to the implications involved, especially when it comes to sensitive matters such as loss of life or property damage.

While there was a subtle reluctance to new systems in a very hands on and traditional working environment it was seen that this application saved time. Concerns were expressed that nothing would beat pen and paper when it came to recording temporary data. However, this research, as well as others show that the use of pen and paper for recording has many limitations, one being the inadequate distribution qualities. While the act of passing a paper may seem trivial the effort required to record and store the data is tedious and repetitive. The application gained appreciation when it was shown how its management abilities counteracted these issues.

While this application would help solve task management issues, a new concern was identified regarding data integrity. It was expressed that if all users are able to alter contact-information there is a higher risk for the data to be compromised. This not only creates insecurity in the use of the application but it also has a negative effect in the cognitive processes. Different permission levels could assist in maintaining the integrity of the data, disallowing certain users from changing the information, especially in incidents that involve a lot of users.

Visual representation of the data, such as symbols and colors, and the implications it brings is outside of the scope of this paper. However, it is an area that could be further explored. Other functionality such as providing audio cues when data is altered and intregation with other systems have been awknoledged as valuable for future improvements.

The value of this paper lies in how two perspectives are merged into a concept-solution. On one side, the theoretical analysis enabled an understanding of how to provide information making response work more efficient. On the other side, the contextual inquiry contributed to the understanding of work-practices within fire and rescue work and how these can be improved. The importance of the outcome also lies in showing that by managing contact-information through a shared network the cognitive processes can be supported. From a research perspective this paper contributes by bringing theories associated with emergency response into the setting where they can be applied. Additionally it provides a knowledge platform for future research in this field.

VIII. Conclusion

This paper has presented an analysis of how contact management can support sensemaking and situation awareness in emergency response work that includes inter-organizational collaboration. Based on this analysis and a study of how the fire and rescue services in Göteborg work in large scale emergencies, a prototype for handling temporary contact information has been developed. The prototype has been used in a field experiment where it was found to be valuable for emergency response work. It assisted the emergency responders in both entering, distributing and using the contact information, but also in providing the information at the right time and when needed. Further it was found that the prototype could be enhanced to better assist emergency responders in their post-incident reporting. Managing temporary contact information in large scale emergencies is an issue for emergency response organizations, providing a tool like this prototype will assist them to make emergency response work more efficient. While there is still more to be done, this research has contributed with a small piece towards further improvement of efficient response work.

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