An Empirical Study of Firefighting Sensemaking Practices to Inform the Design of Ubicomp Technology

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ABSTRACT
In this paper we present an ethnographic study conducted with the Paris Firefighting Brigade to understand the sensemaking practices of firefighters on the first line of intervention and explore ideas for the design of supporting ubicomp technologies. We argue that sensemaking is a core element of firefighting practices particularly when firefighters work on creating a shared understanding of unknown spaces. After exploring a building under very limited visual conditions, firefighters draw ad hoc maps and representations of the environment, which play a crucial role in collaborative sensemaking processes. We conclude on the importance of the central role that sensemaking should play in ubicomp solutions supporting firefighters on ad hoc mapping.

AUTHOR KEYWORDS
Sensemaking, Ubiquitous Computing, Emergency Response, Ethnography, Empathic Design, Firefighting

ACM Classification Keywords
H.5.1 [Information interfaces and presentation (e.g., HCI)]: Multimedia Information Systems – Evaluation/ Methodology

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INTRODUCTION
When a crew of firefighters enters an incident site to perform a reconnaissance mission, they usually have little or no knowledge of the situation and context around them. Information resources are scarce at different levels. On one side the available information could be incomplete due to the complexities of an intervention, and on the other side, processing time for this information could be limited, as the attention of the firefighters must be focused on many different tasks during an intervention. For these reason, an essential part of the work of firefighters is to continually collaborate on building a shared understanding of the situation they are dealing with.

This sensemaking process happens under a very challenging set of conditions. The environment is highly unpredictable. Smoke can fully reduce visibility, heat forces firefighters to crawl on the floor and heavy equipment limits mobility and makes the work physically exhausting. The changing dynamics of the praxis and the dangers that it involves force firefighters to work under strong time constrains and consequently under heavy loads of stress.

One of the key sensemaking activities of firefighters is understanding space. Navigation in an unknown space with low-visibility conditions is a common situation for firefighters as they usually need to perform reconnaissance missions inside buildings without lights or filled with smoke. Although firefighters are trained to deal with them, such situations always represent a source of risk. On entering an unknown building under poor visibility and potentially dangerous conditions, firefighters face a situation where orientation and navigation are of extreme importance [2]. Reconnaissance missions play a central role in this process, as their main goal is to gather information in order to answer the questions “What’s going on here?” and “What do I do next?”. This information includes descriptions of the space and relevant places, identification of potential factors of risk and definition of usable systems of reference for navigation.

In the wearIT@work project, the Fraunhofer Institute FIT is working with the Paris Firefighting Brigade in conducting a participatory design approach to bring ubicomp technologies to the firefighters working on the first line of intervention [13]. In such a scenario, ubicomp represents a progressive instrumentation of the reality [10]. Networks of computing devices embedded in the environment, sensors attached to clothing, intelligent infrastructures, all of them provide a growing amount of information that on the other side, through ubiquitous user interfaces, can be delivered to the firefighter to be consumed in real time. This process yields to new communication channels, and produces deep changes on the existing ones, thus altering the delicate structures of collaboration in the sensemaking activities of firefighters.

Our goal is to empirically observe the sensemaking processes and find opportunities for providing ubicomp based support.

THE CONCEPT OF SENSEMAKING IN FIREFIGHTING

Studies on time-critical work in general and in firefighting in particular show the importance of understanding sensemaking in emergency response. An analysis of breakdowns in firefighting [14] for example, illustrates how the effort to make sense is central in operative emergency response. In his works Landgren [7,8] has also strongly pointed out the relevance of sensemaking in the practices of incident commanders.

There are various approaches to the concept of sensemaking [1, 3, 11]. In this paper we understand the term sensemaking as defined by [14]: "Reality is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs." Sensemaking, for Weick, emphasizes the way in which people try to make things rationally accountable to themselves and others.

Sensemaking is essentially different from decision making, where the question is what we shall do, whereas in sensemaking the question focuses on what is going on: "sensemaking is about the interplay of action and interpretation rather than the influence of evaluation of choice. When action is the central focus, interpretation, not choice, is the core phenomenon" [15], According to [6] firefighters rarely reflect on several decision alternatives but rather use a single option strategy. Sensemaking and not decision making is the issue that is central to the firefighting work in emergency response [7].

One of the points observed by Landgren in his works [7] is the importance of verbal communication as one of the key elements for coordination and discusses how verbal communication can be made persistent and accountable. In further studies on the firefighter domain [8] identified interaction patterns and gave an insight into information technology mediated intra- and inter-organizational collaboration. This observation is particularly relevant for our work, given the intrinsic potential of ubicomp to deeply modify the forms of communication and interaction.

UNDERSTANDING SENSEMAKING EMPIRICALLY

Design methodology

To develop an intuition or sense for making better design decisions, we follow an empathic approach to design. We participated in the training of firefighters, dressed with the complete required garments. Helped by an experienced firefighter, we learned some basic techniques for dealing with the fire hose, walked our path in a tunnel full of smoke, and got as close as possible to a high temperature fire made by the trainers inside a metal container. Obviously, we can not claim that afterwards we became expert firefighters, but we are on the process of developing a more fine intuition of how technology could work (or not) in such extreme situations.

Inspired by participatory design approaches, we are also conducting field studies with firefighters and trying to learn about the context of use for our solutions. This knowledge serves as an input for a collaborative design process of technologies for mediating or facilitating the work by using technology. Most of the time, these opportunities are in the form of basic or incomplete ideas that we understand as possible seeds to the development of tools with a higher level of complexity. Exploring these ideas in the context of use is a central part of our design approach.

Simulated Reconnaissance Missions

We ran several simulated reconnaissance missions in a training facility of the Paris Firefighting Brigade with teams of up to eight firefighters. We planned the missions with the help of an independent professional firefighter who had no further involvement in the project. He provided us with scenarios matching real-world interventions, which we later used to design our missions. The missions were run in a building specially designed for training and the firefighters were equipped with the complete required equipment for such missions, including protective clothes and breathing apparatuses. To simulate null visibility conditions, we placed a layer of paper in the breathing masks, thus blocking sight, but allowing a rough recognition of light sources. The mission in every case was a reconnaissance mission which consisted in walking through the building and finding bottles of water that were previously hidden by members of the team. On-site, we introduced the mission to the commander of the teams, who then instructed the firefighters on how to conduct the missions. Even though finding bottles was strange to their common practices, moving around in an unknown building looking for certain landmarks was not, and with this in mind, we asked the firefighters to conduct their work as close to the reality as possible. The complete set of experiments was filmed, transcribed and analyzed afterwards.

Collaborative sensemaking

Two of the situations that were important in terms of collaborative sensemaking in our studies were handover and debriefing. It was of particular relevance for us to understand how a team communicates their findings after a reconnaissance mission both for debriefing the events and for passing the information to the next team entering a building. Regulations require firefighters to work no longer than half an hour with a breathing apparatus. Communication thus becomes important to hand-over information to the entering team. To observe this process, we chose to sequentially send two teams of two firefighters each on a reconnaissance mission in the basement of the training building (see figure 1), and had the first team to hand over their mission to the second one. The basement has a quite complex structure with many small rooms filled with mock-ups of technical machinery. The firefighters did not know the training facility before, and due to the paper in their breathing masks both teams worked under null visibility conditions.

The team members were connected through the so-called ‘lifeline’, a rope latched at one of the firefighter’s belt and hold by the team lead. By following this rope, firefighters are able to find their way back.

Figure 1: Firefighters on a reconnaissance mission

Details of the mission

The first team entered the building, stepped down the stairs, passed a hallway and scanned a room with a large heating installation. Before leaving the building back, they latched their lifeline to one of the door handles and left the building.

In a hand-over session following the mission, the team shared their impressions with two instructors and the other team by talking and drawing an ad-hoc map (see figure 2). Based on this map, the team lead told the commanders where they had fixed the lifeline. In this way the second team could engage the mission and go into the building, finding their path using the already deployed lifeline. For the second team, the instructions for their mission were to further explore the basement by scanning two more rooms.

Figure 2: Ad hoc map

After doing that and leaving the building the second team drew an extended map and reported new details of their exploration to the commander.

We analyzed the conversations and clustered them in patterns of sensemaking.

Patterns and Findings

1. Ad hoc maps serve as boundary object

Commander 1 encouraged the team leader to draw a basement map in order to make his explanations as clear as possible. He set his verbal explanations in a spatial context by talking and pointing to certain places on the map. Thus, the map serves as boundary object [12] among firefighters. This map is of relevance for the understanding of space during debriefing, and does not have a major role in conserving information, as it is dismissed after the debriefing session.

> Firefighter 1: We walked on and on this level there is a room.
>
> Commander 1: Come on, come on, draw the room! (…)
>
> Firefighter 3: Well and here is a big empty room …you can see that. And here you get to another room about 12 square meter. Here you start, I do not think the room is very big. We get in here, start on the left and here I found the victim. We then stopped the reconnaissance …made another round in that room and continued this way …

2. Information is perceived different across actors according to their roles

In this collaborative reflection process we were able to observe actors in different roles as part of a working organization [9] that is important for successful coordination in firefighting work [14]. During the interactive talk the commander guides both team members in their retrospective reflection process by asking targeted questions. He encourages firefighter to draw sketches of the basement in order to place his oral explanations into the experienced spatial context.

> Firefighter 1: You see, we go down the stairs here.
>
> Commander 1: How many steps? Draw your map … if you draw it from the front, it'll be much easier. (…)
>
> Firefighter 1: (starts to draw a map) Well, the door is here … and there are about 6 steps.
>
> Commander 1: … go on!
>
> Firefighter 1: We walked on and on this level there is a room.
>
> Commander 1: Come on, come on, draw the room!

Firefighter 1: Well, here is another step … we have found the beginning of the fire here, at this position. And the bottles are here. On this level there are fences and here you get out again. Here is a wall … hm … from this side here … didn't you … we continued here …

Firefighter 2: … continued right!

During the conversation with the team, Commander 1 develops interpretations and tries to derive a bigger picture from their detailed explanations.

Firefighter 1: Here you get to a hallway. We entered a room on the left. (…)

Commander 2: Isn't the room on the right here? (…)

Commander 1: OK, so there you could see tubes … of what color?

Firefighter 1: I don't know, I could not see anything … tubes, other stuff, manometers etc.

Commander 1: Good… you could not see anything (…)

Firefighter 1: There was smoke everywhere … and only here we could …

Commander 2: And here you could not see either? There were no bottles?

Firefighter 1: I don't know, I only had this on in my hand …

Commander 1: OK, so you scanned 3 rooms!

Commander 2: Did you find any bottles in the room with the heating installation?

Commander 1: This one is for sure a heating installation.

3. Firefighters make the levels of uncertainty of the reported information explicit.

When the team lead reports to both commanders, he depicts impressions and gives interpretations but he states explicitly the level of uncertainty in his interpretations.

Commander 1: What did you do next?

Firefighter 1: We went back to the hallway and you get to another step and … hm … also with a door. The door is open … no, is it on the other side? The door is on the level of the step and ah … we started ah … to scan this room … I could not estimate the size and then we got the signal and continued to go on. (…)

Firefighter 1: Here you get to a hallway. We entered a room on the left. Well … this room is about this size and it's bigger than that room here. Here there is lot of tubing, could be a heating installation (...).

Commander 1: Leave him alone! OK, so there you could see tubes … of what color? (…)

Firefighter 1: I don't know, I could not see anything … tubes, other stuff, manometers etc. (…)

Firefighter 3: So, I have scanned this room, and that could be a heating installation. I am not so sure, here you get to a big room about 15 square meter. (…) We made a round here and then made a right. There is a little recess here … clac clac … nothing there. I do not know how high this is.

4. Firefighters make informed guesses of more precise information

When we observed the reconnaissance of the basement and both debriefing sessions, we found indications that showed that the firefighters try to develop a set of cognitive categories that organizes the flux of experience [15]. Even though the firefighters had to work under null visibility conditions they guess precise information from their impressions.

Firefighter 3: (…) After that I went back and made a small round in this room continued that way and finished all the rooms. So, I have scanned this room, and that could be a heating installation. I am not so sure, here you get to a big room about 15 square meter. We made a round here and then made a right. There is a little recess here … clac clac … nothing there. I do not know how high this is. (…)

Firefighter 2: We make a round in this part and here is a little wall, about 40cm high. Here is another room part about 2 by 2 meters and empty.

CONCLUSIONS AND FUTURE WORK

In our studies in Paris we were able to empirically observe how sensemaking defines a crucial ability for firefighters and plays a central role in their professionally trained practices.

We explored this role by means of ethnographic studies and found that firefighting work is highly reactive to changes in technology [2]. Introducing positioning information, for example, caused large breakdown situations where technology forced firefighters to abort missions and negatively affected the ability of firefighters to draw ad hoc maps [2]. This sort of effects must be taken into account to

achieve a balance between the benefits of the new technology and their impact into existing practices.

As described in the previous section, maps that are drawn ad hoc become a central means of communication for collaborative sensemaking. In our future work we want to support this process using ubiquitous computing and explore a system that allows bringing this information from hand-over and debriefing to different perspectives. Our approach is on one hand to also use those maps on a local perspective inside the building and on the other hand to aggregate maps for a global perspective used in the overall mission control.

We have learned how important it is for firefighters to build cognitive maps [4, 5] as part of a sensemaking process and that in an ever-changing space, information cannot be trusted and is in continuous need of updates. A system has to provide ways for attaining these continuous updates and clearly point out that the information might be incorrect or might have changed. At no time the users should fully trust the system and imagine themselves safe just because of the information displayed. The user should be able to mark information that has been identified as incorrect, as we consider their abilities and senses to have precedence to the information of the system. In this way users play the active role to verify, complete or discard the existing information about the incident site.

The goal of the system should be, far from giving directions, to support the firefighters on building their own paths. Our design approach does not try to replace human skills by technology, but attempts to support and amplify the existing human ability of making sense of situations.

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