Response to Emergence in Emergency Response

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Abstract. This paper develops a (constructive) critique of the potential of ambient intelligence technologies in emergency response. We explore some difficulties in, and successful practices of, inter-agency collaboration in emergency response, revealed in ethnographic field studies and collaborative design workshops with first responders undertaken in the frame of the Bridge project. We describe four challenges with reference to literature and our own fieldwork in Emergency Management Information Systems (EMIS) design: data transparency, interpretation/intuition, flexible working and information overload. We posit that ambient intelligence has a great deal to offer in the creation of emergency management information systems but that these offerings should be guided by 'modesty' and an ongoing entanglement with emergency practitioners.

Keywords: Emergency response, coordination, collaboration, emergence

1 Introduction

> *... the development of networking technologies must also take account of the social processes that form an important component of command and control and inter-agency cooperation*. [1: 79]

Almost without exception, reports and reflections after disasters express concerns over the different emergency agencies' abilities to work together (whilst also highlighting exemplary successes). These concerns often inspire innovation, investment and research. Recent research in Ambient Intelligence (AmI), for example, develops new support for coordination in emergency response through ad-hoc networking [2], agent-based workflow support [3], self-management and self-healing of emergent systems of systems [4], activity recognition [5], and risk analysis [6]. These technologies have great potential, yet there is often a lack of attention to the complex causes of the difficulties that emergency responders experience and to the often sophisticated practices that enable successful coordination. A deeper understanding of such factors and practices is needed to design useful support for real world practice.

In this paper we focus on aspects of collaboration and coordination between different emergency agencies during large-scale incidents to present a constructive critique of ambient intelligence systems. We explore how AmI tools may feature in a sociotechnical arrangement or 'system of systems' which supports inter-agency collaboration during emergency response.

2 Background

The EU funded Bridge project develops architectural support for the assembly of systems of systems for emergency response. Emergency management encompasses a variety of activities such as planning, training, risk assessment, and organizational change. Emergency response involves an exchange of data between different agencies and institutions, movement of people from service to service and cooperation from other actors (such as utilities companies, insurance providers, and telecoms operators). The emergence of appropriate assemblies of responders and resources depends on coordinated improvisation in a time critical, often dangerous and unpredictable environment. Collaboration is paramount and 'effective' collaboration may save lives. Ambient Intelligence or AmI has great potential in this context, as it can contribute in coordinating and orchestrating emergent interoperability, and help people identify actors and services relevant for the situation at hand. Innovation in this area, however, must be grounded in an understanding of the difficulties emergency responders experience, and their often multi-dimensional causes, as well as an appreciation of the often highly sophisticated and delicate practices of collaboration that make coordination possible. Undermining and failing to appreciate the local, lived and often successful collaboration efforts of those operating 'on the ground' can lead to costly failures with the potential to damage relations between organizations [7]. It is important for emergency management information systems design [8] to focus its efforts on supporting collaboration where it is needed without disrupting the social practices which enable these disparate yet cooperating entities to work together.

To understand the complex practices of intra- and inter–agency collaboration in large scale emergency response, we use in BRIDGE a range of methods that 'entangle' use and design. We have chosen to involve users deeply and equally as co-designers in long-term processes of socio-technical innovation. Our experience with participatory design shows that in-depth, long-term engagement with users and contexts of use can be a powerful source of constructive critique of technocentric visions and a breeding ground for new ideas that are grounded in and more appropriable for real world practices [9, 10]. This can make emergence of viable (and desirable) socio-technical futures possible, and inform the design of technologies for such futures.

In the frame of BRIDGE, we have carried out over 80 hours of interviews, domain analysis workshops and ethnographic observations with professional partners in police, fire and medical emergency services in the UK, Belgium, Norway, Germany and the Netherlands since April 2011. This work includes observations, go-along or walk-along [11, 12] and sit-down interviews, as well as 'sandbox' discussions, where emergency responders use props to describe real emergency response efforts from their own experience. Reflecting the nature of emergency response, the methods chosen in BRIDGE are often mobile and multi-sited. Since it is the detailed organisation of social and material practice what matters to system design, we follow an ethnographic approach based on the use of recordings of interviews and of naturally occurring activities.

In the next section we explore some difficulties in, and successful practices of, inter-agency collaboration in emergency response, revealed in ethnographic field stud-

ies and collaborative design workshops with first responders undertaken in the frame of the Bridge project.

3 Collaboration in emergency response

3.1 Emergent Collaboration

Some of the concerns expressed in official reports over a lack of collaboration following emergency response efforts sit uncomfortably with empirical studies of emergency responders' work practices. Such studies show, for the most part, first responders work well together, their practices fold into each other's and they address incidents effectively through collaborative working and engagement on a day on day, week on week basis. Empirical accounts of practices highlight an economical yet sophisticated process of configuring awareness [13, 14], the emergence of 'adhocracies' of emergency response actors (e.g. in the aftermath of the 9/11 attacks, [15, 16]), and the ability to 'stretch' communicative capabilities with new technologies [10], creatively avoiding a 'fracturing' of perceptual ecologies [17].

Following an inquiry into the London bombings in July 2005, for example, the coroner highlighted how when multi-agency responders were presented with uncertain, complex and traumatic circumstances they "*did all that they could to ensure that lives were saved*" [18]. This sentiment is echoed in the results of BRIDGE project. In our observations of and conversations about work practices with emergency responders, collaboration on a human-to-human level is rarely criticized and is not regarded as a problem but rather as routine. In a discussion with fire fighters they explained how 'the men' (sic) on the ground from fire, health and police agencies, work well together. Responders stated that multi-agency front line officers can collaborate effectively, because they work with each other regularly. This reflects a close community of individuals and agencies working together on small and large scale incidents, where plans, standardized procedures, and official terminologies represent resources (not blueprints) for situated action [19].

Reports from disasters often gloss over the difficulties of conceiving and implementing collaboration support in emergency response both at a human and at a technical level. This usually motivates attempts to eliminate differences among participating agencies, for example through centralization, which has not proven to be effective. 'Environmental' constraints, such as overeager centralization, cumbersome legislation, and conflicting business rationales impact on the responders' capabilities to coordinate their contributions and collaborate. Moreover, when that work is augmented by technologies, important, but often taken for granted aspects of emergent collaborative practices can become undermined. In these situations, problems between agencies working together can emerge – they may, for example, be unable to share information embedded within technologies or act on information obtained through communication or observation. What works on a person to person level, for example in 'motorhood' collaboration around physical surfaces in co-present situations, should not be disrupted by radio systems which cannot interoperate or logging systems which

can only be viewed by one agency. As a consequence, new systems need to be designed and integrate existing components with greater sensitivity to such collaborative work practices between agencies, moving between perspectives gracefully, without interfering with the work of responders. Technological futures must focus not only on overcoming breakdowns in collaboration, but also on 'stretching' existing, effective ways of working together.

3.2 Role and challenges for AmI in emergency response

Many authors have written about imagined futures for emergency response where AmI environments could improve collaboration and coordination of response efforts. The AmI environment is envisioned or designed to recognize the needs of people through analysis of abstractions of behaviour, predicting needs and reacting accordingly [20]. In a scenario proposed by [2], for instance, a world is imagined where, as off duty paramedics approach a scene of an incident "*…body-worn AmI devices register them with the ambulance control centre <ad hoc networking, identification and authentication> and they are directed to the place they can be of most use*" [2: 119]. The benefits of such interactions are highly valued and regarded by practitioners when discussing the potential of AmI systems in the context of emergency response. Such use of AmI raises, however, a number of concerns about the way in which the 'social' is removed or made invisible from these envisaged interactions. Critiques of AmI in health care and telemedicine, for example, highlight the ways in which creating intelligent environments disrupt social connectedness – remote monitoring removes the personal connections and the benefits of being cared for [21]. Indeed, cooperation and interagency collaboration is an effect emerging of the sociotechnical system working as a whole. In this sense, AmI tools are just one further element of the assembly. If they undermine the practices of inter-agency collaboration by removing negotiations or the space for interaction between participants, they can seriously disrupt sophisticated collaborative practices.

Against this background, it is a deep challenge for AmI to balance engagement and automation. Dealing with this challenge is possible through appropriation and flexible assembly, rather than designing systems for an imagined future and created by detachment from the realities of human practices. This is not a new endeavor. [10] have suggested that ambient intelligence systems need to be made 'palpable', enabling visibility, de-construction, understandability, coherence, stability, user control and deference. [22] has stated that promoting 'engaged' living, where it is possible to control interactions with the world as an alternate possibility for steering the field. Aiming at these qualities presents a plethora of opportunities for technological innovation yet also raises a number of serious challenges at different levels in the design of AmI systems. In our work, we identified several of these challenges. In the following we describe four of them with reference to literature and our own fieldwork in EMIS design.

Data Transparency. Ambient intelligent environments often make extensive use of instrumented environments via omnipresent sensors and actuators such as CCTV,

RFIDs tags, etc [23], which imply a growing potential for increased surveillance possibilities. In a co-design workshop, we discussed anxieties about breaching the data protection act when sharing data in multi-agency collaboration. A dilemma was presented where a policeman needs to do something with a person and that person is known to have a blood infection. The ambulance representative stated, "*We tell them discreetly 'use your gloves'*". Jim, a Norwegian police officer, described inter-organizational collaboration on the scene of an incident during the workshop,

> *"If there's a known violent criminal who might be armed injured on the scene, you'd tell the medics 'be careful with him'"*

This is not in breach of data protection regulations and highly effective for the safety of emergency response personnel. It is an ethical requirement for information systems to (at least) respect existing health and safety practices. The above exchanges are likely to happen in 'fleeting moments', in direct face-to-face interaction or, less likely, via the radio system. The information would be ephemeral and it is relatively easy to understand who is within reach of this information spatially, organizationally, and temporally. However, in future, such communications may be logged automatically, opening them up for retrospective scrutiny. Moreover, it may be possible to triangulate the personal information implied in the communication with ID information and location. This change of context might make professionals less inclined to divulge what they know to protect their colleagues, for fear of breaching data protection regulations. This raises the question of balancing between the benefits of seamlessly connected system with the privacy concerns that the profiling and monitoring capabilities of AmI systems create.

Information Overload. [24] argue that a 'common operational picture' does not lead to 'situation awareness'. The assumption 'that data is the only barrier to appropriate [understanding and] action' is deeply flawed. This was elaborated on in our fieldwork where it was felt that information should be appropriately available at the different levels of an emergency command structure, that a common operational picture was not reliant on data intensive practices, and that providing excess information would *"blur the lines of command"* (Peter, Advanced Paramedic).

> *"As a commander remote, I don't think you would be interested in that particular information* [the status of individual victims]. *I think you'd want the headline; the numbers."* (John, Senior Fire Fighter)

Yet increasingly, systems are developed that aim to generate more and more 'data' for emergency responders in order to 'improve' situation awareness, creating the potential to mask what is of importance. There is a delicate balance to be made between information overload and information simplification where digitally extended and augmented environments change interaction and involvement possibilities and threaten the ability to 'dig deep' enough into the system to see modes of information generation or aggregation.

Interpretation/Intuition. It is not possible for an intelligent environment to be *intelligent enough* for situated sense-making. In human communication and collaboration, there is interpretation and intuition used to understand intent. It is therefore difficult (if not impossible) to design a system that would produce an appropriate response due to its incapacity to fully 'appreciate' context and intentions. During a co-design workshop, in a discussion regarding the allocation of resources, responders talked about how the allocation or movement of personnel from one location to another is not simply the movement of people from one place to another. Ex-police officer and resilience manager, David, states:

> *"One little thing that we questioned slightly is… automatic deployment… We felt that wasn't really taking account of the dialogue that goes on between control rooms and the units that they are deploying: officers or paramedics are feeding back local knowledge and things like this and we felt that that's something, an area that really needs looking at. It's never a one way process, deploying resources."*

Resource allocation implies a process of negotiation that define the task itself, its parameters and how it should be accomplished. The work that is 'done' during the allocation of resources cannot necessarily be broken down into matching an individual's skills with an area requiring assistance. As the example shows, asking someone to do something may involve trust in their professional capabilities, and delegation of responsibility or collaboration and negotiation: to determine whether the person being moved is fit for duty and indeed the best resource to move in the circumstances.
Further to this, the accuracy to which such systems can 'abstract' human conduct underlying collaborative practices is restricted. A police officer might move from one side of the building to another, for example. What does such movement represent? Does it mean that one area is now safe? That the area where they were standing is now dangerous? That there is more need for them in the new location or that they are due to go home? AmI has no capacity to 'read' scenes in a way that could answer such questions. It can, however, make them, or digital representations of them, available to support the construction of awareness and the situated sense-making of its users.

Flexible Working. The above examples go some way in showing how coordination between different agencies in emergency response is an emergent phenomenon that depends on people's ability to flexibly assemble technologies, people, and resources. It must allow for role improvisation. Our empirical studies and design collaborations with professionals provide insights into experiences of camaraderie and trust, and effective practices of improvisation and 'motorhood' coordination, that is, gatherings where knowledge and different perspectives are brought together, often around a shared physical surface, but increasingly also utilizing digital technologies. After it had been determined that there were no further bombs in the government buildings in Oslo after the attack on 22/7/2011, ambulance doctors went inside the buildings, doing triage with fire fighters. This was in response to a perceived danger

of fire fighters evacuating the wrong victims. Medical staff could do triage inside the buildings and allocate scarce transport resources more efficiently.

4 Conclusion

The Bridge project's aim is to "*augment human intellect …, extending their ability to learn, make decisions, reason, create, solve complex problems and generate innovative ideas*", based on Rogers 'New Agenda' for ubiquitous computing [22: 411]. Rogers states that UbiComp should move to "*a mindset that wants to make the environment smart and proactive to one that enables people, themselves, to be smarter and proactive in their everyday and working practices*." [22: 418]. In this paper we have presented a constructive critique of AmI environments for emergency response based on longitudinal socio-technical design entanglements with emergency service responders. We posit that ambient intelligence has a great deal to offer in the creation of emergency management information systems but that these offerings should be guided by 'modesty' and an ongoing entanglement with emergency practitioners. We argue that collaboration practices are habitually successful and that AmI systems design should attempt to build on what makes possible this success.

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