Towards an Ontology Broker to Improve Cross-agency Sharing in Emergency Response

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ABSTRACT

Major incidents and disasters tend to be highly complex, contain high levels of uncertainty and may often force official responders to set aside their standard operating procedures and work collaboratively with a range of agencies and actors on the ground. Prior work has shown that establishing clear lines of communication and maintaining a shared understanding across organisational boundaries can be challenging to achieve, particularly in stressful and unusual circumstances. In the present paper we discuss ongoing work into specifying a meta-process for facilitating communication and collaboration based on the observation that common themes that emerge in communication within and across organisational boundaries can subsequently be tracked and built into an Ontology Broker. This work draws on experimental work in our laboratory, observations made in emergency control environments and, emphasised in this paper, lessons learned in the 2005 London bombings.

Keywords

Disaster response, information networks, socio-technical networks, terrorism.

INTRODUCTION

The emergency services can be considered to work as a Community of Practice. On attending a routine incident, official responders will typically be able to follow their Standard Operating Procedures with a clear demarcation of roles and well-defined opportunities for collaborating with colleagues from other services. As the incident escalates, responders will share information about the ongoing situation with a view to resolving common issues and deconflicting activity. Much of this resolution activity will take place on-scene, between members of different agencies working together. This is the fundamental basis of creating a Community of Practice (Wenger et al, 2002).

However, the nature of major incidents means that they are outside the normal or routine. Major incidents tend to be large-scale and complex, with high levels of uncertainty, due to their unexpected and sometimes unprecedented nature (MacFarlane, 2006). Consequently, they require collaborative problem solving, which in turn requires close coordination between the emergency services at all command levels. When these incidents occur the ability for the emergency services to act as Communities of Practice is affected because the escalating incident will often challenge the capability to share information and maintain a common view of the situation. In these circumstances what is required is a process for developing a shared multi-agency understanding of the incident domain, known as a Common Operating Picture. McNeese et al. (2006) defined Common Operating Pictures as the representation of information in order to generate situation awareness across team members. The Common Operating Picture will generally be managed at the incident control room, rather than on-scene. It has the potential to facilitate decision making, situation awareness, collaborative planning and assists the various levels of command across the services in achieving shared awareness of the situation. As well as ensuring that only relevant information is passed to the personnel at the scene, a Common Operating Picture with multiple layers would allow commanders to have oversight of the status and distribution of the other services, enabling implicit collaboration (Baber et al., 2007; Keuhlen et al., 2002). Broadly speaking, a Community of Practice could be viewed as a social response to the problems of supporting inter-agency collaboration, while a Common Operating Picture could be seen as the technical support for collaboration.

Using the emergency response to the 7th July bombings in London 2005 as a case study, our analysis of the event shows the problem of creating a Common Operating Picture during a major incident is exacerbated by

communication issues such as 'stove-piping' within organisations. Using this as motivation we propose that there is a role for a technology, working as an Ontology Broker, that could potentially encourage the cross-agency sharing of information and development of Communities of Practice.

BACKGROUND

On the morning of 7th July 2005, four bombs were detonated on the public transport system in central London; three of the explosions took place in quick succession on London Underground trains, with the fourth detonating on a double-decker bus. 52 commuters were killed and over 700 were injured. The attack was designed to cause maximum disruption and London's emergency services quickly activated a large-scale response. Despite their best efforts, the emergency services encountered problems in organizing their initial response in terms of a collaborative cross-agency effort. These difficulties were arguably attributable to problems of organizational control and information sharing (7 July Review Committee, 2006). Whilst service control rooms and resources at the scene were able to share information, and pre-existing response-plans agreed by the services indicate that they should liaise with each other from the start of an incident (LESLP 2007), the emergency services still faced problems in coordinating the collection and assessment of incident information and in providing appropriate resource levels at each scene. Response data presented in the Report of the 7 July Review Committee suggested the reason for this may lie in the fact that the services were organising their responses using their individual command structures and information management systems, with little incident information being passed between them.

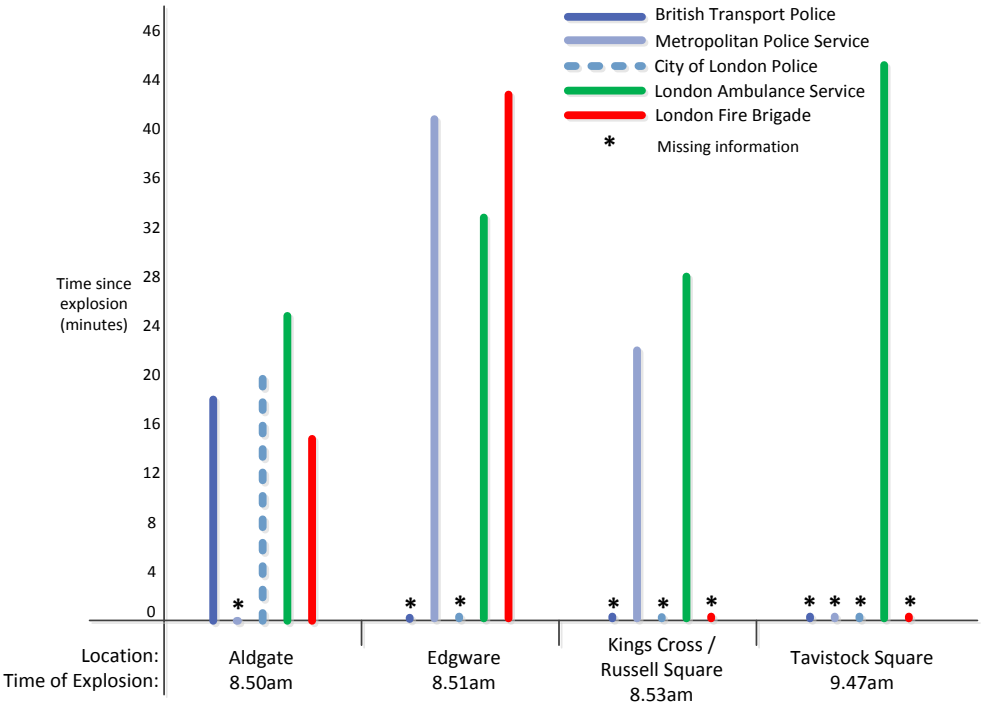

Figure 1 - Time since explosion for emergency services to declare a major incident at the scenes (based on timings in The Report of the 7 July Review Committee)

Figure 1 shows the elapsed minutes before each organisation involved in the response effort declared a major incident at the various scenes and emphasises the variation in response across organisations. The large disparity between the declaration times suggests that the services were unable to adequately share information in order to reach consensus on the nature of the incident during the initial response and were operating as three separate services. Additionally, as the number of major incidents increased there is a decrease in response efficiency. This is hinted at by the increasing time to declare each major incident and the number of services that failed to make or acknowledge that declaration. This may have been partly due to information overload in the emergency service control rooms.

The issue of communications overload is implied by Figure 2, which shows the social network diagram for all incidents on the 7th July. The central nodes in the network are the various response agencies' control rooms. The diagram shows the control rooms are heavily engaged in communication with their respective response units; in essence stove-piping information. This is to be expected, as the control room centrally coordinates operations during the initial response phase of an emergency. In contrast, the communication between the

various control rooms is quite sparse, which suggests that the services were organising their responses to the emergencies separately. Figure 3 shows and explains the structure of emergency response command adopted in the UK. In response to sudden emergency situations, Gold Command is only initiated once a major incident has been declared.

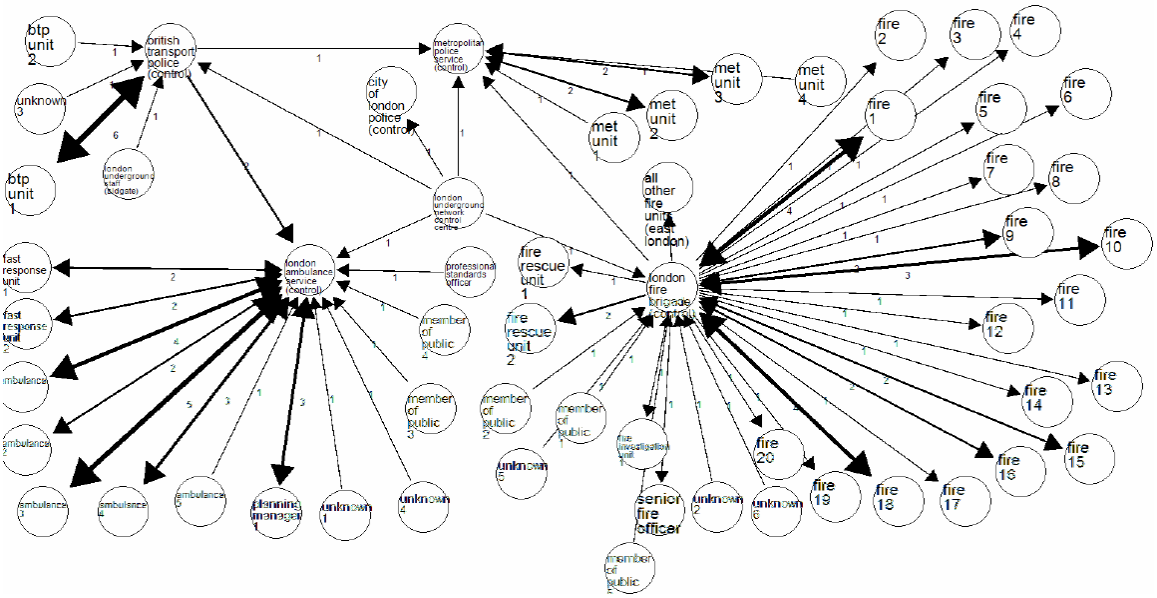

Figure 2 - Social network for the initial response to all incidents on the 7th July.

Major incidents require close coordination between the emergency services, due to high levels of uncertainty (especially during the initial response), the presence of hazards within the inner cordon and the potential for the situation to rapidly change, requiring the use of different tactics. Given the demands of major incidents, it might therefore be expected to find that the emergency services had employed some form of Common Operating Picture to facilitate information collection, analysis and sharing and therefore aid rapid, coordinated response planning. However, the account of the immediate response in the Report of the 7 July Review Committee indicates that this was not the case; each emergency service investigated, analysed, resourced and classified each of the incidents separately.

This problem of stove-piping was countered by bronze level on 7th July by the formation of cross-agency huddles at the sites of the incidents. This shows a social solution to the problem of resolving cross-agency situation awareness. This huddle can share knowledge, set goals and start operating as an inter-agency Community of Practice. However, this solution is not always ideal, as the huddle can only be formed at a point when the rhythm of the incident dictates there is time to do so. The emergency services also have information liaison officers whose role is to carry information between services. However, as the communications load increases this role can quickly become over-burdened. The issue of stove-piping at silver level occurs because incident control rooms are geared towards managing their own people rather than managing and sharing incident information across control rooms. These difficulties can be considered a by-product of the larger problem of managing the ontology of the incident domain.

The Common Operating Picture relies on the collection and organisation of incident information that supports the strategic brokering and dissemination of this information to the appropriate units. Contemporary approaches to the development of a Common Operating Picture often draw on the notion of ontology as a means of structuring the underlying knowledge. In order to better support Joint Service response, there is a requirement to develop a Common Operational Picture (see above). While there are attempts at creating complex, structured ontologies for emergency response (Babitski et al, 2009), we suggest that there might be a simpler solution. The use of complex ontology structures may not be necessary since the emergency services, in an effort for creating cross-agency Common Operating Pictures, have already started standardising the way in which they report information back to control. It is appropriate for the first resources that reach the scene to use the acronym 'CHALET' (Casualties Hazards Access Location Emergency Services Type) for structuring their initial reports.

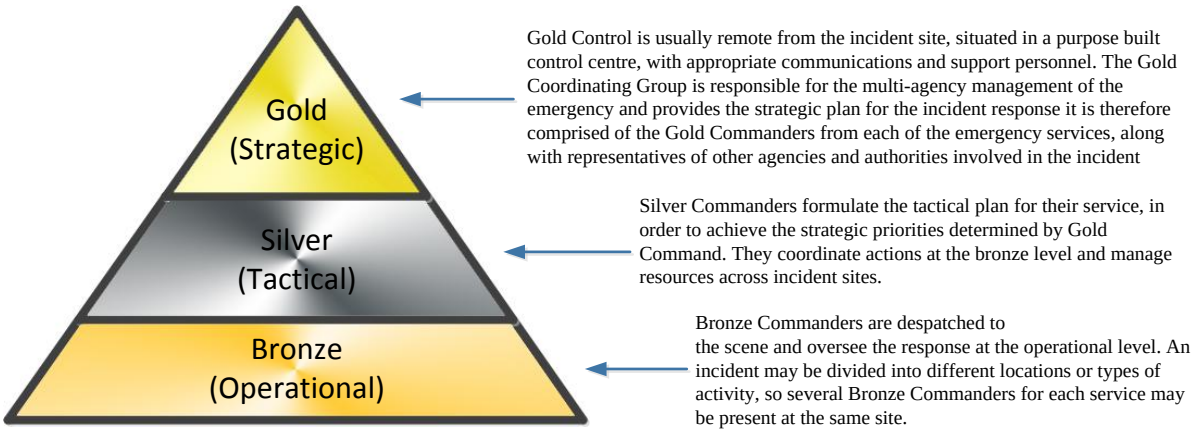

Figure 3 - UK Emergency Response Command Structure

A Proposed Solution

The proposed solution to the challenge of strategic brokering and dissemination of information is an Ontology Broker that will propose communication links between emergency responders (akin to virtual huddles). The goal is to support the development of a Community of Practice by inviting people with common issues to collaborate. In Social Network terms, the Ontology Broker could take the form of a 'boundary spanner' (Thompson, 1967) across agencies, or a 'weak tie' (Granovetter, 1973, 1983) operating between cliques, or an 'information orchestrator' to manage information exchanges across agencies (Bharosa et al., 2008) or, (in military parlance) a Liaison Officer. While a person could perform this role, due to the amount of information involved, it would most likely be a technical system that would track themes in incoming communications to highlight areas of commonality between responders.

The technology is now in place to allow coordination of communications and information. In the UK, the potential to use TETRA-standard (TEerrestrial Trunked RAdio, the European Standard for digital emergency services communications) networks and handsets across all three emergency services is now in place (Airwave, 2010). Having the different organisations operating compatible digital radio networks will greatly enhance the ability to communicate within and between services. This technology enables the creation of 'chat groups' in different channels and also all radio communications are automatically recorded and can be played back instantly via the communication software. However, it is fair to say that the emergency services have so far struggled to make use of the new technology for cross agency collaboration.

The envisaged Ontology Broker would operate on the application layer helping to analyse the network layer of communications below it. Its primary task would be to analyse the (transcribed) information flowing through the emergency services communications channels. Given the potential for the logging of radio traffic (either manually or automatically) the assumption of a transcription of calls is reasonable. Through text analysis the system would extract and organise an interlinked set of key terms that would be put forward as contributions to the incident ontology. This ontology then defines the limits of the domain of the incident and allows tracking of key themes as the incident develops. This could provide an essential contribution to the dynamic construction of a Common Operating Picture. However, rather than flagging these themes to users, the Ontology Broker would suggest links between users who were including specific themes in their reports. In this way, the brokering becomes not only a matter of managing the ontology but also a means of creating the Community of Practice across agencies. The Ontology Broker could then maintain a network of community members who have ownership of particular ontology components. Fundamentally this acts like a map of who knows what, i.e., as a technological proxy for 'transactive memory' (Wegner, 1986).

CONCLUSION AND FURTHER WORK

In this paper we have highlighted some difficulties experienced by the UK emergency services in relation to the bombings of 7th July 2005 in London and suggested a potential technology that may aid in the response of a similar major incident. Specifically the problems highlighted were to do with multi-agency collaboration in relation to inter-agency communications. We have shown how that technology could address those issues by acting as an Ontology Broker whose job it would be to collate incident information extracted from monitored communication channels. Importantly that technology would perform analysis that could equally be performed by a human role or by a combined socio-technical system. We showed how this system relates to our

understanding of the meta-processes involved in emergency response. Using this analysis as motivation, the intention is to proceed in building and testing a proof-of-concept prototype system.

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ACKNOWLEDGEMENTS

This work is supported by a grant from the Human Factors Integration Defence Technology Centre, part-funded by the Human Capability Domain of the UK Ministry of Defence Scientific Research Programme.

Robert J. Houghton is supported by RCUK through the Horizon Digital Economy Research grant (EP/G065802/1)