Multiple attacks on transport infrastructure: an inter-disciplinary exploration of the impact of social networking technologies upon real time information sharing, response and recovery

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Abstract

Terrorist attacks on public mass-transit transport infrastructure, are usually graduated over a number of transport mediums and hubs. These attacks disrupt rescue and co-ordination efforts, not only to maximize immediate casualties, but also to increase casualty rates because of delays to treatment. We consider that Web 2.0 technologies have produced a paradigm shift in the ways in which emergency response and evacuation on transport networks is coordinated. Part of the challenge is to understand how information proliferates through new social media in real time and the manner in which this information may be used to inform individual decision making in a crisis scenario. This involves considering the nature of networks and game theory, the embedding of social media in transmedia and the role of sentiment. The high level of disciplinary integration within this project is used to work towards overcoming these challenges.

Keywords: social media, inter-disciplinary, terrorism, technologies

Introduction

Terrorist attacks on public mass-transit transport infrastructure, such as those which occurred on 7th July 2005 in London and Madrid in 2004 were graduated over a number of transport mediums and hubs. The attacks also had the (perhaps intended) effect of being in situ and of disrupting rescue and co-ordination efforts not only to maximize immediate casualties but also to increase casualty rates because of delays to treatment. Due to the diversity of attacks, and their disruptive nature, it is often difficult to co-ordinate emergency response across already complex mass transit networks. In addition, traditional modes of crisis communication are now challenged by mobile technologies whereby individuals can source information for themselves in real time through the use of social networking technologies (e.g. through using Twitter as both a network and as a broadcast media). Data mining and crowd souring of geo-spatial street level information may have the potential to lead to increased transport system resilience in the event of an evacuation (e.g. the capture of damage in 7/7 through citizen images which could be used by first responders). However, the same technologies which may increase resilience may also lead to a lack of coordination and control and the propagation of false rumor which may lead to, or compound, a transportation crisis event.

In order to tackle this problem we take an interdisciplinary approach drawing on the skill of researchers working on social networking media, physics, mathematics, sociology, organizational resilience, pedagogy and econometrics. Specifically this integrated project, which is funded through a £865K grant by the EPSRC (Engineering and Physical Sciences Research Council), will ultimately use qualitative data capture to inform tools from the theory of complex adaptive networks and game theory. We hypothesize that in responding to multiple attacks on transport infrastructure the use of social networking technologies by individual citizens may lead to both challenges and opportunities for those attempting to coordinate mass evacuation as official

information competes with informal information flows. It is considered throughout that agent behavior is responsive to incentives and adaptive and game theoretic considerations are important. We need to consider how individuals use information and the strategic incentives for them to do so.

We consider that Web 2.0 technologies have produced a paradigm shift in the ways in which emergency response and evacuation on transport networks is coordinated. Information can now be controlled and disseminated by various publics, including (potentially) by terrorist groups. The ways in which such interference in social media could disrupt evacuation and emergency response in mass transit systems has been under estimated. In part it may be because this is difficult to explore empirically. Part of the challenge is in understanding how information proliferates through new social media in real time and the manner in which this information may be used to inform individual decision making in a crisis scenario. The high level of disciplinary integration within this project is used to work towards overcoming these challenges.

Discussion

Terrorist attacks on public transport infrastructure are both opportunistic and, unfortunately, complex. The opportunistic nature of attacks means that they can cause widespread disruption with the use of relatively low levels of technology. The *Aum Shinryko* attack on the Tokyo Subway in 1995 was perpetrated using liquid Sarin, plastic bags and umbrellas. The 7/7 attacks on the London Underground in 2005 used homemade organic-peroxides packed into rucksacks. These simple, and thankfully small scale terrorist attacks, become incredibly disruptive and tragic when overlaid with the complexity of transport systems, communications capacity and social network information exchange. The 7/7 attacks, for example, led to the failure

of several mobile phone systems due to increased traffic and at least one network, Vodaphone, initiated ACCOLC (Access Overload Control Scheme procedures) to limit calls by the general public. In addition the attacks led to the complete closure of the London transport system, the need for the Bank of England and Treasury to put into place special measures to ensure that financial markets would keep trading and a wave of rumors on mainstream and official media concerning the scale and location of the attacks. Inter-dependencies mean that small scale disruptions to one part of a system (in this case transport) can become large scale infrastructure, social and communications disruptions.

Problem statement

These compounded and complex difficulties described above are both a communication and co-ordination problem. The failure of communications in the 7/7 attacks is well reported. However, less well considered is the opportunity for bootstrapping and technological / cultural convergence in the auto-poetic (self sustaining) regeneration of these systems. W. David Stephenson, an expert on disaster management who sees Twitter and other Web 2.0 playing a central role in emergency response, suggests that 'disaster response strategy is at its best when it is out of control' (Mills et al. 2009). Whilst we would not fully concur with this statement (as lack of intervention by authorities produces the opportunity for misinformation) we consider that systems can be self-regenerating and creative. For example, on the tube trains which were attacked (in the absence of external communication) police had to revert to runners to carry messages, the BBC (British Broadcasting Corporation) in the absence of systematic news reporting) put out its first public call for user generated content (and received thousands of images and texts) and the Bank of England used 'chat rooms' to reassure financial markets. These

solutions are bootstrapped in that they are intermediate solutions around an emergent problem and convergent in that they often bring together 'new' and 'old' media (for example, social media / mobile phone cameras and mass television broadcasting). The proliferation of new technologies and bootstrapping ('mash ups' that use geo-spatial and social networking technologies) generate further solutions but also potential problems. In particular, the proliferation of false rumors (which may lead to tipping points in terms of behavior) and the possibility of planting rumors by terrorist groups. We are in a situation where control of information and co-ordination is impossible – the spectra are too wide and the networks too large and diffuse - so solutions in terms of influence and suggestion are more plausible. Additionally, the scale of a multiple attack, or a natural disaster, on a major transport system in an English city has not always been a focus for academic research and there is a paucity of work in modeling extensive evacuations in England (Lumbruso & DiMaruo 2008) where 'large' or 'mass' evacuations present '…the greatest challenge' (HM Government, 2006).

Potential Solution and Research Methodology

Potential social network solutions to emergency management problems have already been widely identified in the empirical literature. Much academic research exists on mining on-line social media for a broad range of tasks including automated sentiment extraction (Hopkins and King 2010, Jansen et al. 2009), network mapping (Ediger et al. 2009), revenue forecasting (Asur and Huberman 2009) and discourse analysis (Diakopoulos 2010). This trend is reflected in crisis communication research where on-line social media analysis is used for real-time earthquakes monitoring (Sakaki et al.2010, Li and Rao 2010), swine flu pandemic forecasting (Ritterman et al. 2009; Corley et al. 2009) and influenza spreading prediction (Culotta 2010). Particularly relevant

to evacuation studies is the application of situational awareness theory (SA) both in the context of natural disasters (Vieweg et al. 2010) and of terrorist attacks (Oh et al. 2010). SA theory has been developed in a military context and it is defined as the 'understanding the state of environment' (Endsley 1995) which is gained through three distinct cognitive processes (perception, comprehension, projection). However, the application of the same theory to two different types of emergencies (natural and man-made) has lead to apparently contradictory conclusions on the use of media during emergency situations. For example, Vieweg et al. (Vieweg 2010) show how information exchanged on Twitter can assist evacuations during floods and grassfires, where Oh et al. demonstrate how Mumbai terrorists gained 'informational superiority' and maximized the impact of their attacks by collating real-time situational information from social media. Both research findings open a number of pressing questions over the role of social media in crisis communication since the data that may save lives may also put lives at risk. For this we argue that researchers and practitioners must recognize the importance of understanding the content, the structures and the dynamics of social media communications. More specifically, our research aims to understand content patterns of daily conversations, how these patterns change in a time of crisis, what triggers change and how these triggers can be monitored and – if necessary - controlled at a time of an emergency.

For this we are looking at the characteristics of daily social media conversation and how this may react to specific events through automated content and sentiment analysis of Twitter data. For the purpose of our research, only geo-located twitter data posted from UK/NI are being collected and a range of tools will be applied (Rayson 2008, Piao 2009, Kågström 2010, Simm 2010). More specifically, our research aims to understand content patterns of daily conversations,

how these patterns alter in a time of crisis, what triggers change and how these triggers can be monitored and – if necessary - controlled at a time of an emergency. Innovatively, we consider the underlying mathematical properties of social networks and the ways in which agents might respond to information, in particular to conflicting information. The current project addresses these new challenges through a systematic computational agent-based modeling approach. We are using models of the behavior of populations in an attack on transport infrastructure (and other crises) focusing on the effect of receiving, spreading and acting on information on the behavior of agents. Based on these mathematical models an understanding is being developed of how the behavior of agents can be modified and controlled through the use of real time intervention in social networking and communications technologies. In doing so we are mindful of the ways in which social networking technologies are just one way in which information may spread in an attack on a transport system. It is more desirable to consider social networking technologies within an interconnected series of networks involving both new and old media. Indeed, the term transmedia, referring to how strands of stories are carried across a range of media might be applied. 'Stories' about an evolving attack on a transport system involve information exchange between old media (face to face, television and radio broadcasting) and new (social networking, blogging, crowd-sourcing). For example, in the 7/7 attacks described above there was reciprocal exchange between mainstream media, bloggers and (emerging) social media (Jenkins, 2006). How to interact and to harness the resources of citizens and responders in a transmedia environment requires understandings of viral marketing and sentiment as well as learning theory and pedagogy. These are subtly different from the model of social networking as a technological panacea and as purely an information exchange and problem solving tool.

The main outputs of the project are the identification of intervention strategies which makes public response safer and faster. After completion of the project we will make recommendations to stakeholders as to the efficiency of different communication channels and control strategies arising from our simulations. This will provide a sound basis for policy makers and responders to strategies about intervention in communication and social networking technologies. Possible interventions could involve 'inoculating' networks with warning messages targeting all or only a selected set of individuals; dismissing false rumors or 'seeding' networks by planting valuable information (again potentially on a selective basis); making use of ubiquitous technologies in evacuation such as personalized, localized information; ambient signage that responds to real time information and the strategic selection of warning messages sent. Whatever the social and technological applications used the overall effect on real populations in the event of an attack on a transport system would be to make warning, recovery and response 'smarter'. That is, to work with the population as (differentially) networked decision makers who treat a crisis as a series of decisions. In this context, information sharing and incentives rather than sanction and media blackouts are an enabling strategy for helping real populations evacuate safely and effectively.

Beneficiaries of the research

To create strong synergies a three stage data collection, validation and dissemination process will be used to engage key stakeholders from across local government, community groups, private and voluntary sector within each of the sampled cities (London, Birmingham and Carlisle). An opportunity will be offered for stakeholders to participate in focus groups and to play a role in both validating the outcomes produced and in learning from dissemination

activities. The main beneficiaries will be the stakeholder community, including emergency responders and planners, policy makers, businesses and voluntary agencies. The benefits of engagement will be in terms of advising and informing the project so that the proposed solutions are amiable to practical application. In addition, the project will have a benefit in terms of informing the ways in which policy and practice is shaped in the future.

Challenges and preliminary results

There are a number of challenges in using social networking technologies in the event of an attack on a transport system and our initial results indicate both the scale of the problem and some indicative solutions.

Firstly, our initial results from recent work in the UK conducted by the project team has found wide variation between sampled UK cities in relation to the level of engagement by emergency managers with social networking technologies. In London the emergency management structures are very complex and the main hub of public information, the 'London Prepared' website, was difficult to navigate and lacked tailoring towards particular audiences. There is too much documentary information and this to some degree obscures the advice this sits within the site. The different boroughs within London also had very different levels of engagement with these technologies. A particular issue raised within the review was that the area of Newham will be hosting the Olympic Games in 2012 and so there is a particular concern that this borough is responsive in terms of the use of social networking in an emergency. In contrast the city of Birmingham appeared to use social networking technologies frequently as a mode of public information and had a more interactive and user friendly homepage that encourages individual and community learning. However it was found that there was arguably incongruence between the

emphasis on pro-activity within the Birmingham information and the passive citizen constructed in relation to evacuation. Whilst there were multiple information streams (e.g. Facebook, Twitter, Flickr) the key message from evacuation highlighted that in the event of a crisis that citizens should monitor traditional media (e.g. television).

Secondly, we have identified a need to move away from thinking in terms of specific technologies (such as Twitter) and towards more generic social network solutions. Not everybody uses Twitter. Even if prevalent now, it is a private sector technology which is subject to future changes in demand and technology. It is common for networks to fail during emergencies and Twitter is no exception. Location information is still difficult to automatically extract: during emergencies members of the public define locations in a number of different and often arbitrary formats.

Thirdly, there are other dangers in the proliferation of social networks in disaster communication. Loose networks may lead to increased risk. In section 1.21 of the UK National Security Strategy the potential impact of a new 'mass of connections' upon security was highlighted. It was argued that networks, including social networking technologies and 24 hour news media, could impact security as interest groups become more able to pressurize governments and a wide range of ideas easily proliferate globally (National Security Strategy, 2010). A recent article on ZDNet covered nation 'unfriend day' which argued that loose connections on Facebook lead to increased risk of terrorism (ZDNet, 2010). Loose networks can lead to the propagation of both intentional and unintentional rumors. In January 2010 a Twitter rumor led to the evacuation of Grand Central Station in Manhattan (Bnet, 2010). Finally, at The Red Cross hosted Emergency Social Data Summit a key conclusion was that 'the major obstacle

to the use of social media in crisis situation is the same obstacle to adoption we've seen since the beginning of the technology: a hesitation to shift from broadcasting information to engaging information' (Emergency Data Summit, 2010). Getting emergency managers in particular to embrace and adapt to these new technologies in an age of not only uncertainty but resource scarcity may be a key challenge. There is also the danger that feedback loops between new technologies and the media escalate rumor and speculation as is evident in the work of Gotham (2007) through the development of the notion of 'spectacle' in the media coverage of disaster events (see also Cottle, 2009).

However, despite reservations around particular technologies our initial findings show how social networking technologies around transport attacks are potentially transmedia orientated and make use of sentiment. In particular, we are specifically looking at the characteristics of daily social media conversation and how this may react to specific events through automated content and sentiment analysis of Twitter data. For the purpose of our research, only geo-located twitter data posted from UK/NI are being collected and a range of tools will be applied (Rayson 2008, Piao 2009, Kågström 2010, Simm 2010)

As a proof of concept we have carried out an initial manual content analysis on our Tweet dataset to understand how the attack on Domodedovo airport had been discussed in the UK Twitterverse. From a dataset of over 300,000 tweets posted from 24/01/2011 and 27/01/11 we extracted tweets that contained the following keywords: 'bomb', 'explosion', 'Moscow', 'Domodedovo', 'airport'. Of the 198 posts retrieved, 61 were directly related to the attack, 17 referred to other attacks and 120 were of 'conversational' nature (e.g. 'calm as a bomb'). It was also noted that all the data directly related to the attack could be grouped into the following four

categories: 1) Broadcasting 2) Factfinding 3) Reacting 4) Projecting. The categories closely match the three-step cognitive process of SA theory (Endsley 1995) as each step seems to emerge in chronological order and it coincides with a deeper understanding of the event. For example, first the news is broadcasted '*Russian media reporting that at least 23 people were killed and 100 injured in Moscow airport bombing'*. As the news is being broadcasted, people look for more information – a transmedia interaction between old (broadcast) and new (social) media - '*Any word on number of bombs? News reports saying possible multiple*'. Once the gravity of the situation is understood (comprehended), the public react with emotional posts *'Very sad about bombings at Moscow Domodedovo airport [...]*'. Few final tweets contain references to past experiences and 'projections' of future threats *'Need to find my blog from years ago about suicide bombs [...]' 'Have FIFA said anything on the Moscow bombing? Tragedy all round. Questions over airport security ahead of WC that relies on them so heavily'*

Although these are very initial observations, it is clear that there is scope for applying automated content and sentiment analysis, within a transmedia context, to assist researchers and stakeholders in gaining a deeper understanding of the content and modalities of daily conversation and crisis communication.

Conclusion

Our conclusion is that social networking technologies have obvious capabilities in both dispersing information and coordinating response in an attack on a transport system. In the UK the implementation of this at a city level is, at present, heterogeneous, although there are examples of good practice. However, an interdisciplinary, and not simply technology led, approach is required to investigate this issue. Despite the technological advances in this area we

also need to understand the mathematical structure of networks and the inter-relatedness of agent behavior including the limitations of the models and associated barriers and obstacles in practical implementation. As our findings show, we also need to consider the role of sentiment and interactions between new and old media (transmedia) in solving these complex problems.

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