

Hastily Formed Networks for Disaster Response: Technical Heterogeneity and Virtual Pockets of Local Order

Eva Törnqvist

Dept. of Technology and Social Change
Linköping University, Sweden
eva.tornqvist@liu.se

Johan Sigholm

Dept. of Military Studies
Swedish National Defence College
johan.sigholm@fhs.se

Simin Nadjm-Tehrani

Dept. of Computer and Information Science
Linköping University, Sweden
simin@ida.liu.se

ABSTRACT

As natural and man-made disasters become increasingly common, ensuring effective disaster response, mitigation and recovery is growing into a high-priority task for governments and administrations globally. This paper describes the challenges of collaboration within multi-organisational hastily formed networks for post-disaster response, which are increasingly relying on emerging ICT infrastructures for communication and cooperation. We present an interdisciplinary analysis of the conditions for establishing an effective mutual conversation space for involved stakeholders, and how the development of socio-technological systems affects cognitive and behavioural aspects such as established communities of practice and virtual pockets of local order.

Our observations thus far suggest that some of the key issues are overcoming organisational and cultural heterogeneity, and finding solutions for technical interoperability, to ensure effective, pervasive and sustainable information exchange within and between organisations participating in hastily formed networks.

Keywords

Hastily formed networks, disaster response, mobile ad-hoc networks, virtual pockets of local order

INTRODUCTION

Summing up the year of 2008, in terms of its natural disasters, leaves us with a depressing result. The magnitude 8.0 earthquake in China's Sichuan province, the cyclone Nargis over Burma, and the Atlantic hurricane Ike were some of the highest-impact disasters of the year, making 2008 one of the deadliest and costliest years of all time. According to Munich Re, the world's largest reinsurance company, the disasters demanded a toll of over 220 000 human lives and caused damages exceeding \$200 billion (Münchener Rückversicherungs-Gesellschaft, 2008).

World population growth, increasing urbanisation, overexploiting of natural resources and changes in the global climate are some factors which make both natural and man-made disasters likely to grow in scale and frequency over time (Parry, Canziani, Palutikof, van der Linden and Hanson, 2007). These hazards must be faced on both an international scale, involving multinational coalitions, and on regional and local scales, with challenges such as major accidents, fires or flooding. Even though regional and local disasters may be limited in area, or in the number of people affected, they may still require response from a large number of agencies and organisations, who each make distinct and valuable contributions to disaster mitigation. These involved parties need to be able to collaborate during and after the disaster, often in a complex, chaotic or completely unplanned context or in an unexpected environment (French and Niculae, 2005, and references therein). Such conditions are hard to prepare or train for in advance, which requires the involved parties to arrange themselves into ad-hoc groupings that have to emerge spontaneously, and be flexible enough to adapt to the given circumstances at the incident scene.

The concept of *hastily formed networks* (HFN) (Denning, 2006) describes a multi-organisational collaborative environment where a shared communications network is used to interact and fulfil a common, urgent goal. The ways in which the parties interact through the given network, in combination with the acknowledged rules and protocols, defines the *conversation space* (see below). These types of networks are formed when an incident occurs where response is required from several different organisations (players), and where collaboration is an important factor for success. HFNs also have to handle insufficient resources and a lack of supporting infrastructure.

TRENDS IN EMERGING DISASTER ICT

The physical communication system, and how well it performs in a given environment, is an integral part of the conversation space available to the players in the HFN. During disasters we cannot count on fixed infrastructure to be operational. This includes wire line or mobile telephony systems, power grids and mass media broadcast networks. Although some of the most critical infrastructures benefit from a higher level of protection, such as certain protected energy sources or government communication systems, it is not viable to rely on these functioning during extreme events. Another problem is that what little infrastructure is still available is subject to severe overload, e.g. by victims and their families trying to get in contact with each other.

One possibility is to establish temporary infrastructures, such as diesel generators, container-based mobile telephony systems, microwave links and satellite communication equipment. Although this is an available course of action, and in fact the one mainly in use in today's disaster response operations, it is a very costly approach in geographically extended incident scenes. The use of specialised equipment might also prevent seamless integration of voluntary forces or non-governmental organisations. A trend is that disaster management stakeholders, such as government branches, emergency services, police, defence forces and similar agencies are moving towards forthcoming partly or completely infrastructure-less ICT solutions (Asplund, Nadjm-Tehrani and Sigholm, 2008). In many countries this is realised through networks based on the Tetra (Terrestrial Trunked Radio) standard.

Another development is the shift towards IP-based mobile ad-hoc network (MANET) communication platforms. These systems, often based on software-defined radio (SDR) technology and open source platforms, have the possibility to span considerable distances without relying on any external infrastructure when combined with delay-tolerant routing protocols (Asplund et al., 2008). The SDR technology also allows for inter-organisational collaboration, as the SDR-units can be programmed to interoperate with almost any legacy radio used by a collaboration partner. An example of this is the Joint Tactical Radio System (JTRS) being developed by the United States Armed Forces. Although the rationale for this change in technical approach to disaster response communication might be apparent, the development of new systems and applications has consequences for the users and their interaction (or lack thereof) through these systems.

PROFESSIONAL PRACTICES

The complexity and diversification that characterise society of today are reflected both in socio-technological systems and labour organisations. The above-mentioned changes involve increased demands on the capacity to communicate, and since cooperation in inter-professional groups is tending to increase, it is important to acquire communicative competence. This includes an ability to use the language in an appropriate way depending on the people involved and the specific setting (Sudweeks and Allbritton, 1996). The competence is also essential in the collaboration with various volunteer groups which might be involved during a major disaster. Through the language, we create, recreate, negotiate and establish a common understanding of phenomena. Furthermore, the language changes or confirms social relations. The transfer of knowledge, meaning and understanding through communication is not neutral and unproblematic. The risk of misunderstandings in communication increases in organisations with different technologies, structure, cultures and geographical collaborative groups. These misunderstandings must be minimised since they can lead to costly – both human and material – consequences.

Emergency Services have undergone changes – and are still doing so – and these activities make great demands on coordination, organisational as well as geographical. The development of ICT has led to new technology and new organisational structures being established within the former organisation. The research about High Reliability Organisations (HROs) (Roberts, 1993) shows that the dynamics of the complex socio-technological systems are based on well functioning communication and a never-ending learning process. Communication is also highlighted in the research about HFNs. One of the conclusions made by Denning is that the quality of the conversation space established at the outset of an incident is of great importance for the effectiveness of the HFN (Denning, 2006). A conversation space can be summarised as in Table 1 below.

Category	Characteristics	Examples
Physical systems	Media and mechanisms by which people communicate, share information and allocate resources	Telephone, power, roads, meeting places, supplies, distribution systems
Players	Players included and their roles, core competences and authorities	Citizens, fire department, policy department, highways departments, federal emergency management agency
Interaction practices	Rules of the "game" followed by the players to organize their cooperation and achieve their outcomes	Situational awareness, sharing information, planning, reaching decisions, coordination, unified command and control, authority, public relations

Table 1. Components of a conversation space (Denning, 2006)

An organisation is according to Wenger a social construction, which consists of different constellations of practices (Wenger, 1998). The people within a practice negotiate their own activities even if they sometimes are responses to regulations. A practice includes language, tools, documents, symbols, well-defined rolls, regulations etc. Just as important are non-visible unspoken norms, embedded understandings, tacit agreements etc.

POCKETS OF LOCAL ORDER – TECHNOLOGY AS RESOURCE OR RESTRICTION FOR COMMUNICATION

Pocket of local order (PoLO) is a concept that is used in time geography – it resembles communities of practice but the focus lies on the time space (Ellegård and Vilhelmson, 2004). A process has certain duration in time and it takes place in a physical location, a specific location in time space. In this time space goal oriented enterprises consisting of different projects take place in certain order. These projects are not only connected to individuals but also to groups, organisations and companies. PoLOs are located in the time space and they are organised to facilitate the performance of the projects, in our case disaster response performed by different organisations. The individuals taking part in the projects performing activities have different roles with different authority.

Resources and restrictions are also important components in the pocket of local order, but it is not foregone once and for all what is a resource respectively a restriction. It can differ between different people taking part but also over time. Both psychological and physical tools are seen as structuring resources and they are used to interpret and arrange components in new situations. During a disaster response a technological platform can be both a restriction and a resource. For example, a VHF radio is a resource when it comes to conveying information to a large number of units, but at the same time it could also be a restriction because it can be overheard by those who may not need the information, or even must not have it. Today a cellular phone can be a solution in some part, but the pace of information dissemination will be restricted as well as the authenticity of the original message if has to pass through a chain of actors. The time factor also affects the validity depending of the dynamics of a disaster response situation (see Table 2). Skill and competence, as well as technological changes, can of course alter these conditions.

Communication is central in communities of practices and pockets of order. When members of an organisation talk to each other and with people outside, apart from communicating, they are constructing the organisation (or the network) through the process and the substance in the communication. It can be said that a network is created, maintained and activated through communication, and if the communication is misunderstood, the network's possibility to exist is weakened. As different technologies are developed, the information flow increases and makes it possible to reach more people over greater distances. This, in turn, results in a larger number of people reacting to an alarm and the PoLO develops, through the technological change, into a *virtual* pocket of local order (Törnqvist, 2004). The more people and organisations taking part in a rescue mission, the greater is the need for unit coordination to ensure effective cooperation. For the person in charge of the rescue operation it is important to be able to interpret the information and to sift out the parts that are essential in the information flow. This raises demands of a high communicative competence for all the people that are involved in a rescue operation.

Scenario 1:	VHF	Cell phone
SAR Officer communicating with multiple dispatched units	Resource	Restriction
Scenario 2:	Restriction	Resource
SAR Officer requesting personal information about a disaster victim		

Table 2. Technologies as resources or restrictions

POSSIBILITIES AND CHALLENGES OF ICT USE

The technology of today makes it possible to coordinate and lead a rescue operation from a distance. Almost all important communication is mediated, i.e. the people that are communicating are not present in the same geographical location, and most of the people involved in a rescue operation have never met face-to-face. How is trust and confidence created for someone you have only “met” via phone or radio? Several researchers mean that you can create a well functioning relation through computers if time is given (Walther, 1996). An example how this trust creating can be done comes from observations at the Swedish Maritime Coordination Rescue Centre (MRCC) (Törnqvist, 2004). A resource database is updated as soon as something changes and the person responsible for the resource contacts the Search and Rescue Officer who commits the update. The change could be that a boat has a new type of a water pump or that the boat is leaving its normal port during a couple of hours due to an exercise. You would suspect these calls to be relatively short but they are surprisingly long. Besides transferring the information about the change, they talk about the weather, cases they have been working on together, new equipment they have seen or read about, common friends, or what they are going to do during the weekend – small talk about all or nothing, that can seem meaningless to a temporary guest.

This type of communication does not function as information exchange or to convey any knowledge about their mediated, professional activity, but rather to create a mediated relation for forthcoming cooperation during rescue operations and missions. This media-created relation usually needs to be recreated when the parties meet face-to-face. ICT can, however, promote a substitute for the physical space in a PoLO. Such a virtual local pocket of order is created where the projects are carried out according to the resources and restrictions that exist in the different PoLOs present during a mission (Törnqvist, 2004).

The challenges in establishing trust, avoiding misunderstanding and promoting efficient knowledge sharing in a spontaneously formed HFN can partly be met by the availability of various collaborative technologies, in combination with suitable social processes (Kock and Davidson, 2003). However, there are still problems which need to be addressed, such as the lack of resources in today’s mobile devices (e.g. energy and small footprint constraints). Our current project works on resolving some of these issues, including an ability to do many-cast communication in a resource-constrained ICT network (Asplund and Nadjm-Tehrani, 2008).

SUMMARY

Advanced ICT systems for disaster response bring the potential for hastily formed networks to operate more efficiently and without having to rely on existing infrastructures in an incident area. However, irrespective of the available technology, it is still the people who are involved in the disaster response who matter most for the success of the mission. In the end, it is their experiences, competence and commitment that are of decisive importance. The virtual PoLOs that form during the disaster response process do nevertheless require relevant resources. This paper describes work in progress in a project where an efficient ICT system is a key tool. By making use of collaborative technologies, involved players may overcome some of the restrictions of heterogeneity, created by variations in knowledge, location, technology and organisational affiliation. Organisations designated for response in disaster situations should additionally prepare by establishing appropriate social processes, practicing how to interact both internally and externally in a HFN, and how to function in their specific community of practice.

REFERENCES

1. Asplund, M. and Nadjm-Tehrani, S. (2008) Random-walk Gossip-based Manycast with Partition Detection (fast abstract), *Proceedings of the 38th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN'08)*, Anchorage, AK, USA.
2. Asplund, M., Nadjm-Tehrani, S. and Sigholm, J. (2008) Emerging Information Infrastructures: Cooperation in Disasters, *Proceedings of the Third International Workshop on Critical Information Infrastructures Security (CRITIS'08)*, Rome, Italy.
3. Denning, P. J. (2006) Hastily Formed Networks, *Communications of the ACM*, 49, 4, 15-20.
4. Ellegård, K. and Vilhelmson, B. (2004) Home as a Pocket of Local Order: Everyday Activities and the Friction of Distance, *Geografiska Annaler: Series B, Human Geography*, 86, 4, 281-296.
5. French, S. and Niculae, C. (2005) Believe in the Model: Mishandle the Emergency, *Journal of Homeland Security and Emergency Management*, 2, 1, 1-16.
6. Kock, N. and Davidson, R. (2003) Can Lean Media Support Knowledge Sharing? Investigating a Hidden Advantage of Process Improvement, *IEEE Transactions on Engineering Management*, 50, 2, 151-163.
7. Münchener Rückversicherungs-Gesellschaft (2008) Catastrophe figures for 2008 confirm that climate agreement is urgently needed, Press release, 29 December 2008.
8. Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (eds.) (2007) Climate Change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.
9. Roberts, K. H. (1993) *New Challenges to Understanding Organizations*, Macmillan Publishing Company, New York, NY, USA.
10. Sudweeks, F. and Allbritton, M. (1996) Working Together Apart: Communication and Collaboration in a Networked Group, *Proceedings of the 7th Australasian Conference of Information Systems (ACIS96)*, Hobart, Australia.
11. Törnqvist, E. K. (2004) Bland grynnor och blindskär: Kommunikation, lärande och teknik i samarbetsprojektet Sjöräddning, Linköping Studies in Arts and Science 297. (English abstract available at: <http://www.bibl.liu.se/liupubl/disp/disp2004/arts297s.pdf>)
12. Walther, J. B. (1996) Computer-Mediated Communication: Impersonal, Interpersonal and Hyperpersonal Interaction, *Communication research*, 28, 1, 3-43.
13. Wenger, E. (1998) *Communities of Practice: Learning, Meaning, and Identity*, Cambridge University Press, Cambridge, UK.