Communicating Probability: A challenge for decision support systems

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ABSTRACT

This paper presents observations made in the course of two interorganizational crisis management exercises that were conducted in order to identify requirements for a decision support system for critical infrastructure operators. It brings into focus how different actors deal with the uncertainty of information that is relevant for other stakeholders and therefore is to be shared with them. It was analyzed how the participants articulated und comprehended assessments on how probable the reliability of a given data or prognosis was. The recipients of the information had to consider it when making decisions concerning their own network. Therefore they had to evaluate its reliability. Different strategies emerged.

Keywords

Crisis communication, critical infrastructures, decision support systems, decision-making under uncertainty, interorganizational cooperation

INTRODUCTION

The research presented in this paper addresses the management of cascading effects between infrastructures that requires cooperation between different organizations. Decision support systems (DSS) in this field are supposed to assist decision-makers in two ways: Firstly and most importantly, they present a platform to combine various pieces of information on the crisis in order to create a common operational picture (COP) that is the basis for understanding the event and its cause(s). (Endsley, 1988, Wolbers and Boersma, 2013) Secondly, the tools facilitate the coordination of organizational responses in order to control the overall situation and prevent further escalation. In very simplified terms one could summarize, this type of DSS assists interorganizational crisis communication.

Numerous aspects have to be considered in order to make a DSS functional under the specific circumstances in moments of crises such as the lack of reliability of information, its inconsistency, and pressure of time. Much research has been conducted on how to present information visually within one COP or transfer relevant data from one geo-information system to another in order to reduce its complexity and therefore minimize the likelihood of misunderstanding between actors with different organizational, professional and personal backgrounds. (Kehl and de Haan, 2013; Řezník, Horáková and Szturc, 2013; Drury, Klein, Mathieu, Liu and Pfaff, 2013) Presenting information in a language that is intelligible to manifold actors poses a significant challenge, especially as most organizations that operate critical infrastructures use very specialized terminology. (Schulz-Hardt, 2007; Strohschneider, 2008)

This paper focuses on one specific aspect of this interorganizational crisis communication: How do crisis managers communicate the reliability of a piece of information or, in other words, the probability that the given information about one's own system or an incident taking place within its range is correct? Leaving aside the closely related issue of coding and decoding verbal or numerical expressions of probabilities (Beyth-Marom, 1982; Renooij and Witteman, 1999) this paper deals with the decision whether and how to present data that might be inaccurate. What considerations and strategies are being applied in a crisis situation?

Most of the presented data was acquired in the course of two interorganizational crisis management exercises

that were conducted during a research project. One of them was carried out using the prototype of a newly developed DSS that allows for exchanging information but which did not have a feature designed especially for the purpose of communicating the reliability of information (yet). In addition to the tests, numerous interviews and workshops took place with critical infrastructure operators that addressed interorganizational dependencies, cooperation and communication.

While the overall research objective was to develop a GIS-based decision-support tool that facilitates the management of cascading effects, the crisis experiments took place in order to identify cross-border communication processes that lead to wrong or suboptimal decisions. Based on the assumption that the difficulty to communicate while relying on incomplete and uncertain information cannot be solved solely by presenting a technical solution but rather requires accompanying organizational routines that are known and respected by all participants of the communication process the goal of the experiments was to identify conventions that already exist. Subsequently those were analyzed as to whether they had led to desirable outcomes. The observations presented in this paper seem to be significant to any DSS as they are concerned with the decision of users in what way they are willing to share information or whether they would do so at all.

DATA ACQUISITION

The research presented in this paper was conducted in the course two crisis exercises. Four teams were confronted with cascading effects between the utility networks they operate. The participants were mostly experienced professionals who in case of emergency would actually be members of their organizations' response teams. The experiments were communication exercises only. The actors were in conference rooms and they were given information on the development of an imaginary crisis that could only or at least much better be understood and solved when information was shared and actions coordinated. For this purpose the decision-makers could use email, telephone and fax machines to communicate. During the second exercise they could also employ the newly developed DSS that allows users to mark affected facilities, pipes, cables, service areas, etc. on a map of the region. They could attach qualitative information as well as prognoses on expected future developments of the crisis to an incident or a system status. The objective of both experiments was to study the difficulties the participants faced and deduce requirements the tool should meet respectively observe its effect on the quality of the interorganizational cooperation. In return rules of communication were to be developed that complement the use of the DSS in an optimal way. The exercises lasted approximately five hours each.

Visual and sound recordings of all rooms and telephones were taken and processed. For that purpose as a first step all calls were transcribed and the videos were encoded. Due to the research questions the focus was on statements given across organizational borders first. The five dominant themes of content that were discussed in those conversations and a few less relevant subthemes were identified and thereafter the handling of these topics throughout the exercise was retraced within the different existing recordings. For the purpose of this specific research question the communication on unreliable information was examined more closely and how it influenced the subsequent handling of the issues by the crisis managers. In the aftermath of the experiments some of the participants were interviewed on the observations.

COMMUNICATION ON THE RELIABILITY OF INFORMATION

Communicating probabilities in cascading crises

The communication that took place can roughly be divided in two phases that correspond largely with the functions of DSSs mentioned above. Firstly, information on the situation was collected and assessed in order to establish a common understanding of the situation (creation of a COP). In this phase all crisis management teams were presented with a lot of contradicting and incomplete information on their own systems coming from their own organizational units – as can supposedly be expected in a real crisis. Therefore they had to interpret and evaluate this data before passing it on to the other crisis teams. Meanwhile the first organizational response was triggered that mainly aimed at dealing with the imminent damages to the infrastructure network. Secondly, the participating teams had to tackle the cascading effects between their networks. Measures were taken that either aimed at identifying those interdependencies that caused the observed effects or eliminate their consequences.

At this point the nature of those cascades that the exercises were based on cannot be described in detail. But the character of the data that was exchanged in most instances contained information on which facilities of one's network were affected, which areas were out of service and at what time a measure would be in place and/or

show effect. Especially the latter could almost never be predicted precisely. For example in a certain region the power supply was interrupted which affected numerous facilities within other networks and threatened to cause further disruptions of the natural gas or drinking water supply. The power company had repair teams on the site that - based on its experience - expected to restore service within two hours in a certain zone.

As all participants were aware that the other teams might base a decision on any given information, all crisis units had to deal with the question of whether and/or how to present and interpret information whose reliability was questionable. In the following their strategies to do so will be described.

The sender's perspective

First of all, none of the participants used numbers/percentages to describe how reliable they expected a piece of information to be. A proposal made during a workshop to implement a feature of the DSS that allowed the inclusion of such a numerical description was dismissed by all users immediately because they would never give an exact number in a situation when exact information was not expected to be available.

Most information on the reliability or probability of an event was exchanged verbally and by phone rather than via email or through the decision support tool even though it included a feature that allowed for attaching qualitative information to visually presented (geo-) data. It was observed that information was often sent electronically and immediately after that a call was made to add information on how reliable or speculative this given data was.

One strategy that could be observed was to explain why some data's reliability was assumed and which alternative developments the issue might experience in the future. The person on the phone would give her/his estimation on the situation and explain why she/he cannot be sure that all details are correct (e.g. no person on the ground, contradicting information, some indicator that implied a different explanation, etc.). As the infrastructures at hand are highly specialized expert systems these sometimes lengthy and very complicated explanations were difficult to follow for the recipients. But to some extend it allowed them to draw their own conclusions on how to evaluate the matter.

One of the crisis teams instead almost always presented details on the situation as facts rather than in conditional tense or as one of several alternatives. At the end of any report a phrase was regularly annexed that said when this information or parts of it turn out to be false an update will be given immediately. For example they stated an exact point in time when something would be fixed and then add that they would notify the other participants immediately if the repairs would be delayed. On the other hand, when the team received a notification on their network they often discussed whether it was reliable enough to be presented to the other organizations. As a result information was withheld in some instances until its validity was agreed on internally. When asked in the aftermath of the exercise the head of the crisis unit explained that in such a situation it was ineffective to make each team evaluate information concerning his system about which they have no expert knowledge. He said that even though his strategy might in some instances lead to others act under wrong presumptions, it was still preferable in order to facilitate everybody's capacity to act as promptly as possible.

A third strategy that was applied was to present alternative developments in the order of their likelihood without further specification of their probability to come true. Subsequently they started a discussion on the resulting consequences on the interdependent components. Thereby awareness was raised how relevant a specific fact or incident was or would be to the other systems or organizations. In later stages they would inform the other participants particularly on those new developments they knew were relevant to them. This strategy requires some time in the beginning and it is questionable whether crisis managers would invest as much time in this detailed exchange of information in a real emergency situation. In the aftermath the participants praised these phases of the exercise as they learned much about the functioning of the other systems.

The recipient's perspective

When the crisis teams received information they were well aware that, given the situation, it could be inaccurate. Nevertheless, almost none of the participants ever asked for a specification on the probability whether given data was exact, let alone openly question its reliability. Instead, after most conference calls each team would convene and evaluate the influence of new facts on their network which in some instances led to very different results. Especially when timeframes were discussed the participants often decided to add some time to the given schedule to avoid bottlenecks. As a result measures regularly included a certain buffer. When asked for a motive for this approach some participants said it was a security measure, others stated they expected others to describe their systems' status as positive as possible. Therefore when they were presented

with a range of alternative developments, they estimated the most pessimistic one was probably most realistic.

Particularly notable was that the second strategy described above according to which everything was presented as a fact led to the highest level of acceptance. The reliability of data was barely ever discussed before a measure was implemented based on it. And when these statements were revised or actualized later this was also accepted easily with the comment that a changing status is expected to be commonplace in crisis situations.

CONCLUSIONS AND OUTLOOK

Even though every individual participant had a slightly different way of expressing probability it became obvious that each crisis team developed a common strategy. In the course of the exercise it became more and more consistent and independent from any individual that was making the call. Unfortunately the experiments are unsuitable to analyze which strategies lead to the best results because they are strongly influenced by the fictitious scenarios the exercises were based on. Nevertheless it became obvious, that in the second crisis exercise the participants relied easier on each other's information and all teams were less reluctant to share information openly. For example the safety cushion added to a timeframe both by senders and recipients was shorter. Whether this was due to learning effects, growing mutual trust or a better understanding of the functioning of the other supply networks resulting from numerous workshops conducted in the course of the research project cannot be determined with certainty. Still it can be concluded that interorganizational cooperation in preparation for crisis situations does - besides the already known positive side-effects (LaPorte, 2007) - help to avoid distortions due to the varying expectations of the reliability of incoming information.

Regarding DSSs there many questions left that need to be answered. The findings presented here suggest a number of aspects that should be explored further during the development of features for DSS as well as accompanying rules of communication across organizational borders. Firstly, under the likely condition that during crises the operational picture does change due to the withdrawal or modification of statements, the design should not push the users towards only one version of outcome. Instead, features should allow for different alternatives to be presented as easily as possible. How understandable exact probabilities are articulated might be of minor importance compared to the question whether the actors provide each other with their expert evaluation. And if there is a way to do so with little effort, participants are more likely to use this option even under pressure of time. Second, users should not be forced to evaluate the reliability of their statement in writing as they might be reluctant do so. Instead in addition they should have the option to express doubt orally even if this is more cumbersome. This might not only prevent the recipients from making decisions on false presumptions but also keeps them from withholding information until it is perceived as absolutely reliable.

Furthermore, there is still need for methodical approaches to train decision-makers to exercise these communicative skills under the special circumstances of emergency situations. The circumstance that most training methods were developed for exercises conducted within an organization leads to the neglect of aspects that emerge especially between actors that don't share an organizational or professional communications culture.

ACKNOWLEDGMENTS

This work was partially funded by the European Commission under the FP7 Framework as part of the research project Responsibility - Global model and Observatory for international Responsible Research and Innovation Coordination (Grant Agreement No. 321489). Furthermore I thank Michael Hahne, Renate Lieb and Leon Hempel who were part of the team that planned, organized, implemented and analyzed the exercises.

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