Architectural proposal for a context aware sensemaking support system that allows the flexible handling of information from multifaceted sources

Stefan Moellmann
Karlsruhe Institute of Technology
stefan.moellmann@kit.edu

ABSTRACT

The process of sensemaking usually forms the beginning of the management of a disaster and continues throughout its course. Information system provide tremendous opportunities to support this process. However, the vast scientific knowledge on the sensemaking process is given too little consideration in the design of information systems. Meanwhile, new means to get hold of current information on an ongoing disaster are emerging in the form of social media. While the actual value of social media data remains doubtful, it surely increases information overload in stressful emergency situations.

This paper suggests an architecture for a sensemaking support system that assists the user by providing context aware filtering of information from various sources. Further research goals are to derive concrete user requirements from the knowledge on the cognitive process of sensemaking as well as to find the means to fulfil those requirements with actually feasible technological solutions.

Keywords

Sensemaking support, context awareness, social media

INTRODUCTION

When dealing with an emergency situation the first thing a decision maker needs to do before being able to make any decisions is to make sense of that situation. Sensemaking defined by (Weick, 2005, 57) as "a diagnostic process directed at constructing plausible interpretations of ambiguous cues that are sufficient to sustain action" is nowadays also a process that to a great extent depends on information taken from various kinds of IT systems. Those systems can be anything from e-mail accounts, knowledge databases and management information systems to social media and crowdsourcing platforms. The large number of those systems and the enormous dynamics and magnitude of their contents pose a series of challenges to both users and developers of such systems.

From the users' point of view there is the increasing danger of being overloaded with information as a result of which the user will have to filter the information in some way in order to reduce it to a manageable amount which in turn bears the risk of leaving out crucial pieces of information. More important than handling the amount of information is the task to comprehend it and assess its relevance to the current situation. Whether or not one is able to do the latter does also depend on the way the information is displayed. Raw data shown in the form of a table might be useful if one is interested in the actual numbers. However, when time is scarce, one might prefer the data being aggregated as a pie chart to make it intelligible at a glance. One should not forget that all this work needs to be done in a situation that people might experience as very stressful and even threatening. Furthermore since every emergency is different, standard procedures might not always be applicable so the decision maker needs to be able to improvise. However, according to the threat rigidity thesis (Staw et al., 1981) "a threat may result in restriction of information processing" and "subjects in stress conditions have been found to be less flexible in their choice of solution methods than nonstress subjects".

Based on those issues a few requirements can be derived that should be considered in the development of information systems for crisis managers. Those are:

- A system needs to be able to automatically filter information in a way appropriate to the current situation and the task of the user. This way information overload should be reduced and thus according to (Plotnick and Turoff, 2010) the risk of threat rigidity should be mitigated.

- Information from social media such as Twitter and Youtube can play an important part in the early assessment of an emerging situation since those media are often the first sources to be fed with current information by citizens. However, since information from social media is often unstructured and of large extent, the above requirement to filter and aggregate that data in a suitable way applies all the more.
- The user interface should be designed in a flexible way so that the user can adapt it to his or her own style because "rigidity in the interface is what will inhibit creativity or improvisation in unique problem situations" (Turoff et al., 2004)

In the following a design for an architecture for a system that would meet these requirements will be presented and explained. Since the implementation of this architecture requires the solution of certain technical and scientific problems some early approaches to solve those problems will also be proposed.

THE ARCHITECTURE

With regard to the above requirements a crucial aspect of the system has to be its ability to automatically adapt its output to the given context. Thus, a context sensitive component will be necessary to allow for the automatic filtering of information and for the system to decide how to depict its content visually. This context awareness will be achieved by a semantical layer, a situation awareness component and a mapping function that binds pieces of information to a model of the context. The interaction of those components and the remaining parts of the system is shown in Figure 1.

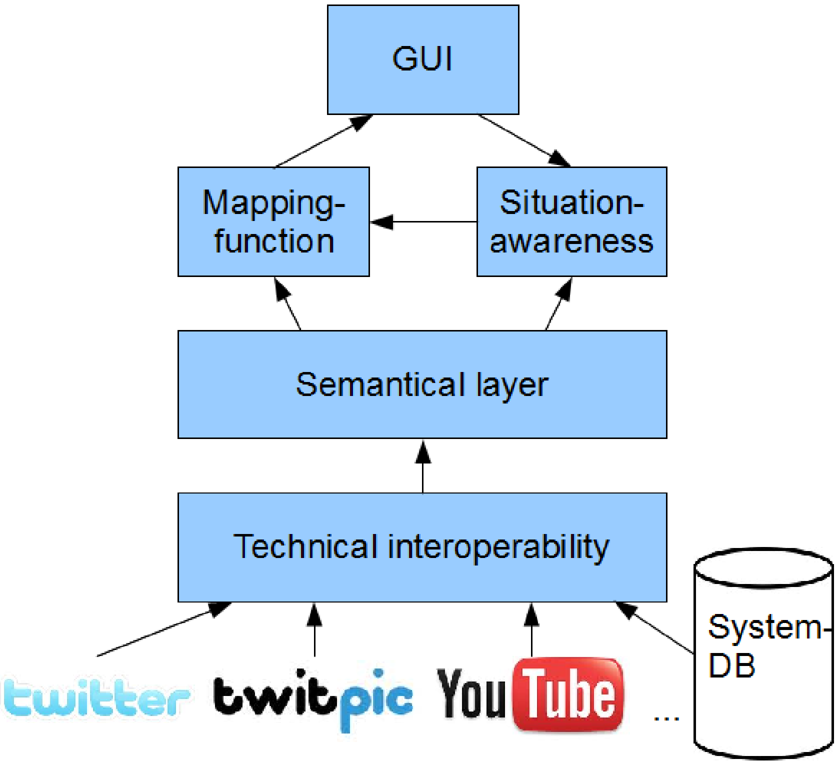

Figure 1: The architecture

The foundation of the system will be all available sources of information that could somehow be relevant in disaster situations. Those sources could be social media, the system's own database, an email-server but also remote web services that could for instance provide weather data and traffic information. The system database may contain data on historical cases as well as data on the current situation provided it is connected to a distributed information system, fed by other users or subsystems. To make all that information accessible to the overall system, adapters will be necessary to connect them to the technical interoperability platform. This platform and its interfaces should be designed in a generic way to facilitate the future addition of further sources of information. Based on that platform a semantical component would have to evaluate the data in order to enrich it with semantic information. This information in turn will be used by the situation awareness component that builds up a context model of the current situation. This model should ideally contain all the information necessary to describe the given disaster situation (e.g. type of emergency (flood, earthquake, etc.), location, time, number of injured). Besides, the system database should also contain details on the user who is currently logged into the system. This information describing the role and responsibilities of the user should be part of the context model. In addition, the situation awareness component should access the user interface to obtain details on the user's behaviour. In that way information on the task currently performed could be procured as well as details on the personal style and preferences of the user. Next, the so derived context model serves as an input to a mapping function which determines how much and what information to display in what way on the user interface. This GUI again should enable its operator to flexibly and intuitively handle that output, perform calculations on it, alter its depiction, exchange it with others and so on.

Suppose a sensemaking support system could be build according to this architecture, one can see that it actually meets the requirements stated in the introduction. Through its ability to filter and depict information in a manner suitable for the current context and the task of its user the system can mitigate information overload and at the same time make sure the user gets the information (s)he needs in a timely manner. By doing this automatically it would reduce the workload of the user. The flexible and intuitive GUI enables people to manage and manipulate information in a way that they can easily improvise new ways of dealing with the information without giving much thought to how to do it. And while the user is doing this, the systems learns about his/her preferred working style and can take this into account when deciding how to prepare the content in future cases. Moreover, the system will have access to social media and offer the opportunity to analyse and aggregate the content provided by involved citizens and witnesses.

IMPLEMENTATION CHALLENGES

When implementing a system according to the above architecture one will come across a number of difficulties that seem to require further scientific inquiry. The major ones will be discussed briefly in this section.

Context awareness

The main issue will certainly be the combination of semantic layer, situation awareness component and the mapping function, because it is a problem of high complexity and at the same time crucial for the system's context aware behaviour. The general problem of creating an ontology that represents the interrelations between available pieces of data, a given disaster scenario and the task of a decision maker seems solvable in principal. If for example a person in charge has to deal with a flood incident and the task is to dispatch the available fire trucks to buildings with flooded cellars that need drainage, the following information (amongst others) would be required:

- Number and current position of available fire trucks equipped with pumps.
- Positions of affected houses including damage assessment (in this case maybe size of cellar and flooding level).
- Streets that cannot be used due to damage, flooding or traffic.

If this information is available including an ontology mapping it to events of the type "flooding", a system could infer the user's need for it. Since many of those data contain geographic positions, the system could even decide to display it as a map layer instead of a table for instance. Unless of course the system "knows" from previous (similar) cases that the current user often prefers tables over maps. In that case a table would be shown first, but the option to switch to a map-view would still be provided.

While an example as simple as the above might make the implementation of such functionalities seem feasable, it is obvious that reality is much more complex. In fact the number of possible elements in a function that would map data items to situations to user preferences would be practically infinite. Hence, it doesn't seem worthwhile to pursue the development of complex ontologies or the like expecting that this job will one day be "done". Instead, the endeavour for more generic solutions of manageable complexity is imperative.

One possible choice of a technology as a basis for this system could be the Resource Description Framework (RDF), as it offers possible solutions to "enable the discovery of relevant data within the multitude of available data sets" and to "integrate data from large numbers of formerly unknown data sources" (Heath and Bizer, 2011). Further evaluation of this technology will show if it is appropriate for the problem at hand and especially if it is generic and flexible enough for large and dynamic data sources.

Social media integration

As pointed out before, an information system to provide a disaster manager with up-to-date information on the situation should include data from social media. But to make that data accessible by a context aware system some meta data will be required, to assess the relevance of for example a Twitter message to the situation at hand. The Twitter API (Twitter, 2012) does already offer a search command that includes parameters like "geocode" and "until" (returns tweets generated before the given date) so that a query can be created in a way to narrow down the search results by location and time. Further steps to pigeonhole the content of the tweets could be done either by automatic text analysis or by crowdsourcing the tagging of possibly relevant content. Therefore, existing solutions for crowdsourcing and text analysis should be evaluated for their compatibility with this system architecture. Especially if the crowdsourcing approach proves to be promising this will raise questions like how to ensure or measure the trustworthiness and the quality of the work done by the crowd. Regarding the social media content itself similar questions have to be answered. While those concerns will mainly have to be solved on a social, organisational and possibly legal level, there will also be implications on the technical side. For example one could automatically rate the trustworthiness of tweets by certain objective criterions like the frequency of tweets with similar meaning. Moreover, it should be possible to check whether certain tweets are independent from each other or if one is just a retweet of another. These factors like reliability and accuracy could be summed up to a value indicating the uncertainty of the given information. Then again, this uncertainty has to be communicated to the recipient of the information in a proper way, which calls for appropriate means of visualization. Summing up, the integration of social media data in a context aware system seems challenging but feasible if the opportunity for further scrutiny is given.

User Interface

Designing a flexible user interface that can be adjusted to the preferences of its user, is nothing new. However, taking into account state of the art knowledge about the cognitive processes of sensemaking in that design process is yet uncommon, albeit (Muhren, 2009) and (Landgren, 2005) have already shown how this can be done. It seems worthwhile to further evaluate the literature on sensemaking in order to derive more specific requirements for the design of user interfaces to optimise the support for sensemaking activities. An ideal sensemaking support system would not only support human thinking processes in an unobstructed manner, but also help to reduce the stress level of its user and thereby forward the user's ability to improvise creative solutions. Harnessing the system's context awareness, even inspiring the user with appropriate hints e.g. taken from similar historical cases seems imaginable.

Since the depiction of the content as well as the functions for its manipulation should depend on the users general role and current task, it needs to be clarified which types of roles come into consideration. Typically the users of disaster management systems can be decision makers (or their assistants) on the various hierarchical levels in different kinds of governmental offices and organisations. However, it is a well known fact that in disasters like earthquakes the real first responders who help the affected people are the ordinary citizens helping their neighbours. One should bear in mind that those citizens have a desire for information because they themselves conduct their own sensemaking process and they are also subject to threat rigidity and might also be overwhelmed by contradictory information coming from different sources. If - thanks to social media - the citizens are considered a source of information they should also be thought of as recipients of information so they can better be involved in the mitigation of disaster situations. Therefore, one possible role in a sensemaking support system could be called "citizen" and the appropriate user interface might be a government website providing information to the public.

CONCLUSION AND NEXT STEPS

Supporting a cognitive process as complex as sensemaking with context aware technology so as to enable the system to - in a manner of speaking - "help the user think" seems a reasonable goal. The development of such a system, however, poses a number of challenges to the software developer. A few of those are outlined in this paper along with early state solution approaches. It needs to be pointed out that focussing on just one of those problems like for example the development of flexible GUIs or the evaluation of Twitter data will not be sufficient to create better sensemaking support systems. Instead, holistic solutions that combine existing answers to partial problems need to be sought. Therefore, it will be necessary to further investigate the dependencies between the components suggested in the above architecture, to develop best practices and design recommendations for better sensemaking support systems.

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