KIS - A Crisis Team Information System

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ABSTRACT

Widespread crises require the deployment of a crisis team, to coordinate the disaster assistance. Because of their low frequency of occurrence and the extensive assignment of volunteers, often only less practical knowledge in managing widespread crises are available on demand. If such a crisis occurs, the gained knowledge must be quickly shared within the team. Current crisis management systems are designed to manage big amounts of situation facts, crisis teams based their work on. But very often these systems are not able to manage information about the linkage of these facts causing the problems. KIS is the first prototype of a crisis team information system, able to combine an ontology based data model for situation representation with the ability to forecast causal chained and spatially related problems derived on situation facts. KIS is able to store and manage this knowledge so that it can easily be shared with others.

Keywords

crisis team, information system, knowledge management

INTRODUCTION

The rising number of natural and technical disasters increase the importance for managing big amounts of data crisis teams base their work on. The fact, that crisis teams start working when a critical situation has already occurred, leads to the need for immediate decisions lacking complete knowledge about the given situation especially in the initial phase. This phase has been termed the “chaos-phase” (Vemmer, T., 2004). In this phase the relevant information needed to deescalate the crisis has to be collected, distributed and analysed faster than new events occur. This process bases on the experience of the crisis team about effects and their consequences. Nevertheless, if there are many interconnected effects influencing each other, it is likely, that important consequences are not noticed and getting lost. Such chains are essential in disaster management and must be expressed explicitly (Babitski, G., Probst, F., Hoffmann, J. and Oberle, J., 2009) in order to derive situational hints.

In Europe, the number of disasters requiring the deployment of crisis teams is very low (Vemmer, T., 2004). In Germany, volunteers do the majority of disaster management. Emergency information systems, like the German emergency provisioning system deNISII[1] provide assistance for managing data in crisis teams. The aim of these systems is mainly the acquisition and supply of latest situation information to enable widespread crisis management. The crisis team uses this information to plan their work. That means, it utilizes gained expert knowledge, to recognize the connection between the facts, to make its plans. The idea of knowledge management (Nonaka, I. and Takeuchi, H., 1995) is to make the expert knowledge explicit, that it can be stored and shared with others. To store and share the expert knowledge of a crisis team, an information system must be able not only to manage the situation information, but also to store the relations between data. In the domain of crisis management, reasoning with semantic web technology is used in cases like decision-making (Shamoug, A., Juric, R. and Paurobally, S., 2012), resource planning (Shafiq, B., Vaidya J., Atluri V., and Chun S. A., 2010), the relational database to ontology mapping (Shen, H., Hu J., Zhao, J. and Dong, J., 2012), or the coordination of crisis response (Truptil, S., Bénaben, F. and Pingaud, H., 2010). But no system known to the authors combines an ontology based data model for situation representation with the ability to forecast causal chained problems derived on situation facts, so the idea to build KIS was born.

[1] http://www.bbk.bund.de/SharedDocs/Downloads/BBK/DE/Publikationen/Newsletter/Newsletter_8-06.pdf

KIS is the prototype of a crisis management information system, which is able to store the crisis teams' expert knowledge about causal relations of events. KIS is working on top of an ontology based data model for situation representation. This enables the system to provide context specific hints based on rules gathered in previous situations to make forecasts of possible consequences. In contrast to other approaches, e.g. (Truptil, S. et al. 2010), in KIS the users do not have to work on abstract graph representations of domain knowledge for situation description. Reasoning is used here to enrich the crisis situation facts and not for interlinking different models.

THE KNOWLEDGE MANAGEMENT METHODOLOGY

In (Fan, Z. and Zlatanova, S., 2011), the two different types of data in the emergency response, static data und dynamic data are presented. Static data could be collected before an emergency situation occurs, such as topographic data, cadastre data or hydrographical data. In contrast, dynamic data could only be obtained after the disaster occurred, such as damages or affected population. Static data may be facts for a specific region, but also rule based expert knowledge formalized in previous emergency situations.

Expert knowledge could be gained after an emergency situation was deescalated using debriefing methods, to explicitly express what happened and what reasons lead to the disaster. The emergency situation can be formalized using emergency ontologies (Babitski, G. et al., 2009; Shafiq, B. et al. 2010). If the crisis team uses an ontology-based information system with access to static data and a management interface for situation facts, the most relevant information about the disaster are already present.

In the next step, critical properties can be identified the disaster based on. For every causal effect, a rule can be formulated classifying the pre-emergency conditions as danger for the occurred damage. Figure 1 shows the described knowledge management cycle.

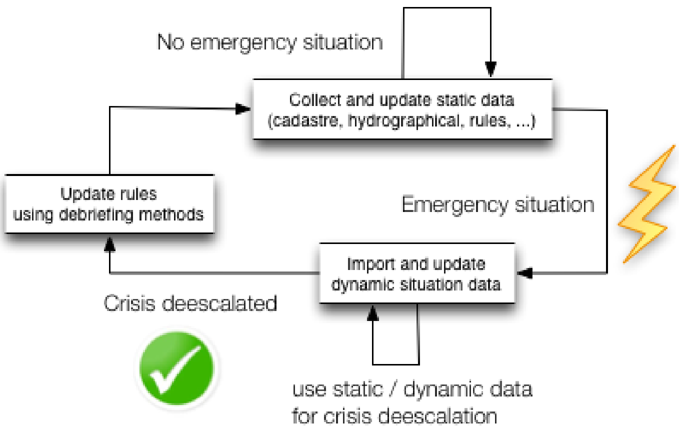

Figure 1. The knowledge management cycle

The next time, these pre-emergency conditions are detected by the information systems reasoning engine, warnings can be generated to inform the crisis team. Regarding the possible damages due to cascading effects, KIS can also be applied as an early warning system.

BLACKOUT SCENARIO

In this section we will concentrate on one scenario, illustrating how ontology reasoning on domain level can result in faster emergency response.

A classic example of a crisis situation is a power blackout. In order to manage the big amount of coordination required by this situation, a crisis team is built. Especially in the initial phase, the crisis team is overwhelmed by incoming facts from subordinated control points, reporting damages due to blackout related or derived issues.

In Germany the crisis teams' activity is divided into six different responsibilities: staff inner service, assessment of the situation, operations, logistics / supply, press / media work and communications. The responsibility of the *situation-role* is to priorities the importance of facts and visualizes relevant information for the whole team. Every fact not visualized for the team is likely to get lost in the decision making process. In widespread crisis like the blackout scenario, there are so many facts that they cannot all be visualized leading to a serious risk, that the crisis team misses possible consequences. The aim of a knowledge management information system for crisis teams is to give the crisis team access to experiences gained in previous situations comparable to the current one by matching the facts from the current situation against known pattern in the knowledge base.

In KIS all facts are stored to a *Scenario Knowledge Base* and are available for later analysis. Some missing information, e.g. about geographic coordinates, could be determined automatically using geocoding web services.

KIS provides each member of the crisis team with a specific perspective, adapted to his role and deliver task-related information to the responders like proposed in (Fan, Z. and Zlatanova, S., 2011). Because of the shared situation data model the described crisis situation is visible for all members in the crisis team. In a crisis team each role has a different responsibility, so KIS offers them the ability to hide the information he or she is not interested in.

Figure 2 shows the map-view plugin of KIS, which visualizes the situation for the whole team. With the help of KIS the *situation-role* has the ability to enter situation facts to the ontology based data model. This domain specific input option is close to situation representation on traditional pen and paper situation maps. The currently used ontology version for situation representation describes the connection between conditions like water level or power supply condition (blue polygons), events effecting conditions and infrastructure dependent on conditions (tactical signs). If the *situation-role* enters an initial event like the blackout into KIS, the resulting events can be determined automatically: Infrastructures have a location and a tolerance for a specific condition. The violation of a tolerance will cause other events influencing conditions relevant for other infrastructures, possibly violating further tolerances.

The responsibility of the *operation-role* is to analyse the current situation, make a forecast of the needed resources and develop strategies to deescalate the situation. In order to be able to make situation forecasts the *operation-role* has to analyse the reasons for effects like crack formation in houses and the lowering of house walls in the scenario region. KIS can determine the violation of which infrastructure tolerances can result in crack formation and the lowering of house walls. It gives a hint to the *operation-role*, that there could be a problem with rising groundwater level. For a later version of KIS it is planned that the *operation-role* is able to open an explanation for this inference so that the *operation-role* can request more detailed information about it to determine the responsible effect for the rising ground water level in detail. In KIS the *operation-role* is able to approve the inferred data, so that it can be stored as fact to the *Scenario Knowledge Base* and further possible consequences can be derived.

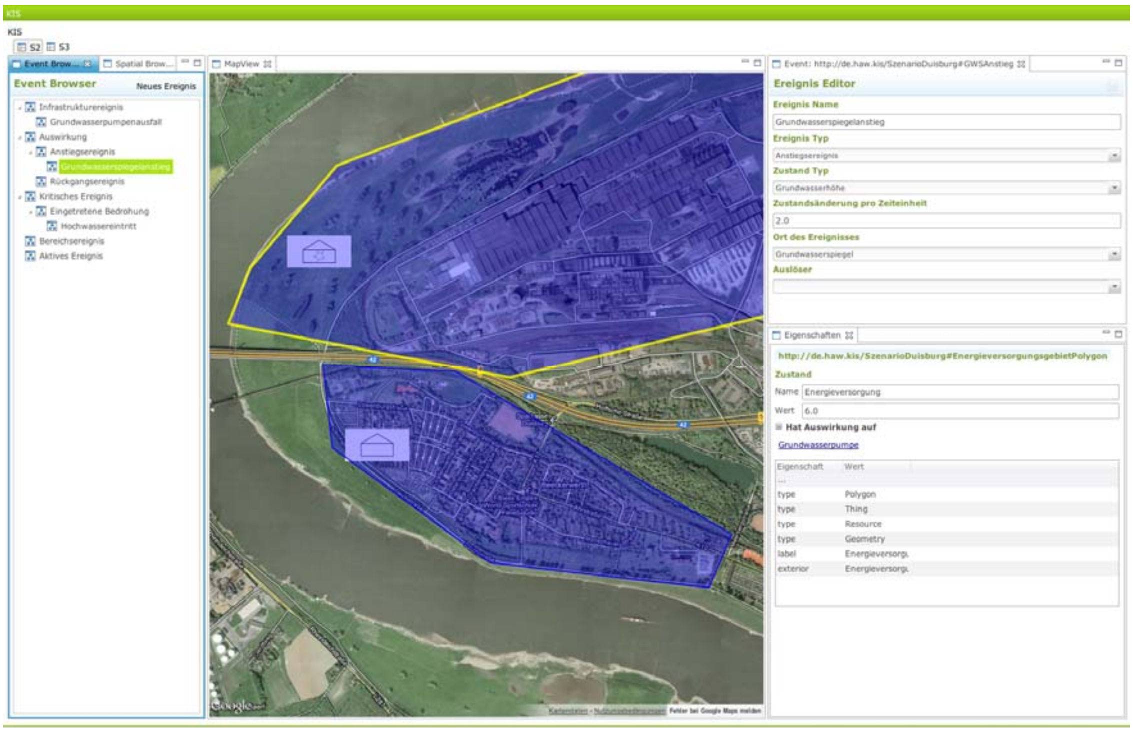

Figure 2. The KIS map-view plugin showing an area exposed by a rising ground water level

Because of its geospatial kernel, KIS is able to infer spatial correspondences for a specific region, even there are no explicit rules given for that situation. This enables the *operation-role* to filter the big amount of situation facts to concentrate on a local problem.

It is also planned that an analyst can specify the facts his or her analysis based on if the *operation-role* enters the results of a forecast, done without the help of the inference system. After the crisis has been deescalated, he or she has the ability to define general rules for the manual forecast, so that his or her expert knowledge can be turned into explicit knowledge, shared and made available to the inference engine as described above.

After the *situation-role* entered the occurred blackout to the *Scenario Knowledge Base*, the inference engine can determine all electricity dependent infrastructures. Without the help of an information system this is a very time consuming task, because the location of all electricity dependent infrastructure must be investigated manually. A plugin can be added to KIS displaying for all hospitals a 24 hours countdown, visualizing the availability of emergency power.

Due to the blackout fact, the inference engine of KIS can also derive a chained problem. KIS determines that the groundwater pumps in a low-lying area could fail, which could result in a flooding for that area. These kinds of causal chained problems are hard to determine for the crisis team and are likely to remain undiscovered until their effects occur.

Figure 3 show a clipping of the semantic network derived by the inference engine. With the help of this domain knowledge the engine is able to draw a connection between the blackout-event (red), the power supply condition (blue) and the affected infrastructure (yellow).

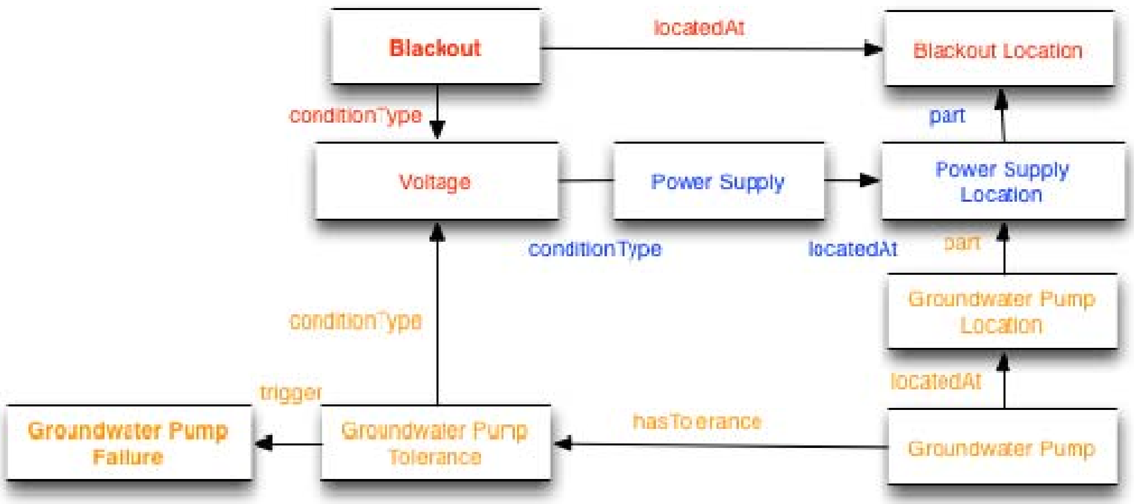

Figure 3. A clipping of the semantic network derived by the inference engine (red: Event, blue: Condition, yellow: Infrastructure)

The information system informs the *operation-role*, that there are 3740 inhabitants in this area, which have to be evacuated in the case of a flood. With the assistance of the expert knowledge stored in KIS, the crisis team has the ability to deescalate the crisis actively in contrast to only react on incoming events.

After the crisis has been deescalated the described knowledge formalization process starts. The level of detail of the rules depends on the level of detail of the whole ontology. The currently implemented ontology is able to describe the connection of events, conditions and affected infrastructure. An example for this rule is the connection between power blackout, power supply condition and a ground water pump shown on figure 3. The question about what kind of rules can be formulated depending on the level of detail of the domain ontology is one topic of further research.

KIS' KNOWLEDGE BASED ARCHITECTURE FOR CRISIS MANAGEMENT

Figure 4 shows the layered architecture KIS based on. The *Rules Knowledge Base* stores the rule based expert knowledge gained in previous situations. It contains information about how to enrich facts contained in the *Scenario Knowledge Base*. The facts generated by the *Inference Engine* are stored to the *Inferred Data Knowledge Base,* until they get approved and applied to the *Scenario Knowledge Base*. To enable quick access to relevant information using geographic coordinates, all facts are stored to a spatial database.

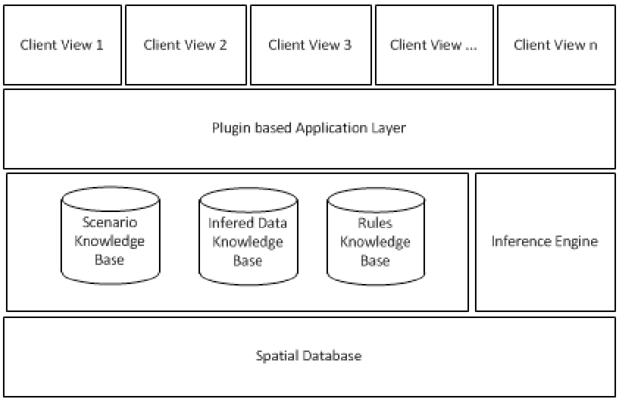

Figure 4. Layered Architecture

To control dependencies between the functional independent parts and to simplify extensibility, KIS application layer based on a plug-in architecture. For every role in the crisis team there is a customizable view, defining which plug-ins are necessary for the role to do its work and how windows for this role are arranged.

CONCLUSION AND FURTHER WORK

The development of a crisis team information system able to store and share crisis teams' expert knowledge in order to derive causal chained problems is a significant step toward comprehensive disaster preparedness. The prototype presented in this paper shows, which benefits smarter information systems may bring along. The KIS prototype is currently intended for demonstration purposes only. The system can derive simple causal connections between facts, like the described example of ground water pump failure. The next steps in prototype development are the improvement of domain specific input options, the display of explanations for inferred facts, and the improvement of the ontology used for situation representation.

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