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Integrating Process Modeling and Linked Open Data to Improve Decision Making in Disaster Management

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Abstract. In disaster management, personnel of the involved organizations need to make quick, but informed decisions. Many activities need to be coordinated within and across organizational borders. The information basis available to decision makers is typically sparse, and still relies mainly on radio reports from the field. We propose an approach to extend this information base: First, techniques from business process management should be used to formally describe the activities in disaster management; second, the elements of the resulting process models should be annotated with tags derived from the concepts characterized by an emergency management domain ontology. These annotated process models serve as basis for retrieving relevant contextual information, e.g. from linked data pools provided by governmental agencies. Our approach will allow disaster management personnel to take a contextualized perspective on planned and ongoing actions, and facilitate quicker and more informed decisions.

Introduction

In crisis situations, emergency management organizations typically establish a command staff, which is responsible for planning and coordinating the actions and measures that are taken to resolve the situation. Today, this command staff mainly relies on paper-based mission blueprints and lists of actions. However, especially for large and catastrophic incidents, keeping track of all ongoing and planned actions within the own organization and across organizational boundaries is a

challenging task. Deciding which action to take next, while considering the dependencies to other actions, is the central and most important task the command staff has to tackle.

Researchers have proposed a number of strategies to support the command staff. Especially the use of techniques from business process management has recently gained attention (cf. [8]). The main challenge, when bringing these techniques to disaster management, is to allow for more adaptability and flexibility to the rather rigid perspective of traditional process engines, taking the rather unpredictable nature of disasters into account (cf. [4, 9]).

While the use of formal process descriptions improve the overview on planned and running actions and the involved resources, it does not provide contextual information, e.g. about objects related to the action or the environment of the location where the action is carried out.

Especially two types of information sources could be leveraged for this purpose: First, the Linked Open Data Cloud, which currently contains about 31 billion triples and 500 millions of links[1], provided in particular by governmental agencies (cf. [2]); second, user-generated content, available on various social media platforms. With the increasing adoption rates of smartphones and decreasing costs for mobile internet access (cf. [3]), this data contains a growing number of reports from crisis situations (cf. [10] for reports on the use of Facebook and Twitter).

In this paper, we describe how both kinds of information sources can be integrated into process support systems via an ontology-based tagging mechanism for process models. This tagging mechanism allows pulling relevant contextual information at runtime (i.e., during the disaster response operation), and thus provides a broader information base to decision makers in disaster management.

Approach

With regard to the four phases of disaster management [11], our approach can be separated into modeling and annotation of activities, which are carried out in the preparation phase, and, process instantiation and execution, which happen in the response phase.

Thereby, the preparatory steps form the basis for the automatic provision of relevant context information during response time.

[1] http://www4.wiwiss.fu-berlin.de/lodcloud/state/ [retrieved 2011-11-30]

Modeling and Annotation (Preparation Phase)
Formal descriptions of the respective processes are prerequisite for any process support system. While this formalization is currently not a common practice in disaster management, a number of researchers have highlighted the benefits it would bring to the domain (cf. [5, 8]). In particular, it will facilitate a more precise tracking of planned and ongoing activities and the employed resources.

As a starting point for formal process descriptions, existing textual representations of emergency plans can be used. However, while traditionally process modeling is typically done by system analysts, we recommend a collaborative approach with a high degree of end user involvement, e.g. [7], to make sure, that process descriptions represent the understanding of actual disaster management practitioners.

The result of the collaborative modeling is a set of process descriptions, which cover typical processes carried out in crisis situations. Figure 1 shows (parts of) such a process model for a dyke fortification. Others may cover the transportation of injured people, or for restoring the power supply.

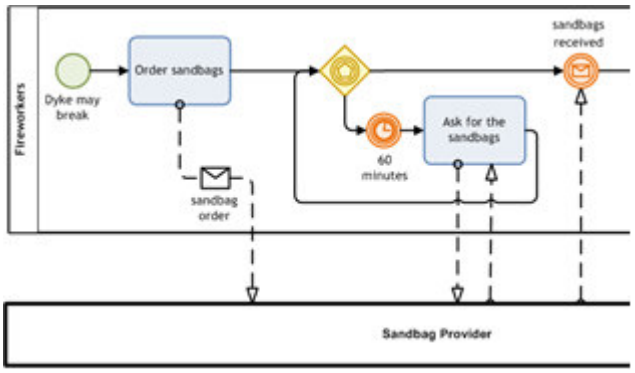

Figure 1: (Parts of) a process model for a dyke fortification activity.

To enable the automatic provision of relevant context information during process execution), the resulting process models need to be annotated with a set of tags that work as information filters. We propose that these tags should refer to concepts from a domain ontology for disaster management (e.g. [1]).
Using concepts from an ontology offers two benefits over plain text. First, concepts are language independent, thus contextual information can be retrieved from foreign data providers. Second, ontologies allow retrieving information for related tags (e.g. parent concepts) for cases in which no information is available for the original tags.

With regard to the example in Figure 1, the *order sandbags* activity could be annotated with the concept *sandbags*, but also with *national guard*, because in disaster situation, dyke fortifications will often require large numbers of personnel to execute the task that cannot be provided by the regular emergency management organizations.

Process Instantiation and Execution (Response Phase)

During the Response Phase, relevant processes are instantiated as parts of a global process, describing the necessary steps to cope with the crisis.

We propose that these process composition steps should be assisted via a process repository, in which previously modeled processes can be found via a comprehensive search interface, and subsequently be placed within the global process via drag&drop. We will subsequently refer to these processes as *subprocesses* to distinguish them from the global process.

Using Linked Open Data as a source for contextual information

While the subprocesses are executed, relevant contextual information is retrieved providing support to the decision maker and the personnel in the field. An activity might contain descriptions, where background information could be helpful. For example, if a fire is near a chemistry plant with sulfur reservoirs, the decision maker can be provided with the chemical properties of sulfur to make danger estimation. Using Linked Open Data, this additional information can be provided dynamically.

Furthermore, based on the proposed annotations, data sets with general knowledge, e.g. DBPedia[1], Freebase[2], or OpenCyc4[3] or Linked Open Government Data (LOGD) [6] could be linked to the activities in the processes, and crawled for background information during execution time. Figure 2 shows an example for such, potentially valuable, background information from the city of Vienna: maps of the city quarters are provided as part of a Linked Open Government Data initiative. As shown in the example, current traffic information (green for free streets, yellow for those with more traffic), and road blocks (red) could also be included. This information could be beneficial to decision makers in the command staff when planning routes to bring injured persons to the nearest hospital (marked with blue H's on the map).

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1 http://dbpedia.org/ [retrieved 2011-11-30]

2 http://www.freebase.com/ [retrieved 2011-11-30]

3 http://sw.opencyc.org/ [retrieved 2011-11-30]

Other important information may include contact persons of public buildings, e.g. the president of a university building, which is endangered by a fire. Using LOGD, this information is provided by the university administration, and a direct contact could be established to secure the university buildings.

Figure 2: Example information retrieved from Linked Open Government Data from the city of Vienna[1]

Contextual information should be presented in a non- obtrusive way, e.g. as information boxes near the current activity to show that there is additional information available. Figure 3 shows a design concept that illustrates how this may look in a process support system.

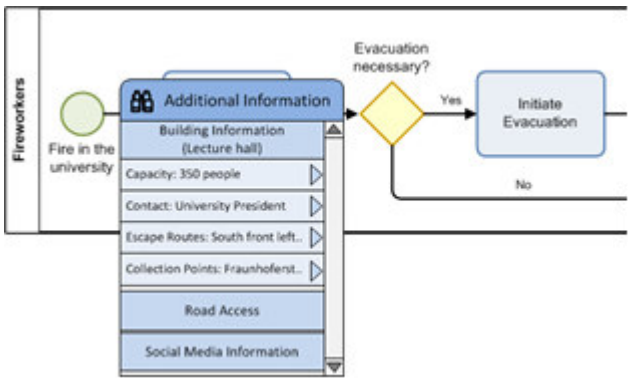

Figure 3: Design concept of a contextual information window for a decision gateway in an evacuation process.

Using user-generated content as a source for contextual information

[1] http://data.wien.gv.at/ [retrieved 2011-11-30]

As initially stated, user-generated content might also provide valuable information for decision makers during the execution of business processes. For example, common social platforms could be crawled in the response phase, searching for text, audio and image information related to the current incident; the relevant information could be extracted using a combination of the tags (provided in process models), spatial and temporal information. This way, the command staff may retrieve additional information that is difficult to gather when personnel is short, e.g. blocked roads after a hurricane.

Using contextual information from existing IT systems
Other important context information might come from internal IT systems. For example, the local energy network operators can provide spatial information of areas with power outages. This information allows the command staff, for example, to judge whether a specific hospital can currently support injured persons.

Conclusion & Outlook

In this paper, we presented an approach to broaden the information base for decision makers in disaster management. Our approach is based on the idea of process modeling for disaster management, but extends it with an ontology-based tagging mechanism, to provide users with contextual information that helps them to make quicker and more informed decisions on the next steps to take. We discussed how Linked Open Government Data, user- generated content and information from existing IT systems can be used to provide this contextual information without additional efforts for disaster management organizations.

For the future, we will also consider a retrospective phase in our approach: after a crisis has been resolved, insights from the execution could be used to adapt processes. In a manual retrospective, new tags may be created, and tags, which were found to provide little valuable information, can be erased. Also, the processes may need to be adapted, e.g., if activities were missing.

Furthermore, based on usage logs, machine learning algorithms could be applied to identify valuable information sources by their usage. In this case, activities could be annotated automatically with useful tags.

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References

1. Babitski, G., Bergweiler, S., Grebner, O., Oberle, D., Paulheim, H. and Probst, F., SoKNOS - Using Semantic Technologies in Disaster Management Software. in ESWC '11: Proceedings of the Extended Semantic Web Conference, (2011), Springer, 183-197.
2. Bizer, C. The Emerging Web of Linked Data. IEEE Intelligent Systems, 24. 87-92.
3. Burke, J., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S. and Srivastava, M.B. Participatory sensing. IEEE Internet Computing, 14. 12-42.
4. Catarci, T., Leoni, M.D., Marrella, A., Mecella, M., Salvatore, B., Vetere, G., Dustdar, S., Juszczyk, L., Manzoor, A. and Truong, H.-L. Pervasive Software Environments for Supporting Disaster Responses. IEEE Internet Computing, 12. 26-37.
5. De Leoni, M., Marrella, A. and Russo, A., Process-aware information systems for emergency management. in EMSOA '10 : International Workshop on Emergency Management through Service Oriented Architectures, (2010), Springer, 50-58.
6. DiFranzo, D., Ding, L., Erickson, J.S., Li, X., Lebo, T., Michaelis, J., Graves, A., Williams, G.T., Zheng, J.G., Flores, J., Shangguan, Z., Gervasio, G., McGuinness, D.L. and Hendler, J. TWC LOGD: A portal for linked open government data ecosystems. Web Semantics: Science, 9. 325-333.
7. Döweling, S. and Nolte, A., Closer to the Model - Collaborative Modeling with Wall-Size Interactive Displays. in MENSCH &COMPUTER '11: Proceedings of the Workshop on "Anforderungen und Lösungen für die Nutzung interaktiver Displays im Kontext kollaborativer Arbeit", (2011).
8. Fahland, D. and Woith, H. Towards Process Models for Disaster Response. PM4HDPS '08: Proceedings of the International Workshop on Process Management for Highly Dynamic and Pervasive Scenarios. 254-265.
9. Rosa, M. and Mendling, J., Domain-driven process adaptation in emergency scenarios. in PM4HDPS '08: Proceedings of the International Workshop on Process Management for Highly Dynamic and Pervasive Scenarios, (2009), Springer, 290-297.
10. Vieweg, S., Hughes, A.L., Starbird, K. and Palen, L., Microblogging during two natural hazards events. in CHI '10: Proceedings of the SIGCHI conference on Human factors in computing systems, (2010), ACM, 1079-1088.
11. Wallace, W.A. and De Balogh, F. Decision support systems for disaster management. Public Administration Review, 45. 134-146.