La Rosa, Marcello and Mendling, Jan (2008) Domain-driven Process Adaptation in Emergency Scenarios. In Mecella, Massimo and Yang, Jian, Eds. *Proceedings 1st International Workshop on Process Management for Highly Dynamic and Pervasive Scenarios (PM4HDPS)* Lecture Notes in Computer Science, Milan, Italy.

Domain-driven Process Adaptation in Emergency Scenarios

Marcello La Rosa[1] and Jan Mendling[2]

[1] Queensland University of Technology
126 Margaret Street, Brisbane QLD 4000, Australia
[2] Humboldt-Universität zu Berlin
Unter den Linden 6, 10099 Berlin, Germany
m.larosa@qut.edu.au,contact@mendling.com

Abstract. Business process models are a suitable means to describe the temporal and logical order of tasks for achieving a given goal. Therefore they become crucial in the coordination of intervention actions to efficiently recover from a disaster or tragic event. Past experience is vital in handling these scenarios, but every new emergency would almost always present peculiar characteristics. So although generic business processes for disaster management would typically be available in a recovery infrastructure, these need to be adapted every time to the specific scenario. In these situations goal achievement is very time-critical, thus the adaptation process should be done in the most efficient way and be error-free. This paper proposes to capture multiple variants of an emergency recovery process in a configurable model, and to control the model adaptation via the use of interactive domain-based questionnaires.

1 Introduction

Business process models can be used to efficiently describe the coordination of tasks and resources with the purpose of achieving a business goal. For this reason they can be employed in emergency infrastructures, e.g., to coordinate the plan of actions for prompt intervention in case of a disaster or tragic event. However, these processes typically do not capture all possible situations for a given emergency scenario. They are rather available in the form of generic guidelines or templates. For example, if an earthquake happens to cause an explosion, the generic process model for handling earthquakes would need to be promptly adapted to this specific emergency, by taking into account aspects such as the nature of the explosion and the number of people injured.

Besides a thorough understanding of the domain in question, the adaption of these off-the-shelf process models requires knowledge of the modeling language which the process has been built in. This may hinder the involvement of domain experts, such as the coordinator of an emergency infrastructure or the rescue team leader, who are usually not proficient in modeling notations. Also, in emergency contexts where goal achievement is very time-critical, model adaptation is to be pursued in the most efficient way and be automated wherever it is possible, since any little mistake may lead to an inefficient action plan, or be even fatal. In fact, depending on the time available before implementing a disaster response, it may not be realistic to undertake a manual process adaptation.

Therefore, despite their striking benefits, today business process models are not effectively used to deal with emergency situations. To facilitate the adaptation of these generic process models, and thus to foster the employment of business process management in emergency scenarios, we propose a questionnaire-driven approach. This approach consists of two aspects.

1. The representation of process model variants in an integrated artifact, namely the *configurable process model* [1]. Through a configurable process model we can meaningfully combine all devisable situations (or process variants) related to a specific emergency in a single model, in which differences are pinpointed via so-called *variation points*. Configurable models offer opportunities for adaptation, by removing those process variants that are no longer relevant for the scenario under consideration.
2. The adaptation (or configuration) of these models is controlled via the use of interactive questionnaires [2]. A questionnaire model is based on a language-independent representation of domain choices and their dependencies. Questions are expressed in natural language, thus can be answered by domain experts without extensive knowledge of the underlying process model. This abstraction from unnecessary information is particularly needed when the involved decisions are to be taken in a critical timeframe. Also, the use of *domain constraints* amongst questions prevents the user from making inconsistent choices a priori, that may lead to incorrect action plans.

Against this background, the remainder of this paper is organized as follows. In Section 2 we discuss the requirements for using process models in emergency scenarios. In Section 3 we show how our work on questionnaire-based configuration of process models can be applied to this setting. As an illustration of our argument, we use an example derived from the requirements analysis of a civil protection scenario, as described in the European Project WORKPAD [3]. Finally, in section 4 we summarize the results and draw conclusions.

2 Emergency Scenario Requirements

Emergency refers to natural or man-made hazards including accidents, drought, famine, disease or disasters [3]. Characteristic for a disaster is that it affects the socio-economical environment of the people living in the affected area. It typically leads to the disruption of the community's infrastructure and its institutions, in such a way that the community cannot cope with it on its own.

Emergency management refers to mitigation activities related to a disaster. These activities can be described in the emergency management cycle [3] (see Figure 1). The first three activities of planning, mitigation and preparedness are preventive. *Planning* refers to the analysis and documentation of a potential disaster and its impact. The results of this documentation are used in the *mitigation* phase. Its goal is to minimize the probability of a disaster and to reduce its effects. *Preparedness* covers all the measures taken by government authorities and other organizations for saving lives in case of a disaster. Its goal is to guarantee an efficient and effective response. Operational plans from preparedness activities are used in the *response* in case a disaster happens. Its goal is to stabilize the situation and to minimize the probability of secondary damage. *Recovery* finally includes all actions to re-establish normal living conditions as before the disaster happened. A similar classification of disaster mitigation activities is presented in [4].

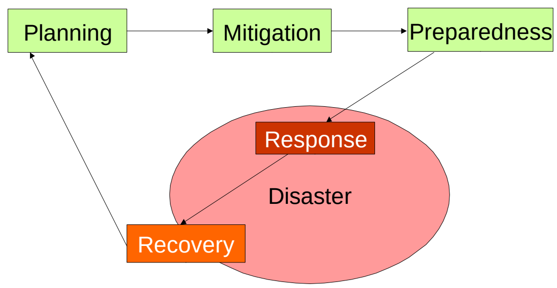

Fig. 1. Emergency Management Cycle.

During the course of this research, we analyzed emergency scenarios for potential information technology support, e.g. in [5], and identified three design considerations as essential for supporting response and recovery actions. First, there is a need for quick and efficient decision making. Due to a disaster there might be lives at risk of people still being in the affected area. This requires quick and efficient action. Second, the people involved in response and recovery actions are experts in their domain but not information technology or modeling experts. As a consequence, any support has to be simple and self-explanatory. Finally, a key characteristic of response and recovery actions is that standard procedures are available, but they need to be adapted to the situation at hand. In the following section we illustrate how a questionnaire-based approach can be used to adapt these standard procedures (or business processes) in an efficient way.

3 Process Model Configuration for Emergency Scenarios

Our approach starts from the description of configurable process models in Section 3.1. We then show how these models can be configured through the use of interactive questionnaires in Section 3.2.

3.1 Configurable Process Models

Event Driven Process Chains (EPCs) [6, 7] are a widely used modeling language whose main components are events (hexagons), functions (rounded boxes), connectors (circles) and arcs linking these elements. Events represent triggers or conditions, functions correspond to tasks, and connectors denote splits and joins of type AND, OR or XOR.

Configurable process models [1] are captured via an extension to the EPC notation, namely Configurable EPC (C-EPC). C-EPCs provide a means to explicitly represent variability in EPC process models by identifying a set of *variation points* in the model, to which configuration values can be assigned. By configuring each variation point to exactly one value among the ones allowed, it is possible to derive an EPC model from the starting C-EPC. In C-EPCs any node of type function or connector can become a variation point (highlighted in bold) and be assigned configuration values. A *configurable function* can be either switched off (i.e. the function is dropped from the model), set optional (i.e. the decision whether to execute this function or not is taken at run-time), or left on. A *configurable connector* can be restricted to a subset of its paths.

Figure 2 shows a simplified C-EPC model for deciding the response activities to be taken in case of a disaster. The process starts with the assessment of the emergency scenario, which is always carried out. A number of aspects have to be evaluated in order to undertake prompt intervention actions. For example, in case of railway being affected, the railway service needs first to be blocked in the direction of the struck place, and only later, once people have been rescued, the service can be restored.

As part of the situation assessment, a habitability check (fitness for habitation) needs to be carried out for any building in the affected area. If premises have been damaged, they have to be evacuated, and if the disaster has caused building collapse, entrapped people have to be rescued out of debris. In this case there might also be a need to set up a tent city to accommodate the homeless people. This implies the transfer of the resources to e.g. the nearest football field and may imply to manage the tent city.

This C-EPC model features two configurable connectors and five configurable functions. These variation points are motivated by the fact that railways and buildings may not always be affected. If, for example, a weak earthquake hits an area, there might be no need to rescue people from affected railway areas, or no building might have been destroyed, but still there might be affected premises that need to be evacuated for security reasons. Similarly, if there are no homeless people, there might be no need for setting up a tent city. On the other hand, the assessment of the situation and the establishment of a medical point are compulsory actions. Therefore the respective functions are not configurable in the model.

3.2 Questionnaire-based Process Configuration

The second part of our approach consists in the definition of a questionnaire model [2] describing the variants of a given domain, such as disaster management. A questionnaire model can then be linked [8] to the variation points of a configurable process model (e.g. in C-EPC) and used to control the adaptation of the latter. The aim of this approach is to allow domain experts to abstract

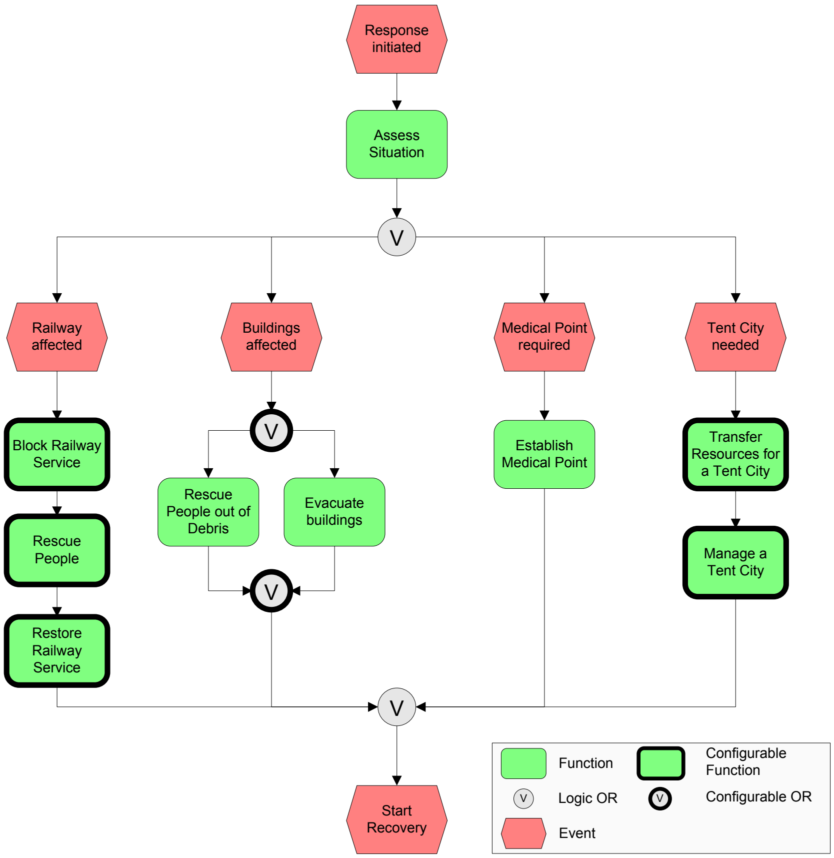

Fig. 2. A configurable process model for deciding response activities.

from the peculiarities of process modeling notations, so as to focus on the critical decisions that need to be taken.

A questionnaire model essentially contains questions, a set of possible answers for each question, order dependencies and domain constraints. *Questions* are expressed in natural language, thus can be answered by a subject-matter expert without extensive knowledge of the underlying process model. Figure 3 shows an extract of the questionnaire model for response planning. Here there are questions to inquire the result of a situation assessment, the condition of the affected railway, etc.

Order dependencies, represented by arrows between questions, are used to constrain the order in which questions have to be posed to the user. For example, according to the model in Figure 3, the first question to be asked is "What is the result of situation assessment?", since it is the only one without any dependency, while question "Is a tent city needed?" can only be posed after

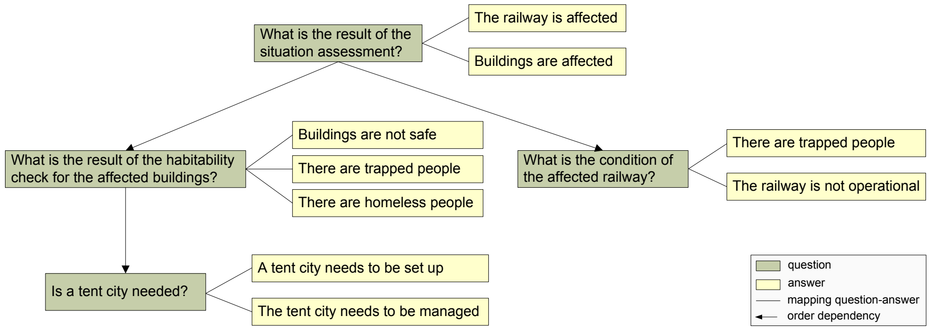

Fig. 3. Extract of the questionnaire model for disaster response.

answering question "What is the result of the habitability check for the affected buildings?"

Domain constraints capture relationships between the possible answers to different questions and reflect the requirements of the domain of focus. In response planning, examples of domain constraints include: "a tent city needs to be set up if there are homeless people" and "the tent city needs to be managed only if it is set up in the first place". Accordingly, question "Is a tent city needed?" will not be asked at all if in question "What is the result of the habitability check?", answer "There are homeless people" has not been selected. By enforcing the domain constraints, we can prevent the user from making inconsistent choices a priori, that would lead to wrong configured EPCs.

To assist domain experts during the configuration of process models through the use of questionnaires, we have developed a toolset called Synergia. Quaestio – the front end of Synergia, automatically generates an interactive questionnaire from a questionnaire model where questions are posed according to the order dependencies, and answers that may lead to invalid configurations are avoided a priori, by enforcing the domain constraints. For each question, the tool provides guidelines and suggestions to aid the user in answering the questionnaire (these guidelines are extracted from the questionnaire model itself). A screenshot of Quaestio is shown in Figure 4. Here the user is prompted with the question inquiring the status of the railway, while the question about the situation assessment has already been answered. If an answer needs to be reconsidered, the tool allows the rollback of answered questions.

The advantage of using interactive questionnaires is that C-EPCs that have been defined by modeling experts can be easily adapted by people who are not familiar at all with process modeling. The questions directly relate to the work practice of the domain experts such that process configuration becomes transparent to them. This abstraction from unnecessary information is particularly needed when the involved decisions are to be taken in a critical timeframe.

Once the questionnaire has been completed, an adapted EPC can be automatically derived from Quaestio. A configured process model can have a number of applications. First and foremost, it can be used to coordinate the response to

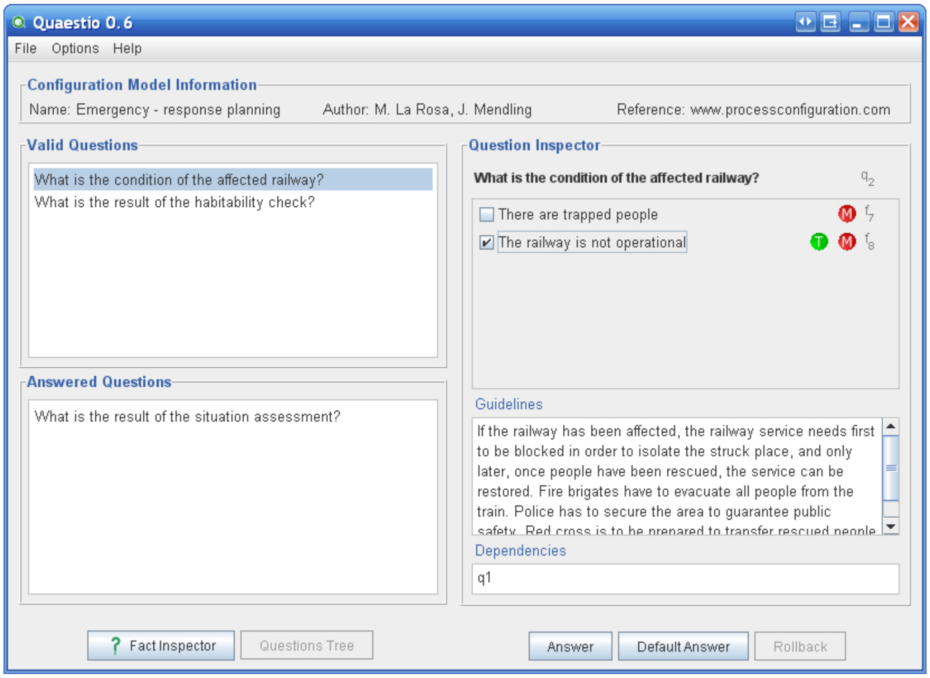

Fig. 4. The interactive questionnaire tool Quaestio.

a disaster. Moreover, it can be simulated to estimate the required resources, or executed by a workflow management system to automate certain emergency procedures. Figure 5 shows the EPC resulting from configuring the C-EPC process example to intervene in an area hit by a weak earthquake, where the affected premised have to be evacuated for security reasons, although there has not been any structural damage.

4 Conclusions

In this paper we have discussed the applicability of an approach based on configurable process models and questionnaire-based configuration for handling emergency scenarios. The approach seems to be promising in order to address essential requirements of emergency scenarios, such as quick and efficient coordination, lack of information technology know-how, and adaptation of standard procedures. A central assumption of this approach is that all potential actions can be exhaustively captured in a configurable process model and its questionnaire by the combination of a finite number of options. While dynamic modifications to both process and questionnaire model (e.g. the addition of new activities or new questions) might still be needed in exceptional situations, the analysis of emergency scenarios (e.g. [3]) shows that most procedures can be effectively documented beforehand.

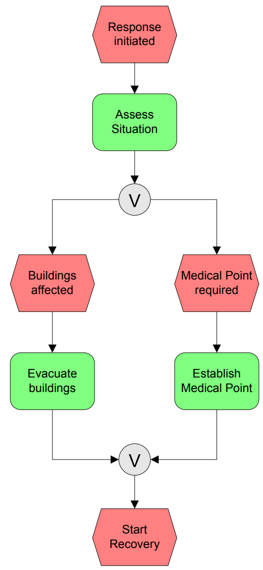

Fig. 5. The configuration of the C-EPC in Fig. 2 to handle weak earthquakes, obtained via Quaestio.

References

1. Rosemann, M., Aalst, W.: A Configurable Reference Modelling Language. Information Systems **32** (2007) 1–23
2. La Rosa, M., Aalst, W., Dumas, M., ter Hofstede, A.: Questionnaire-based variability modeling for system configuration. Software and Systems Modeling (2008)
3. Bortenschlager, M., Truong, H.: Workpad deliverable d1.3: Requirements and conceptual analysis (version 1.0). EU STREP project FP6-2005-IST-5-034749 WORKPAD D.1.3 v1.0. (2005)
4. Weichselgartner, J.: Disaster mitigation: the concept of vulnerability revisited. Disaster Prevention and Management **10** (2001) 85–95
5. de Leoni, M., Mecella, M., Rosa, F.D., Mecella, M., Poggi, A., Krek, A., Manti, F.: Emergency management: from user requirements to a flexible p2p architecture. In: Proc. of the 4th International Conference on Information Systems for Crisis Response and Management (ISCRAM), Delft, The Netherlands (2007)
6. Keller, G., Nüttgens, M., Scheer, A.W.: Semantische Prozessmodellierung auf der Grundlage "Ereignisgesteuerter Prozessketten (EPK)". Heft 89, Institut für Wirtschaftsinformatik, Saarbrücken, Germany (1992)
7. Mendling, J., Aalst, W.: Formalization and Verification of EPCs with OR-Joins Based on State and Context. In: Proceedings of the Conference on Advanced Information Systems Engineering (CAiSE'07). Volume 4495 of LNCS (2007) 439–453
8. La Rosa, M., Gottschalk, F., Aalst, W., Dumas, M.: Linking Domain Models and Process Models for Reference Model Configuration. In: Proceedings of the Business Process Management Workshops (BPM'07). Volume 4928 of LNCS. (2008) 417–430