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Integrating Decision Support Applications in Computer Based Emergency Management Processes

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Abstract

As over the last decades natural disasters are increasing all over the world, Disaster and Emergency Management Systems (DEMS) play an important role to shorten the response time and to improve the supporting measures in case of disaster incidents. Many different DEMS where developed in the last years within national and international research projects. In contrast to those approaches, in this paper a concept for a process-driven emergency management system is presented. With this system emergency processes may be modelled, steered and monitored using a formal process modelling language which also allows dynamical changes. The focus of that paper will be on the integration of decision support applications in the emergency management processes. In integrating these applications, the incident command team using the system may not only be supported by guidance through formally modelled emergency processes but also through the results of the decision support applications, represented as "automatic activities" in the process models.

1. Introduction

Since the 90ties of the last century, natural disasters are heavily increasing all over the world. Especially windstorms, floods and earthquakes cause high numbers of affected persons and huge economic damages (CRED 2007). Against this background, disaster and emergency management becomes crucial in order to prevent disasters and to effectively respond to emergencies. The emergency management is nowadays supported by Information and Communication Technology. Regarding mainly the pre-impact, emergency and restoration activities of a disaster, the incident command staff may be supported by Disaster and Emergency Management Systems (DEMS). DEMS which are already used in practice mainly provide aggregated information and monitoring functionalities, using web, database and GIS technologies. In the recent years, different research projects on national and international level are developing systems focusing on the analysis of emergency incidents and decision and planning support. Nevertheless, the various activities and tasks occurring in emergency management which have to be accomplished by the actors are mainly neglected or less supported by these emergency management systems. Although certain tasks and activities are described in emergency response plans – as best practice applications known from former disaster and emergency incidents – they are not sufficiently formalised and integrated in emergency management systems using process models.

In this paper, the concept of a process-driven emergency management is shortly presented, with a focus on the integration of decision support applications in the emergency management processes. At first, a short description of the conceptual composition of the system and its functionalities is given. Then, the process modelling language used in the system is described briefly. Subsequently, the integration of decision and planning support applications in emergency management processes as web services (W3C, 2004) is explained. The mechanism is illustrated by an exemplary process of flood disaster management. Finally, a conclusion is given.

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2. Process-Driven Emergency Management System

In contrast to other concepts for DEMS, the emergency management system, introduced in this paper focuses on the actions, activities and procedures which occur in emergency management and integrates them by using formal process models. The core of the system is the process server, which allows the modelling, execution and monitoring of emergency management processes (see Figure 1). Not all emergency processes can be modelled prior to the incident, some have to be individually adapted to the emergency situations. Therefore, dynamic changes of emergency processes which were already started shall be possible. For that reason the formal graph-based modelling language ADEPT (Dadam/Reichert, 1998) will be utilized (see section 3.1).

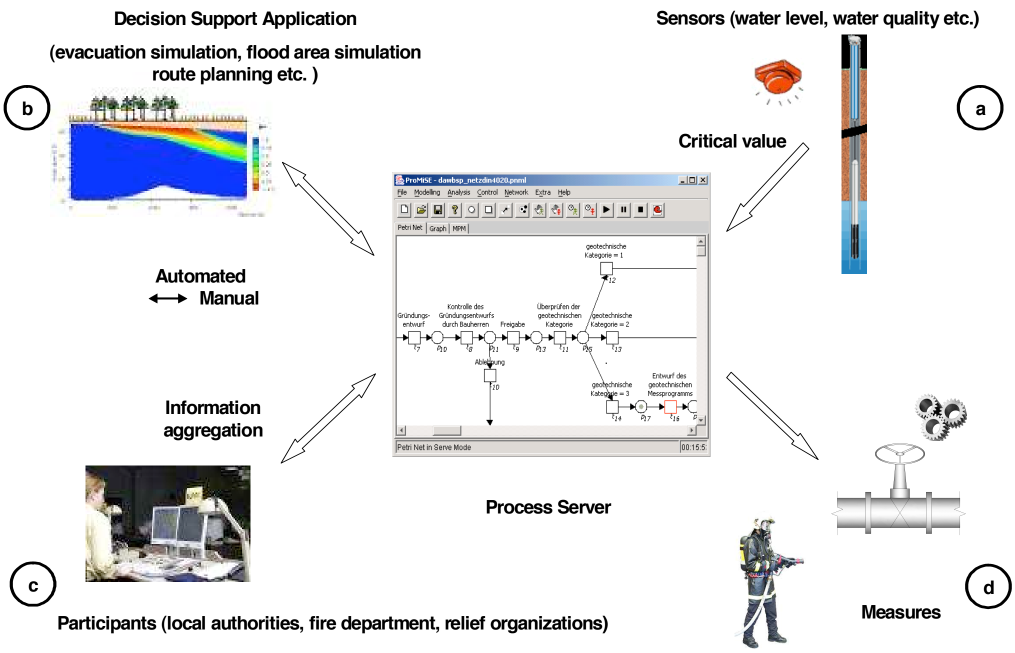

Figure 1: Architecture of the Process-Driven Emergency Management System

The process-driven emergency management system shall support the emergency management of the disaster event from its detection to the planning and monitoring of supporting measures to the completion of the measures. As exemplary scenarios for the general concept of a process-driven emergency management system, emergencies in the water domain (floods, ground water contamination) are chosen. Sensors like measuring probes for water level and water quality (Figure 1a) serve as alarm devices which trigger the process models of the process server if defined critical values are reached (Rueppel, et al, 2006). Decision support applications (Figure 1b) can be integrated in the process models (see section 3.2) in order to help the incident command team to evaluate the situation and in order to support planning and tasking of measures and resources (equipment, forces etc.). The participants involved in the emergency management processes have individual access-rights to the process server (Figure 1c). Depending on their role in the emergency management, they are supplied with relevant information. Also supply measures (e.g., closure of sewers during flooding) may be triggered by the process server (Figure 1d). Finally, the incident command team can monitor and change running emergency processes and may manually start processes (e.g., command orders to forces) using the decision support applications and their own expertise. The following section focuses on the formal computer based representation of emergency management processes and especially the integration of decision support applications in these processes.

3. Integrating Decision Support Applications in Emergency Management Processes

In contrast to other approaches for Disaster and Emergency Management Systems (DEMS) the presented approach has its main focus on modelling, steering and monitoring emergency activities in form of formal processes. For this purpose, a formal modelling language is needed. This language should have an intuitive graphical representation and should allow the modification and the extension of emergency management processes before and also during the operative use of the system in case of emergency. The formal dynamic process modelling language ADEPT seems to comply with these requirements. Hence, it will be used in the system. A detailed description of ADEPT is beyond the scope of this paper but an introduction to its graphical elements is given in the following sub section because the elements are used later within an exemplary emergency management process.

The advances in information technology have enabled the development of powerful applications which support the incident command team in their decisions. It is not the purpose of this paper to enumerate all different types of these applications. In this paper especially flooding incidents with flood area simulations and evacuation simulations are used as example applications for decision support tools, helping in emergency planning and response. These applications may be integrated in the processes of the emergency management system using web service mechanisms. This aspect will be presented in greater detail and demonstrated within an example following the short introduction of the process modelling language ADEPT.

3.1 Formal Dynamic Process Modelling Language

The process modelling language ADEPT is graph based and possesses a formal syntax. The base model has mainly six modelling elements which can be expressed as nodes and edges of different types: the control flow, a simple activity represented by a square, AND-split, OR-split, AND-join and OR join.
The control flow edges connect the different activities in the process. With these elements, activity sequences, conditional and parallel branching may be modelled. Furthermore, special control flow edges for loops and synchronisation of activities of parallel branches exist. Other details about the ADEPT base model and about the change operations (called $ADEPT_{flex}$) which allow the user's modification of running process instances can be found in (Reichert/Dadam, 1998).

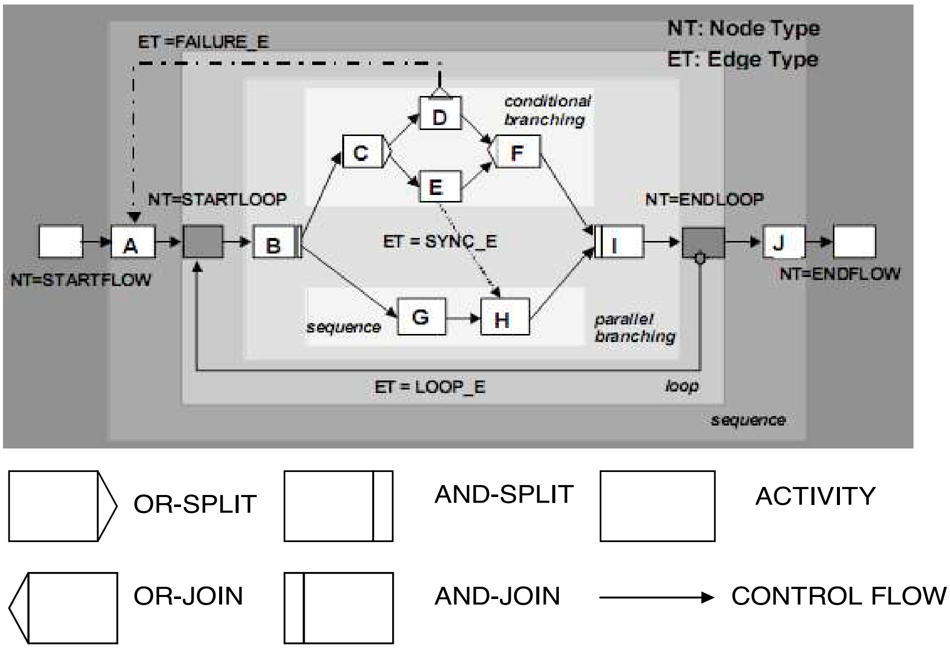

Figure 2: ADEPT base model (Dadam/Reichert/Kuhn 2000)

3.2 Decision Support Application Integration

For disaster and emergency management, various decision support applications exist which support the incident command team in making planning and decisions. As these applications – in the presented work flood area simulations are also be seen as activities of an emergency management process respectively of an emergency planning process – they should be integrated in a process-driven emergency management system. Therefore, the task such an application is performing (e.g., to calculate areas which will be flooded in 24 hours) will be represented as an activity in the process modelling language ADEPT. In contrast to human-centric emergency activities, this activity is automatically performed by the decision support application.

For that purpose, the decision support application has to be linked with the corresponding activity element of the process model in ADEPT, so that it is started at the moment, the activity is triggered in the emergency process model.

Furthermore, the application has to be supplied with input parameters (in case of flood area simulation, e.g., with a hydraulic model of the investigated area). These parameters may be delivered by preceding activities in the process model. After the completion of the activity which represents the task, the decision support activity is performing the results (e.g., prognosis for the flooded area). They have to be passed as output parameters back to the process model, so that the following activities of the process model may use these results.

In order to allow the described integration of decision support applications in the emergency processes of the process-driven emergency system, it is supposed, that the functionalities of the system are accessible via a web service interface. If this is not the case, web service wrapper methods may be used to subsequently provide such an interface. Having a web service access to the decision support application, it may be integrated in the emergency process in the following way.

Firstly, the web service of the application has to be registered in the registry component of the emergency system (see Figure 4). Secondly, mappings for input and output parameters between the process-driven emergency management system and the web service of the decision support application have to be manually defined. Once the web service is registered and the mappings are defined it can be easily integrated as activity in the emergency process model. Moreover, this web service may also be reused in processes of other disaster scenarios, which are managed by the process-driven system. A similar approach was realized in the workflow management system YAWL (Aalst, et al., 2004). In contrast to that system the presented concept of a process-driven system focuses on disaster and emergency management, whereas YAWL is mainly used for business processes. Furthermore, the modelling language ADEPT used in this approach better meets the requirements of emergency processes, concerning dynamic changes of process models during runtime (Rueppel/Wagenknecht, 2007).

In order to demonstrate the approach to integrate decision support applications in the processes of the emergency management system, a simplified example of a flood management scenario is given. During a flood incident, a flood embankment is over flown, which should protect an endangered area of a city. To prevent it, a sand-bag wall was established, but the wall is washed out by the water masses. In order to avoid the destruction of the sandbag wall the emergency management system suggests the process which is depicted in figure 3. For further explanation of this exemplarily scenario and the meta model which is used for modelling it is referred to (Rueppel/Wagenknecht, 2007).

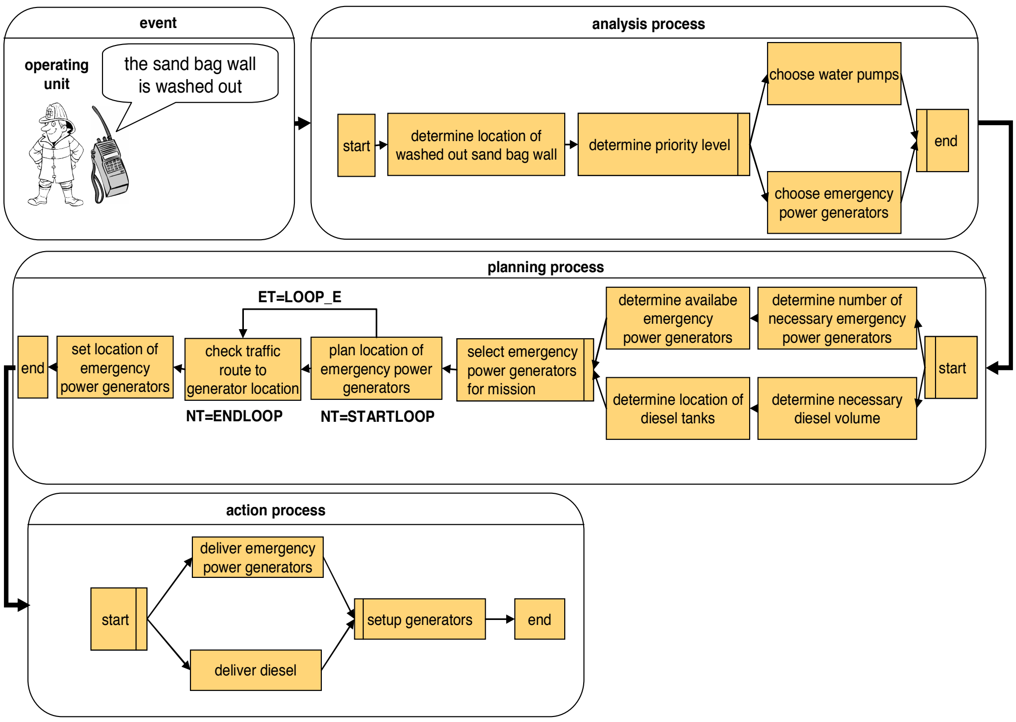

Figure 3: Exemplary Emergency Process

In the emergency process, power generators have to be supplied to avoid further wash out of the sand bag wall. As power generators are stored only at certain locations, and as many traffic routes are not passable anymore because of flooding, it is difficult to detect which power generator units can be delivered to the sand bag wall location in time. For that purpose, a special routing application is linked to the activity "check traffic route to the generator location" as a web service (see Figure 4). So that this application calculates the possible traffic routes that the required power generator units can be delivered and installed in time. The necessary input parameters for the route calculation (the different storage locations of the power generator units and the scene of emergency) are delivered by the preceding activities, e.g., using a GI-system component.

For that exemplarily scenario, the routing application has to supply a web service interface. The SOAP binding and the WSDL interface (W3C, 2001) of that web service are registered in the registrar component of the system. At modelling time of the emergency process, the activity "check route to traffic location" is linked to the registry entry of the routing service. Furthermore, the mapping for the input parameters between the emergency management system and the routing service and also the output parameters have to be manually defined by the user who models the processes.

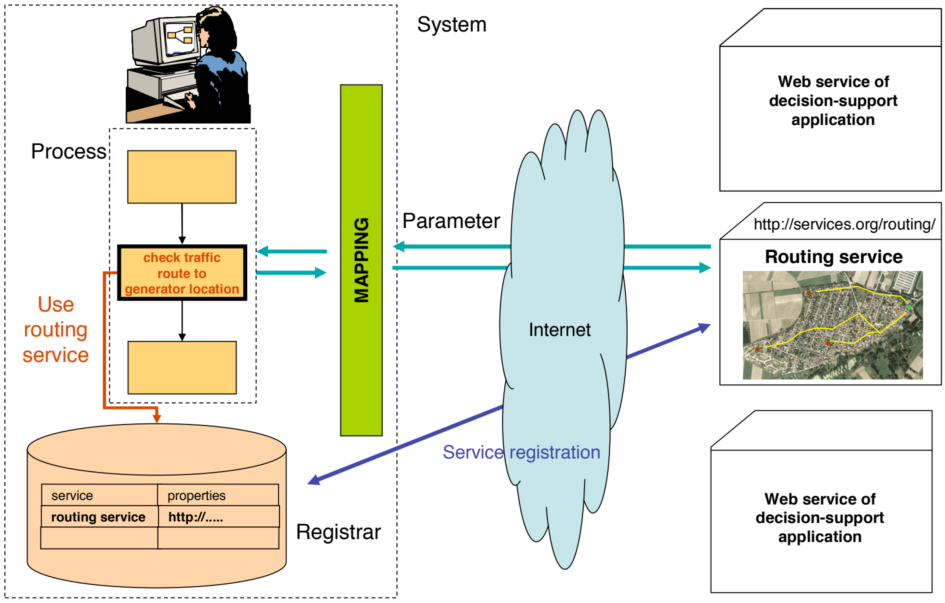

Figure 4: Linking Routing Service to Process Activity

In contrast to the emergency process, in which the routing service is not integrated, the quality of the process results is increased. The calculation of the routing and delivery time for every power generator to the scene of emergency by the service enables the system user to choose the right equipment for the emergency.

4. Conclusion

In this paper the concept for a process-driven emergency management system is presented focusing on the integration of decision support applications as web services in the emergency management processes. In contrast to various other Disaster and Emergency Management Systems (DEMS), in this approach, emergency management processes are explicitly represented in the system using a formal process modelling language which allows for dynamical changes during run time. Using the system, modelling, steering and monitoring of emergency processes shall be realized in order to better and faster react to disaster incidents. As many IT-applications exist which support the incident command team in making his decisions, these applications shall also be integrated in the formal emergency management processes of the presented system. For that reason, a method which uses possible web service interfaces of decision support applications is suggested and demonstrated by means of a simplified emergency scenario. This integration of decision support applications may increase the efficiency of formal emergency process models. In future works, the presented approach will be implemented in form of a prototypical system and will be evaluated in the context of a disaster control scenario.

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