PROCESS FRAMEWORK FOR EMERGENCY MANAGEMENT
Solving of Emergency Situations by Way of Business Processes

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Abstract: The paper deals with an effective solving of emergency situations by using the Process Management. Based on current approaches, there is defined an innovative process framework for emergency management which is described from the methodological and architecture view. The methodology describes the procedures how to deploy processes of emergency management on the specific architecture based on emergency management requirements. The overall quality assurance is ensured by continuous verification, validation and optimization. The application of the process framework for emergency management is showed on a case study, which describes an accident of a vehicle transporting dangerous goods. The case study illustrates the deployment of emergency processes up to terrain case studies.

1 INTRODUCTION

Emergency Management (EM) is a discipline that involves preparing for a disaster before it happens, disaster response, as well as supporting and rebuilding the society after a natural or a human-caused disaster occurs. In general, any EM is a continuous process in which all individuals, groups and communities manage hazards in an effort to avoid or ameliorate the impact of disasters resulting from the hazards (Mak et al., 1999; Rüppel and Wagenknecht, 2007).

Process Management (PM) is a field of combining management and technology focused on aligning organizations with the requirements and needs of clients (Kubíček et al., 2010; Vondrák, 2008). It is a complex management approach that promotes business effectiveness and efficiency while striving for innovation, flexibility, and integration with technology (Jain and McLean, 2003). PM attempts to improve processes continuously. It could therefore be described as a process optimization process.

1.1 Principles of Emergency Management

The nature of emergencies means that all levels of government (federal, state, regional or local) and all sectors of society are responsible for dealing

withthem (Diehl et al., 2006). There generally exists a *Bottom Up* approach for requests for resources support that travel upward until appropriate resources are ensured and the incident stabilised. Each country has different legislation, procedures and obligatory documents to be followed within the EM process (Mak et al., 1999).

Coordination of Activities within the Emergency Management System is done at three levels, *Tactical*, *Operational* and *Strategic*, and is corresponding with the generic conclusion defined by Orchestra (Klopfer and Kanellopoulos, 2008).

The *Strategic Level* of the Rescue and Liquidation Works (RaLW) management is realised by standing or temporary coordinating authorities of the administration, region commissioners and Ministry of Interior – General Management of the Czech Republic Fire Rescue Corps.

On the *Operational Level*, permanent coordination and cooperation within and between individual *Integrated Rescue System* (IRS) components takes place; this includes operational centres of the basic IRS components (Fire Rescue Corps, Police and Medical Rescue Service) and dispatching centres, standing services, and oversight centres of distributive and emergency services.

The *Tactical Level* includes activity coordination at the place of intervention and cooperation of IRS components. The intervention commander proclaims the appropriate *Level of Alert*, which predetermines

the needs of the *Forces and Means* for the RaLW. He or she also follows the document *Model Action Activities of the IRS Components at the Common Intervention*.

1.2 Principles of Process Management

Nowadays, there are two significant streams in the field of Process Management: i.e. *Business Process Management* presented by Object Management Group (OMG) and *Workflow Management*, which was originally created by Workflow Management Coalition (WfMC).

Business Process Management (BPM) is based on the observation that each product that a company gets to the market is the result of a number of performed activities (Weske, 2007). Business processes are the key instruments to organize these activities and to improve the understanding of their interrelationships. Information technology deserves an important role in business process management, because more and more activities that a company performs are supported by it (Rüppel and Wagenknecht, 2007). Business process activities can be performed manually or with a help of information systems (Sell and Braun, 2009). BPM activities can in general be grouped into five categories (phases): *Design*, *Modelling*, *Execution*, *Monitoring*, and *Optimization*.

Workflow Management is built on architectural representation of a workflow management system called *Workflow Reference Model*, that is developed by WfMC. It identifies the most important system interfaces, covering broadly five areas of functionality between a workflow management system and its environment (Hollingsworth, 2004).

Process Management and Business Processes are generally used to solve issues related to EM (Kubíček et al., 2010; Sell and Braun, 2009; Vondrák, 2008). The aim of this paper is to define *Process Framework for Emergency Management*, which allows more effective and complex process support for EM. During the deployment of processes there is also necessary to guarantee their overall quality (Jain and McLean, 2003). Hence the paper describes methods to assure quality of processes, i.e. verification and validation (Sargent, 2005). Continuous improvement of processes by process optimization is also very important (Rüppel and Wagenknecht, 2007). Practical use of the Process framework, together with methods of process quality assurance is illustrated on the case study that describes an accident of a vehicle transporting dangerous goods.

2 PROCESS FRAMEWORK FOR EMERGENCY MANAGEMENT

Process Framework for EM is a new progressive view on process support of organizations in the private and public sector. It is created for the purpose of better understanding of issues that are connected with process deployment in the specific area of interest. The model covers not only process related issues, but also issues related to emergency management. Deep analysis of current solutions and approaches (Klopfer and Kanellopoulos, 2008; Ludík and Ráček, 2011; Sell and Braun, 2009) shows, that just this unifying view on process deployment is missing. Despite the fact, that the model is focused on the emergency area issues, the idea of creating a process framework is general and could be used also in other areas of expertise, where a complex and global view on the area of interest is needed. The general purpose of the model is given by two main views on the process issues, which are *Methodology* view and the global *Architecture* view.

2.1 Methodology

The first view is created by process oriented methodology. The main goal is to continuously improve process, which is the same idea as Deming cycle. This view is based on the Business Process Management life-cycle (Weske, 2007). In order to talk about process-oriented methodology, it is necessary to meet certain characteristics. The methodology consists of five basic phases, where every phase is further process decomposed. Namely there are these phases: *Defining*, *Modelling*, *Configuration*, *Execution*/*Monitoring*, and *Optimization*. The methodology contains user roles, which are necessary for correct progress of the process and the roles show responsibilities for the particular processes (Ludík and Ráček, 2011). The roles are not just the ones focused on the ICT view of process deployment but there are also roles for EM. The next essential part of created methodology are individual work products, either input or output. Some of these artefacts are included into the process framework. There are primary phases like Defining, Modelling, Configuration and Monitoring. Executing and Optimization phases are described from a different point of view. Process execution is analysed from the view of tools that are needed for execution of modelled process instances. On the other hand the optimization phase is focused on techniques and options of process reengineering. The Fig. 1 shows on the left side the general process
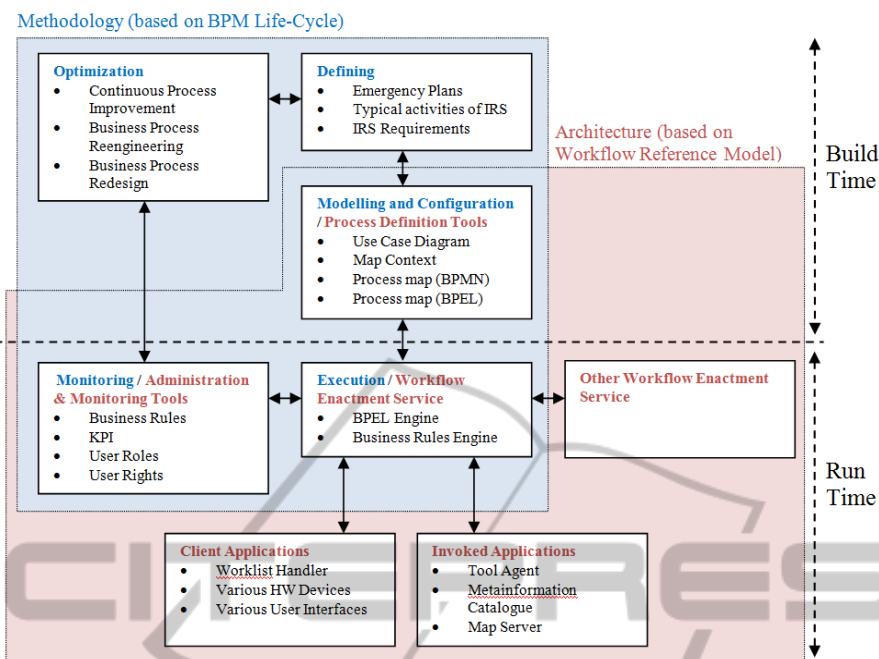
Figure 1: Process Framework for Emergency Management.

oriented methodology.

2.2 Architecture

The second part of the process model is created by process oriented architecture. It is based on WfMC principles and primarily focused on software tools required for process deployment into organisations. The major task is to define suitable interfaces for communication among individual components of architecture (Hollingsworth, 2004). The architecture view is situated on the right side of the process framework. The main parts of the system are described from the view of software tools or hardware components use. Particularly that are parts like Workflow enchantment service, Client Application and Invoked application. The view is completed with issues of emergency management and because of this the model contains also components like Map Server, Metainformation Catalogue and various hardware devices or user interfaces that are necessary to manage specific crisis situations (Kozel, 2007). The architecture view guarantees that outputs from individual phases of the methodology meet certain criteria and standards to use them in the next phase. The aim of the view is to create a global architecture that will serve as the essentials for modelled process instances deployment so that these instances could cooperate with other services and tools within clearly defined interfaces.

2.3 Unifying View

The Fig. 1 shows, that each of this two views covers another part of the spectrum needed for depth process analysis used in the emergency management. In some parts of the model there should be given more emphasis on the procedures and defined processes arising from the legislation and methodologies related to crisis management (Optimization and Defining). The process' architecture and clearly defined interfaces among the components are important to enable fast and effective communication among them (Client Applications, Invoked Applications, Other Workflow Enactment Service). The created process framework for EM contains also parts, where the methodology and architecture views overlap. In these parts, both views have to be taken into account to better understand the research issues. Especially it is very important in the Modelling and Configuration phase of the methodology to determine how the modelling process will proceed (Weske, 2007). On the other hand, software tools are also very important. The main advantage of this approach is independence on particular software modelling tools. It is often necessary to use various software tools and combine them, whether for modelling, simulation or even possible optimization (Kubíček et al., 2010). It is obvious that the resulting interoperability between used tools plays a key role.
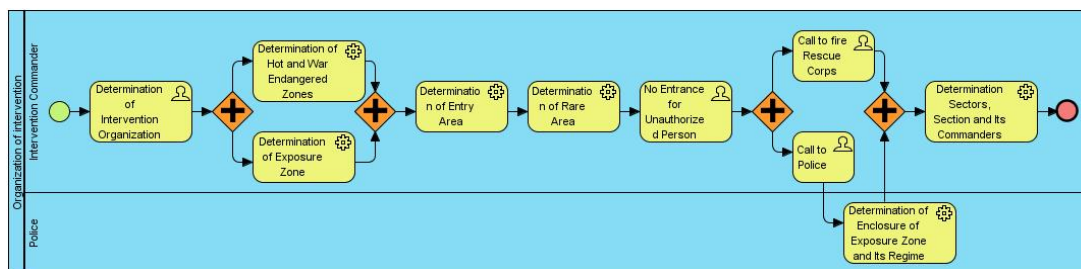
Figure 2: The process map of Organisation of Intervention.

2.4 Quality Assurance

The Process Framework for EM provides guidance on how the processes can be effectively deployed in the field of emergency management. Application of the process framework shows that ensuring the overall quality of the modelled processes must be an integral part of the framework. For this purpose, the techniques of verification, validation, and optimization of the processes are used as well as case studies in the real environment (Reijers, 2003; Sargent, 2005).

Verification and validation (Sargent, 2005) enable continuous monitoring and testing of any software projects. Therefore, it is useful to apply them in the automation of emergency management processes. From the view of the process framework for emergency management it is appropriate to use verification and validation in the first three phases of Process Oriented Methodology. The phases are called: *Defining*, *Modelling* and *Configuration*.

To keep the competitive advantage it is not enough to deploy business processes but also to monitor and optimize them continuously. *Process optimization* is a discipline of adjusting a process so as to optimize some specified set of parameters without violating any constraints. The most common goals are minimizing costs and maximizing throughput and efficiency. This leads to a long-term sustainability. Continuous improvement is therefore crucial. Processes can be improved not only in the *Optimization* phase but also in the *Defining*, *Modelling* or *Monitoring phase*.

3 CASE STUDY

This paper focuses on the tactical level of cooperation – activity of the intervention commander and decision-making support during the organisation of intervention in the model situation called *Accident of a vehicle transporting dangerous goods*. The principal aim of this research is a cross-connection of process modelling and adaptive

visualisation in the field of emergency management. The proposed solution is targeted on support of the intervention commander activities during the response phase of the accident of a vehicle with dangerous goods.

3.1 Process Support of the Intervention Commander

The event *Accident of a vehicle transporting dangerous goods* can be seen in complex view represented by the UML (Unified Modelling Language) Use Case Diagram. It is a basic view of the *defining phase of process framework*. The main purpose of the Use Case Diagram is to find and document modelled business requirements. Created diagram is verified and approved by user's validation. This model is also applicable for EM in other countries, but other actors and use cases would probably be administered (Diehl et al., 2006). The border of the modelled system is defined by the Czech Fire and Rescue Act. By analysing the activities within the event, an actor list is created containing different roles that are assigned to persons or subjects that use the modelled system. Having understood the roles of the individual actors, it is possible to start to design the Use Cases. The external review of final Use Cases is necessary.

The Use Case is perceived as the specification of the activities sequence that the system or subsystem can execute through interacting with external actors. Each use case can be specified by a process map (Fiala and Ministr, 2007) incorporating and defining the activity sequences in the particular directives (the *modelling phase of process framework*). A process is a set of activities arranged in parts. It creates in a repeatable way required output from one or more inputs. To illustrate a process map, the use case called Organisation of Intervention is elaborated. This directive controlled by the intervention commander consists of ten activities illustrated in the process map in Fig. 2. In this way, the process maps of organisation of intervention are created. Subsequently the modelled processes are

simulated. The simulation reveals bottlenecks and inconsistences. Based on the results the processes are optimized.

During the *configuration phase of process framework* all modelled processes (process maps) are transformed to the Business Process Execution Language (BPEL), where the individual process activities are assigned to the required geoinformation. Within the activities of the intervention commander, it is possible to identify specific tasks that are more or less spatially dependent and thus require geoinformation support.

To determine what and how to visualise, it is necessary to decide what parameters will determine the context in which geographic information will be used. In order to simplify the application of process framework for emergency management, the following parameters were selected to define the context: USER – member of Fire Rescue Corps, ACTION – organising of intervention, SITUATION – accident of a vehicle with dangerous goods, DEVICE – TabletPC. Broadly, ACTION and SITUATION determine the knowledge that is needed for decision-making and thus what to visualise. USER and DEVICE specify how to visualise this data, i.e. set the visualisation criteria.

The process formalisation in the BPEL form specifies which geoinformation are supposed to be used and finds an appropriate way to visualize them. The so-called context specific map is used for this purpose and is visualised over the background of a topographic base. This BASETOPO is a set of topographic features that can be reused in other contexts. The BASETOPO is defined at several scales – in the application of process framework, the use of BASETOPO in large-to-middle scale is expected.

3.2 Terrain Case Studies

The case study was led by the researchers of the research plan Dynamic Geovisualisation in Crises Management and represents business processes deployment and their execution and monitoring according to the process framework. The case study was focused on monitoring processes and testing Contextual Web Map Service (CWMS) and also technologies for vehicle tracking in a real situation (Kozel, 2007), namely during a response phase. During the case study the CWMS client was deployed into the complex system that provided support for a fast response to a crisis situation (Palas, 2010). The system is showed in Fig. 3.

Each vehicle transporting dangerous substances carries a GPS receiver with an accident sensor and a

GPRS transmitter. All the time the vehicle is moving, it sends its position in regular intervals via GPRS to the database that contains positions of all vehicles. When an accident happens, a signal alerting the accident is sent to the server which handles incoming accident signals. A simple PHP script constantly runs on the server. When a signal of a new accident is received, the script obtains the current position of the crashed vehicle from the vehicle-position database.
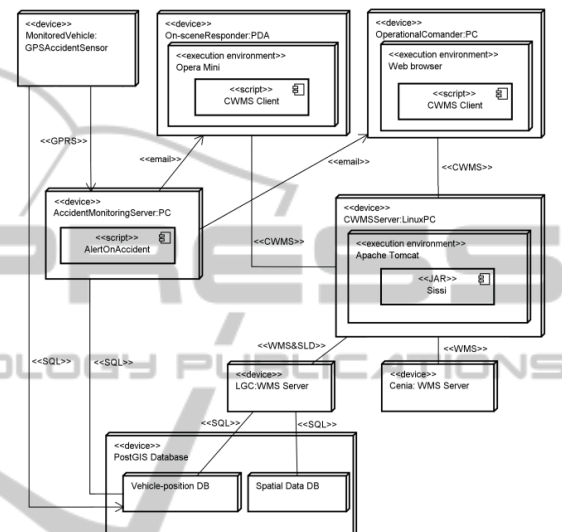

Figure 3: Deployment of the CWMS Client.

Furthermore, the script generates an URL of the CWMS client where location and context of the accident in parameters are encoded. Such a CWMS client's URL is immediately sent to an operational centre of IRS and consequently to on-scene responders for the accident via email. Having received an email informing about the accident, a man in charge clicks the link and the CWMS client opens up in a web browser, showing the accident in the proper context (Bártek et al., 2010).

Regardless of the device, the CWMS client requests deserved map for the current situation from the Map-Server via CWMS. Map-Server immediately requests required spatial data from *Laboratory on Geoinformatics and Cartography (LGC) WMS Server* or *Cenia WMS Server* and builds the deserved contextual map which is sent to the CWMS client afterwards.

Spatial data for contextual maps including positions of tracked vehicles are provided by LGC WMS Server, which obtains them from the PostGIS database via SQL. Cenia WMS Server provides just aerial photos which might be required for several contextual maps. Based on the terrain case study results the complex optimization of the processes

according to the process framework is available.

4 CONCLUSIONS

The paper introduces a new perspective for the process analysis and deployment named Process Framework for EM. A model showed the issue of processes in two perspectives, both in terms of process-oriented methodology and in terms of process architecture. The designed model covers the issues of crisis management, which makes the benefits of bridging the two different views even more transparent. The created model is a supplement with specifics for crisis management and is therefore accessible not only to users of IT but also in emergency management.

The functionality of the Process Framework is guaranteed by continuous verification, validation and optimization of emergency processes. Applicability of the solution is also guaranteed by the terrain case study that simulates the progress of typical activities of IRS that describe the Accident of a vehicle transporting dangerous goods in the real environment.

To complete the Process Framework, it is necessary to create and describe a process-oriented methodology, which will define actions for the support of processes in crisis management. The second part consists of hardware and software analysis. It is also necessary to define interfaces between components. The use of standards in this area considerably eases the demands for interoperability. Functionality and efficiency of established methodology and architecture will be validated by case studies. Up to this point the proposed Process Framework will be considered final and it can be deployed in practice.

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