Architecture for Operational Processes Improvement in Emergency Management

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Abstract: - The aim of the paper is to introduce the novel architecture enabling effective improvement of operational processes in emergency management. For this purpose, the principles of Process Management were used. The architecture, allowing the deployment of comprehensive emergency management operational processes, was developed based on a detailed analysis of the features of emergency management (internal and external factors). Verification of final solution is illustrated in two case studies that illustrate the use of defined architecture at commercial and open-source Business Process Management Suite. The results of the paper represent a smart solution capable of effective improvement the operational processes in emergency management.


1 Introduction

Emergency Management (EM), sometimes called disaster management, is a discipline of dealing with and avoiding risks. It 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 [8], [11]. Effective EM relies on thorough integration of emergency plans at all levels of government and non-government participants.

Process Management (PM) is a field of combining management and technology focused on aligning organizations with the requirements and needs of clients [15]. It is a complex management approach that promotes business effectiveness and efficiency while striving for innovation, flexibility, and integration with technology. Process Management attempts to improve processes continuously [8]. It could therefore be described as a process optimization process.

1.1 Basics 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 with them [14]. 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 [10]. There also exists no universal terminology within EM, not only internationally but even within the agencies across all government levels.

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 [5]. This paper is focused on the Operational Level.

1.2 Basics 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 is based on the observation that each product that a company gets to the market is the result of a number of performed activities [15]. 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 [11]. Business process activities can be performed manually or with a help of information systems [12].

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 [4].

Process Management and Business Processes are generally used to solve issues related to EM [9], [12], [13]. The aim of this paper is to define the novel architecture, which allows more effective and complex process support for EM.

2 Analysis of EM Characteristics
In case, the architecture is used in the field of emergency management, it is appropriate to consider certain characteristics and recommendations that arise from this specific area. The aim of this chapter is to identify and divide them into Internal and External factors that are important to achieving the successful deployment operational processes in emergency management.

2.1 External Factors of EM
External factors cannot be controlled by the organization, but the organization can at least identified them. The external factors may include macroeconomic matters, technological change, legislation, and socio-cultural changes, as well as changes in the marketplace or competitive position.

2.1.1 Organizational Structure
The Integrated Rescue System (IRS) is determined for co-ordination of rescue and clean-up operations in case, where a situation requires operation of forces and means of several bodies, e.g. fire fighters, police, medical rescue service and other bodies, or in case, where the rescue and clean-up operation is necessary to be co-ordinated from the Ministry of Interior or by a leader of region’s level, or by mayors of municipalities with extended responsibilities.

2.1.2 Legislation and Documentation
There are many laws dealing with emergency management in the Czech Republic. Crisis management elements are codified in the Law No. 240/2000 on crisis management (Crisis Code). The other important Law is the Law No. 239/2000 on the Integrated Rescue System. It is the basic legal frame describing situation around IRS.

Another feature of the emergency management is the detailed documentation that defines how to proceed in particular situations. The Contingency Plans belong to the basic documents. They contain a set of measures and procedures addressed to crisis situations.

2.1.3 Different Types of Information
To successfully deal with critical situations, it is inevitable to have all the necessary information at disposal. It is often not trivial because the information used in crisis management can have three basic characteristics or dimensions: time, space and aggregation. The time dimension of the data is important in the crisis situation with dynamic character. Another aspect is that information is bound to the intervention place. It is only the limited area. The last dimension is aggregation. The data is provided in aggregated form, for example as specific maps or map layers. However, they contain also specific data sets that could be irrelevant to the character of a particular intervention location or to the crisis itself. The way to avoid unnecessary information is to use adaptive mapping [6].

2.2 Internal Factors of EM
The internal factors may be viewed as strengths or weaknesses depending upon their impact on the organization's objectives. What may represent strengths with respect to one objective may be weaknesses for another objective.

2.2.1 Process Simulation
Having constructed the initial business process model, various simulations can then be run to identify potential bottlenecks or possible breakdowns. Business process model is able to simulate a whole range of possible actions, such as the interactions between the various processes, and the mechanisms for distribution of tasks and associated information. As a result of this simulation process, an organization is able to gain a better understanding of its business processes, and therefore, restructure them more effectively [10].

2.2.2 Psychological Aspects
There is a new belief that even despite the devastating impact of disasters, substantial lack of resources, and general chaos, there is still a possibility of carrying out some actions that will serve in maintaining at least the basic integrity of the human society and its dignity. Psychological aspects are usually very important for dealing with
crises. All activities of crisis management are performed under substantial time and psychological pressure. Intervention commanders work and make decisions in fear of their possible failure. They often have insufficient and inaccurate information. Other problems arise from lack of necessary resources. The basic requirements of life may sometimes be restricted under the influence of all these factors.

2.2.3 Using of Standards

Unified Modelling Language (UML) is a standardized modelling language used in the field of software engineering. Two diagrams are especially suitable for process modelling: Use Case Diagram and Activity Diagram.

Business Process Modelling Notation (BPMN) provides a notation that is readily understandable by all business users. This way, BPMN creates a standardized bridge over the gap between the business process design and process implementation.

Web Services Business Process Execution Language (WS-BPEL) defines a model and a grammar for describing the behaviour of a business process based on interactions between the process and its partners.

3 Architecture for Operational Processes Improvement

The aim of this paper is to design overall support for deployment operational processes in emergency management [1]. The architecture design is based on workflow reference model [4], which is introduced by Workflow Management Coalition. Workflow reference model represents the highest logical level of the process architecture, which represents the basic framework for emergency processes improvement and deployment. The advantage of this view is that it is independent of specific area of interest and so it can be used for deployment any operational processes. It is also inevitable to add and refill this basic logical design by particular features that are resulted of emergency management processes characteristics (internal and external factors), for this reason.

Another starting point in the design process architecture for emergency management was to analyse several Business Process Management Suites (BPMS). Its aim is to propose such an architecture that can be implemented using current technologies and resources in the area of process management. Of course, the goal of the proposed architecture is its independence of the specific commercial BPMS solutions. The created architecture represents a fundamental set of tools which should be used to deploy the operational processes in emergency management. The resulting final solution may consist of one specific BPMS which has already complied with the process architecture, or there may be a set of different tools and their interoperability is achieved through standardized interfaces, using which the tools can communicate with one another.

The overall architecture for operational processes improvement in emergency management is the result of these considerations (Fig.1). The architecture is described through the deployment diagram and individual components which the architecture consists of [3]. The detailed description of individual components and their properties is dealt with in detail in next section. The proposed architecture also takes account already existing architectures focused on operational processes such as [5], [7] and [12].

For the deployment of operational processes the created architecture covers all the necessary tools, modules and communication interfaces among them. A part of the architecture is not only a visual representation of individual components. Components must be described in detail so that the specific BPMS can be chosen according to them.

3.1 Process Definition Tools

This is the part of architecture responsible for the analysis and design of operational processes. For this purpose, primarily three components are used: the Modelling Tool for modelling business processes, the Configuration Tool for their configuration and integration with other services and also the Process Repository which is used for their storage. It also enables the deployment of stored and comprehensively modelled and configured processes to be stored on the process server.

3.2 Workflow Enactment Service

The Process Engine is the core of the process architecture and is required if you want to execute business processes. Your application services typically invoke the Process Core whenever necessary. The Process Engine is the runtime environment for process applications. It provides a rich and diverse set of functionality for business processes. Business Process Execution Language (BPEL) provides a high level way to define your business processes. Business Process Modelling Notation (BPMN) is another way to define the flow of a business process.
3.3 Client Applications

The Working Environment represents an integrated user experience for business users across the entire Architecture. The Working Environment provides a customizable and collaborative environment for you to monitor, review, and administer common business processes, such as human task flows, modelling, and performance indicators. These features can also be separated in Administration & Monitoring Tool component.

The Working Environment is usually a browser-based graphical user interface that you can use to view and interact with content from various components in the BPMS. The Working Environment not only provides a single web-based point of access for the content, you can use the Working Environment to combine the content in useful and interesting ways. These combinations can give you an insight into your business and the capability to react to changes in it.

3.4 Interoperability

The interoperability between EM systems occurs in two basic levels. It is a synchronous communication (orchestration) and asynchronous communication (choreography). The synchronous communication is achieved through Invoked Applications while the asynchronous communication is achieved through Other Workflow Enactment Services.

A typical example of synchronous communication is the communication between the Process Engine and the Geographic Information System (GIS). The standard web services to work with maps called Web Map Service (WMS), or their expansion named Contextual Web Map Service (CWMS) can be used.

Other Workflow Enactment Services represent the asynchronous communication. Examples of such interaction are communication with the individual systems of the Integrated Rescue System. The Enterprise Service Bus (ESB) is an appropriate software architecture which captures this kind of communication. ESB properties are described in detail in many other papers, for example [2].

3.5 Interfaces

The last blank part of the defined architecture is its interfaces. For the architecture for operational process improvement in Emergency Management it is appropriate to use standardized interfaces, developed by organizations, such as Workflow Management Coalition, Object Management Group and Organization for the Advancement of Structured Information Standards.

Another group of interfaces are interfaces for particular systems. An example is a standardized WMS defined by the Open Geospatial Consortium. For the purposes of EM it is also possible to use...
extensions of this service in the form of CWMS. This extension allows not only to obtain maps from the GIS server, but also to obtain maps in a context that may be specific to different users or emergency situations.

4 Case Studies
Two case studies were used for the verification of proposed architecture that enables effective improvement of operational processes in emergency management. The first case study illustrates the use of commercial BPMS called IBM Websphere the second shows the use of open-source BPMS solution named Bonita Open Solution.

4.1 Case Study – IBM Websphere
To demonstrate the practical use of the proposed architecture a typical activity STC - 05/IZS called “Finding an object that is suspicious to contain B-agents and toxins” was chosen. Typical activities describe cooperation of the Integrated Rescue System (IRS) components for joint intervention. This group of documents was released by the Directorate of Fire Brigade of the Czech Republic.

Intervention from the perspective of the Intervention commander begins when the commander arrives into the site of finding a subject that is suspicious of the presence of B-agents or toxins. The Intervention commander immediately conducts an evaluation of the situation. In case of a threat the intervention commander decides about organization of the intervention and future joint actions. Coordination with Emergency Medical Service provides medical assistance to affected civilians and rescue teams. In parallel with this activity intervention units carry out in the affected area disinfection and medical examination of people and decontamination of the area, especially suspicious object and location findings. When all of these activities are finished, the intervention commander ends the intervention.

For this case study IBM WebSphere software was used, which brings together programs that are designed to help managers, analysts and developers to process management. This is a very complex commercial BPMS. The software includes programs that cover the elements of proposed architecture in the paper. Specifically, there are the following instruments:

- **WebSphere Business Modeler**,  
- **WebSphere Integration Developer**,  
- **WebSphere Process Server**,  
- **WebSphere Business Space**,

4.2 Case Study – Bonita Open Solution
The practical usage of introduced architecture is illustrated by Business Process Management Suite named Bonita Open Solution (BOS). The BOS represents the open source solution for process automation and support. Unlike other commercial BPMS, the BOS has some advantages and disadvantages typical for smaller software solutions based on open source technologies. The Processes Reporting an Emergency Incident and Alarm for Fire Protection Unit have been chosen for the specific use of the defined architecture. This architecture helps automation of emergency operational processes in the Czech Republic.

The Bonita Open Platform Solution is primarily based on the three integrated tools built on the Java language. It is Bonita Studio, Bonita Workflow Engine and Bonita User Experience. There are also extensive opportunities for integration with other tools using predefined connectors.

The Bonita Studio is a modelling tool that allows process design through the BPMN. In addition, besides a simple drawing, tool is also able to design almost a complete implementation process. For this reason, the tool contains the Form Designer and Connectors. The Connectors are software classes written in Java and they implement the interface. They are intended for partial or full automation of processes in the Bonita Open Solution.

The Bonita Workflow Engine (Bonita Runtime) is a generic and extensible workflow engine which performs proposed process. To achieve the deployment of the entire process on the production server the Bonita Studio Export of applications is necessary. Therefore, a ZIP archive with a complete application is generated and it can be deployed on the Java EE application server.

The Bonita User Experience (XP User) is a Web-based user interface that is similar to web email clients (Gmail) and serves to the entire administration and running processes from both the user and the administrator perspective. The User Experience Bonita accesses workflow engine through client Java API. In the same way, other remote applications can also access.

The implementation of novel architecture cannot be considered as complete unless the BOS is integrated with the instruments for cartographic support for emergency management. Particularly, it is contextual cartographic visualization [6] which allows to visualize map elements by a different way for different users in different emergency situations.
5 Conclusion
The aim of the paper was to define novel architecture suitable for the emergency operational processes deployment in the Czech Republic. The created architecture defines a set of tools necessary for automation of operational processes and it is independent on the particular BPMS.

For an overall understanding of the described issue it is also appropriate to familiarize with the Process Framework for Emergency Management [8]. This contribution emphasizes the importance of the two perspectives in the deployment process of emergency management. It should be noted that the architecture itself is not sufficient for the automation of emergency management processes. It should be supplemented by the methodology [9] that defines how to proceed with process automation and deployment.

Finally, it should be noted that the proposed architecture is suitable not only for the automation and deployment of emergency operational processes in the Czech Republic, but also for educational purposes. Thus the defined process oriented architecture allows reflecting any changes in emergency scenarios quickly and also creating new scenarios for educational purposes based on real examples. The resulting architecture allows students to model emergency scenarios using process maps, optionally supplemented with additional process data which can enable simulation or deployment on a process engine to test their effectiveness in the model situation in practice.

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References: