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Process Analysis of Dynamic Geo-Visualization in Environmental Crisis Management

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Abstract

This contribution describes the results of the research project “Dynamic Geo-Visualization in Crisis Management” supported by the Czech Ministry of Education. The paper is focused on the process analysis in the crisis management, particularly the analysis of the Czech Fire and Rescue Services Act. The analysis is based on using some use case diagrams, process maps, logical data models and CRUD matrixes. Based on the obtained knowledge from this process analysis, an application ontology has been created. This ontology describes the relations among crisis situations, person resources and information, mainly in regard to the geographical structure. The process maps are described by XPLD language. The application ontology is described by OWL language. Using the standards is aimed on reaching high interoperability.

1. Introduction

Daily many crisis situations have to be solved. The solutions are not simple. We have to realise, that crisis situations do not threaten only material or environmental values but also human lives. In other to solve crisis situations in the most effective ways we have to abandon function management, which is focused on the knowledge of individual persons. In this system the tasks are assigned to individual people who execute them. According to the character of these tasks people are divided into separate function units. Process management is a better option. This way of management is focused on work results. Work is not done separately in individual function units but it flows through them. When this kind of management is used, improvements are reached by optimization of the workflow and by simplifying it. Process management leads to more effective coordination of work and also to decrease of fault occurrence. To make the process management even more effective application ontology is created. It is a knowledge base of executed processes. The ontology supports the process management. This methodology is applied to the Czech Fire and Rescue Service Act.

2. Process analysis

2.1 UML – use cases

Before focusing on the process maps it is necessary to understand the Czech Fire and Rescue Act as a complex. It is possible to create a good complex view with the help of the use cases when the Act was applied [5]. It is represented by the use case diagram in the Unified Modelling Language (UML). The main purpose of this diagram is to find and document the modelled system claims. The first stage of creation of

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this diagram is to specify the borders of the modelled system. In this case, the borders are defined quite clearly by the Czech Fire and Rescue Act. Everything else is considered to be surroundings of the system.

Next, an actor list should be created. It is a list containing different roles which are assigned to persons or subjects that use the modelled system. In order to create the complete actor list, it was necessary to analyse all the documents of the Czech Fire and Rescue Act. When analysing these documents the most important question was: “Who or what uses the system, who or what communicates with the system?” While creating the actor list it was found out in the documents that the properties of the actors are repeated or they are partly the same. If we do not want diagram with many links between the cases and actors we will use generalization.

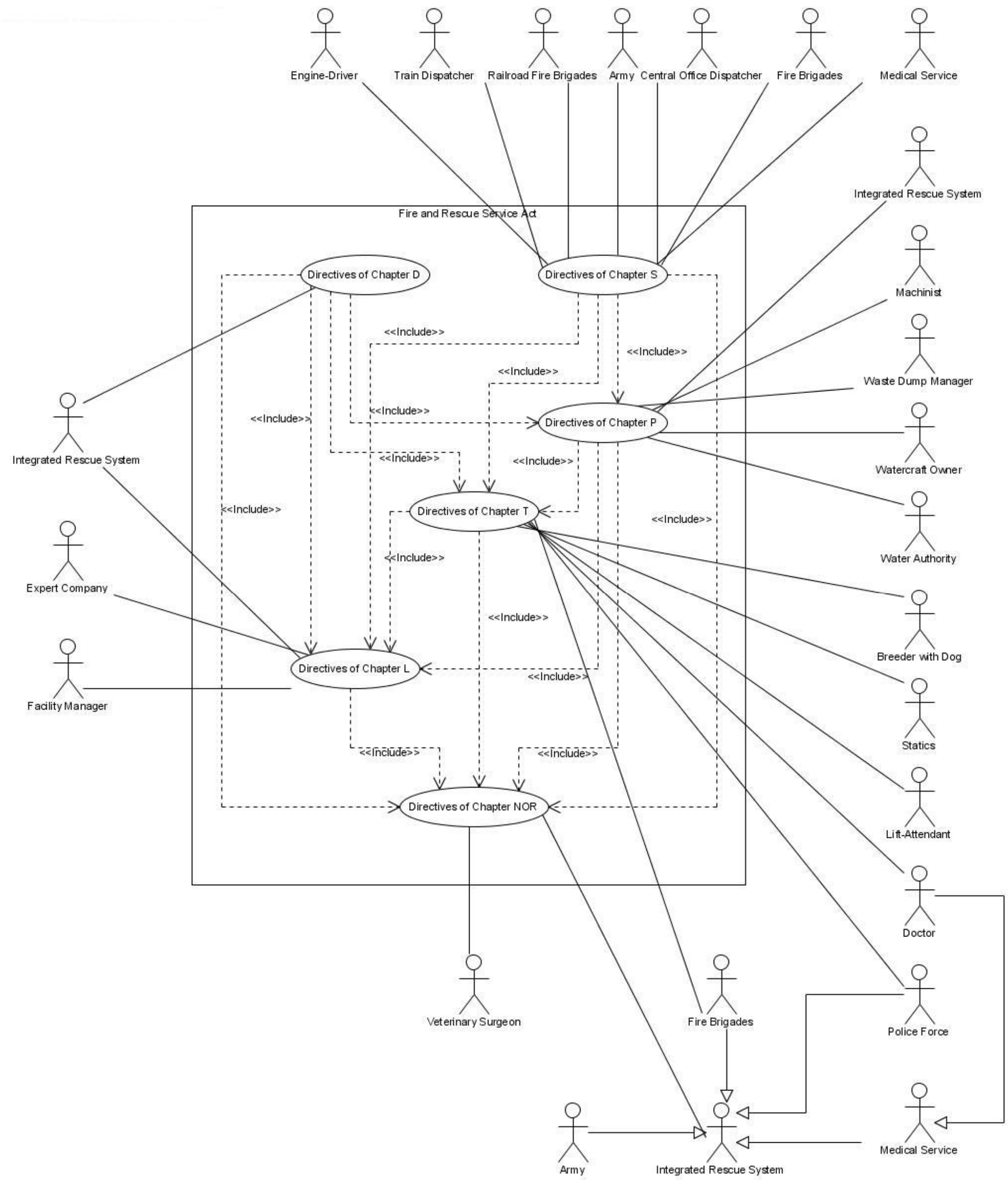

Fig. 1: The main use case diagram

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Having understood the roles of the individual actors, it is possible to start creation of use cases. A use case is perceived as specification of the sequence of activities, including variable sequences or fault sequences, that the system or subsystem can execute through interaction with external actors. The Czech Fire and Rescue Service Act represents a huge aggregate of activities, so if we want to model the system transparently we will have to find and define bigger aggregates of activities. The individual chapters of methodology lists will be considered to be these bigger activity files. We can do it because every chapter contains directives which are thematically very close.

After modelling use case diagrams, we are able to start creation of specification for individual use cases. This specification is described with process maps [1]. They were chosen because they are capable to incorporate and define the activity sequences in the particular directives.

2.2 Process maps

A process is a set of activities arranged in parts which creates in a repeatable way a required output on the base of one or more inputs. Specifications of the individual processes consist of the following entities:

1. Process (Workflow Process Definition),
2. Activity (Workflow Process Activity),
3. Transition (Transition Information),
4. Participant (Workflow Participant Specification),
5. Application (Workflow Application Declaration),
6. Data (Workflow Relevant Data).

Mutual relations among the entities are demonstrated in the Meta-Model of the process in figure 2 [2].

Fig. 2: The process meta-model

To illustrate a process map the directive called "*Action Management*" is processed [5]. The directive has two main parts. The first of them is named "*Characteristic*" and the second one is named "*Tasks and Activity Sequence"*. The majority of the directives of the Fire and Rescue Service Act have similar structure. The part "Characteristic" briefly describes the purpose of the directive and also the basic rules of its processing. The part "Tasks and Activity Sequence" contains detailed descriptions and rules how to process the critical situation which the particular directive deals with.

When we want to create process maps, we need to focus on the "Tasks and Activity Sequence" part where included processes are easier to recognize. In the directive "Action Management" this part is divided into tree sub-parts, which are called "*Management Structure"*, "*Subordination"* and "*Representation, Change, Exchange"*. Each of these three parts is considered to be an independent process and their order is not defined either. When we want to represent this situation with a particular process map, we have to use two routing actions, with AND-Split and AND-Join and also three activity blocks for the main processes. Of course, it is necessary to add marks for the start and the end of the process. In this way the basic process map of the first directive of chapter R was created and it is showed in figure 3.

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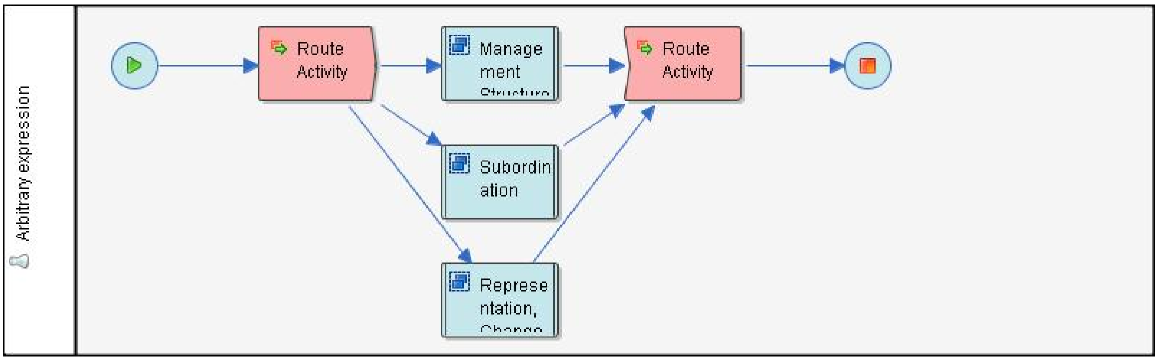

Fig. 3: The process map of the Directive No 1 in Chapter R

To complete the process analysis, it is necessarily to model individual activity blocks or individual processes of the main process. The first block of the activities is "Management Structure". It consists of two activity sets. The first activity set ordains the leadership roles, for example, the chief commander and members of the general staff, sector or part leaders and subsequently it marks them with red slips or waistcoats. These activities are represented by the blocks "*Set Leadership Positions"* and "*Labelled Individual Functions"*. The second block of activities analyses and consequently sets the management structure that depends on the number of managed units, other IRS (Integrated Rescue System) units and possibly on other forces and resources. That is the reason why there is "*Management Structure Set"* which processes the environmental analysis of the strike. Subsequently, the Strike Commander can but does not have to establish sectors and/or parts. They are established according to the strike place or tactics. The activity called "*Sector and Part Creation"* takes care of these actions. Finally, the Strike Commander chooses the way of managing the strike. Our system provides him three options, "*Independent Strike Management"*, *"Assignment of Assistants"* and "*Creation of General Staff"*. As it is possible to choose only one of the options XOR-Split and subsequently XOR-Join are used in the process diagram. In this way all the activities and their relations in the Management Structure were described. The resulting process map is showed in figure 4. The two following sub-processes will be created in a similar way.

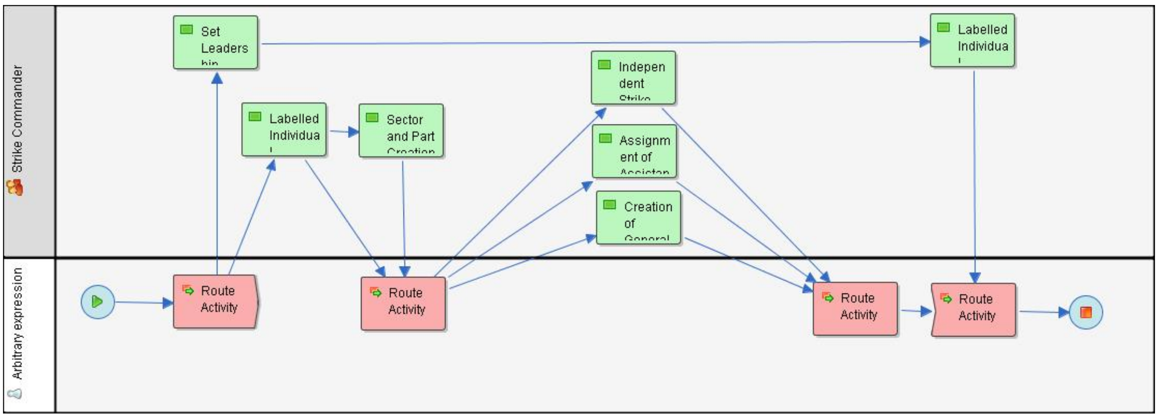

Fig. 4: Sub-process map "Management structure"

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2.3 Initial data model

Another stage of analysing directives is a data and data structures analysis. It means that we had to specify which information is needed to be remembered and to find an appropriate way of their representation. As the directives are focused on describing activities and processes, it is not very easy to find the important data and data structures. Considering this fact [4] an initial data model describing individual data structures on appropriate level was created. This level is as detailed as it is allowed by particular directives.

2.4 CRUD matrix

Subsequently, the process and data model was rebalanced using CRUD (Create - Read - Update - Delete) matrix. The matrix shows which activities are executed in the process and which information from the data model is needed. The lines of the matrix represent data items from the initial data model; the columns represent particular process activities. In the particular matrix fields there are the following operations: create (C), read (R), update (U) and delete (D), which are executed by the process with the respective information.

3. Application ontology proposal

3.1 Terminology

Before describing the creation of the application ontology in the area of the crisis management it is useful to refresh, what the ontology is. From informatics point of view it is ontology known as formal specification of shared conceptualization [7]. The goal of using an ontology is to support understanding among people and also to improve interoperability among computer systems. According to the formalization subject the following ontology groups are recognized: domain ontologies, generic ontologies and application ontologies. Application ontologies are the most specific ones. They represent conglomerates of models adopted for a particular application. The main building elements are:

1. Classes – Determinate sets of specific objects and they are the basic building elements of ontologies. Their representation is derived from the relation concept. For defining classes generalization is often used.
2. Individuals – Represent particular objects of the real world. Individuals (Instance) also represent membership in a certain class.
3. Property – Are the basic parts of ontologies. The relations in an ontology are binary relations, and they can be inverse or interconnected by generalization.

3.2 Application ontology example

While analysing the Czech Fire and Rescue Service Act it was found out that the process maps contained individual activities together with the executive units (people in their functions or executive bodies) who are necessary for solving them. This information is supplemented by the initial data model and CRUD matrix, which describes interconnections among the activities from the process maps and information from the initial data model. This analyse provided three key areas which will be taken as a base for creating the application ontology. They are *crisis situations*, *participants* and *information*, which are used as root classes for the ontology. After that, more sub-classes were added using generalization. In this way, the tree

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hierarchy of classes was created [4, 6]. In the figure 2 (right) it is possible to see the generalization between "*Crisis_Situation*" and "*Crisis_Plan*" classes as well as many others.

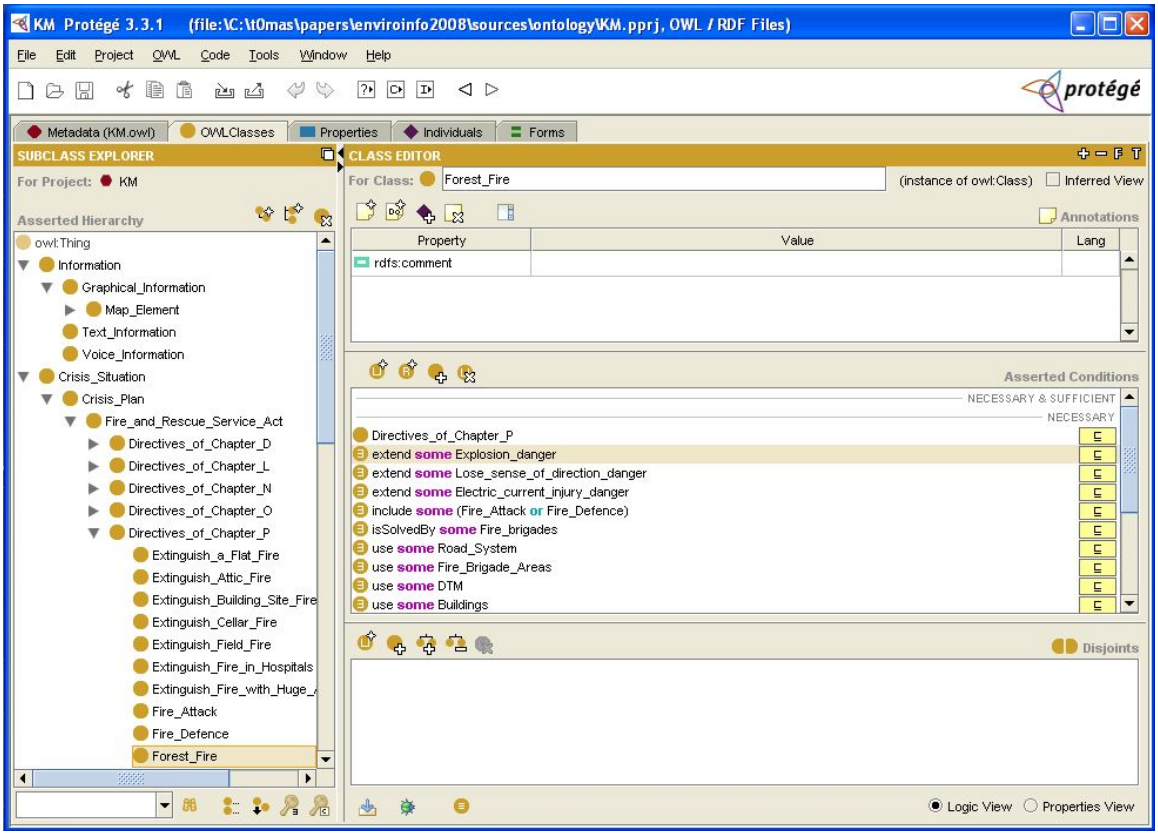

Fig. 5: The application ontology created using Protégé tool

The following stage is creation of the properties. The purpose of the ontology is to define and describe individual crisis situations. So it was necessary to define the properties between the crisis situation and needed information, the crisis situation and needed participants and finally, the properties among crisis situations themselves. The property between crisis situation and necessary information is called "*use*" in the ontology. An inverse property called "*isUsedBy*" is also defined for this property. A similarly property called "*isSolvedBy*" represents the relation between a crisis situation and its participants. Its inversion property is called "*solve*". The last described properties are relations among crisis situation themselves. For them the properties "*include*" and "*extend*" were defined. Their meaning is the same as in the diagram of use cases. The Property "include" means, that solving one crisis situation requires solving another crisis situation simultaneously. Property "extend" says that, under certain conditions a new crisis situation can arise as the consequence of the original crisis situation.

The example, how the application ontology describes solving the crises situation of forest fire with the help of classes and properties, is in figure 2.

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4. Interoperability

When creating the standards for the environmental crisis management and its dynamic geo-visualization framework in the Czech Republic using information and communication technology (ICT), it is necessary to find common understanding and consensus with the European trends. It is expected that the proposed Czech National Standards will allow the users (rescuers, decision makers, local and public administration bodies, business organizations etc.) to cooperate uniformly and effectively and exchange geographical environmental data and information on the local, national and international levels. That is the reason why interoperability of the designed system is so important. It is reflected in the selection of suitable formats for storage of the modelled processes and the application ontology.

4.1 XPDL

All modelled processes are created in XPDL (XML Process Definition Language) format. It is Workflow Management Coalition standard, which is trying to create a uniform format for storage of the modelled processes. Nowadays this standard is supported by 70 software products. The main goal of this standard is to create a process definition in such a format, that the models can be transferred to different modelling tools or automatically processed by the workflow management system [2].

4.2 QWL

The described application ontology is created in OWL (Web Ontology Language). It is one of the newest languages used for ontology representations. This language is proposed for applications, which need to process contained information automatically. This language was created on the base of the experiences with DAML + OIL languages. OWL exists in three variants [3]:

1. OWL Full – contains all language construction, supports maximal expressivity and syntactical freedom,
2. OWL DL – is a subset of OWL Full and contains all language constructions with some restrictions,
3. OWL Lite – is OWL DL with more restrictions. It is suitable for the applications, where it is sufficient to apply classification hierarchy and simple restrictions.

5. Conclusion

Process management is seemed to be a suitable tool for solving crisis situations. Directives transformed into process maps are more comprehensive for striking units. The created process maps can be used for process stimulations and optimizations. Mapping of the processes is also the first step of their automation. The created knowledge base represented by application ontology helps the strike units with theirs decisions. On the base of the included knowledge it is possible to recommend the best procedure how to manage a crisis situation or reveal other threatening crisis situation, which are not apparent. In future we want to extend the application ontology, primarily by including cartographical visualizations elements, and also we want to find better connectivity among the ontology and the process models.

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6. Acknowledgements

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