A New Application of Domain Specific Modeling Towards Implementing an Early Warning Service

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Abstract. Domain Specific Modeling (DSM) has been used for a while in many scenarios, case studies, and applications successfully. This paper intends to present a new application of DSM for facilitating an Early Warning Service (EWS). The knowledge about risks and its representation is an important factor for any EWS. The challenge is to help the users be closer to the understanding of the associated risks and to facilitate them with a new software application so as to provide the ability of risk analysis, we propose in this paper a novel application of using Domain Specific Modeling (DSM) in deploying EWS. The paper presents a case study in which there is a need to develop an EWS for the personnel of institutions involved in the drinking water delivery governance model in the Republic of Ireland.

1 Introduction

Access to safe drinking water is a basic human right, but this right is not being met universally. At least one third of the population in developing countries and almost one fifth of the global population have no access to safe drinking water. Diseases related to drinking water continue to be one of the major health problems globally as there are about four billion cases of diarrhoea each year, out of which 2.5 million cases end in death [1]. In particular waterborne disease outbreaks have attracted the attention of the media and of the public, giving a raise on the discussions about the issues of drinking water safety and risk management of water utilities.

The ultimate goal of our research, which is at its early phase, is to design and develop a domain specific software application that will facilitate Early Warning Service (EWS) development and is to be used by the personnel of institutions involved in the drinking water delivery governance model of Ireland, such as the EPA, local authorities (LA) and the Health Service Executive (HSE). It can be viewed as useful contribution in supporting a proactive risk management strategy.

The goal of this paper is to propose a component and its high level architecture of the EWS; that is a Domain Specific Modeling (DSM)application for modeling and representing the knowledge about risks in WTP operations. Fig. 1, provides a model of the interactions between the DSM application and the entities such as personnel of EPA and WTP caretaker. One of the use cases, for example would be met when an EPA personnel is required to perform an audit on WTP using software application for EWS and in order to do so it is necessary for him to receive input from the caretaker regarding with

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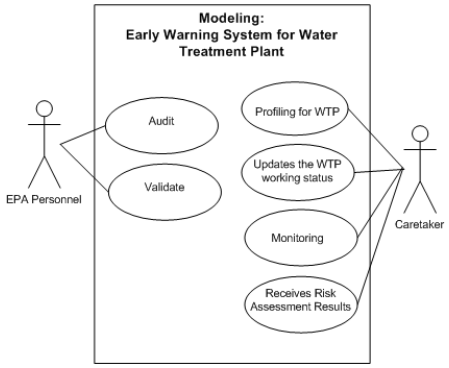

Fig. 1. Functional requirements.

profiling the particular plant and updated working status on water treatment utility. The possibility of automatically generating code from domain specific models can enhance the development of the EWS.

The rest of the paper is organized as follows: Section 2 provides the brief description of the relevant concepts of DSM . In Section 3 a proposed architecture of our novel application of DSM will be presented. In Section 4, related work is high-lighted followed by concluding remarks in Section 5.

2 Concepts

Each of the concepts mentioned below and their research areas has its own substantial body of literature. In this article, we just scratch the surface of each.

2.1 Knowledge Modeling

Modeling in the context of information technology aims at capturing relevant knowledge in a conceptual, often high-level, and abstract form. An ideal situation from a pure knowledge perspective is to be able to reuse the knowledge available implicitly and explicitly, which can be accomplished by the effort of knowledge modeling. The activity of knowledge modeling is to generate knowledge models, which are interpretable models that represent the concepts or entities of a real world, their behaviour, properties and related constraints. Knowledge models are structured representations of knowledge and they maintain knowledge in the form of symbols, entities, events with states, attributes and values, in order to represent the pieces of knowledge and their relationship.

The elicitation and modeling of knowledge for engineering tasks, especially related to a specific domain, has always been a matter of concern. General purpose programming languages represents knowledge in an object oriented style, supports thinking in terms of classes, objects and methods instead of depiction of acquired specific knowledge in terms of their domains. Therefore, for knowledge acquisition activities the knowledge modeling is used as a means of acquiring, validating and storing knowledge for future use.

In model-driven paradigm of DSM metamodels are used to define various modeling languages that represent the key concepts and abstractions for a specific domain. The domain models, built by the set of processes and programming tools in DSM environment are formal models which correspond to entities in the real world and conceptually represents its behaviour, constraints.

2.2 Domain Modeling

Utilizing the DSM approach can be achieved by raising the abstraction level and by understanding the concepts of specific domain. The definition of the modeling language will be based on domain concepts identified during domain analysis [2]. The identified domain concepts of the risk analysis methodologies for drinking water utilities are required to be mapped to the domain semantics, which is a set of rules that specify the well-formedness of domain models and are represented by means of graphical notations; these notations represent the graphical syntax to express the semantics.

For capturing the syntax of the modeling language, a metamodel must describe all the entities and relationships that may exist in DSM [3]. Metamodels provide object-oriented specification of the abstract syntax which is the structure of the language constructs used in Model Driven Engineering where models are primary artifacts. In other words, metamodeling can be defined as a modeling activity for specifying models, where models are abstract representations of the real world entities, processes thus describing the information that concerns with a particular domain. The high level conceptual architecture for defining models for DSM is given in Fig. 2.

In order to complete the DSM definition specifying domain concepts and domain models is not sufficient enough but domain rules and constraints are also required to define the legal relationships between domain concepts and their usage. Different kinds of constraints will be applied to the proposed DSM such as operational constraints expression for modes of operations relevant to failure preventive measures, composability constraints expression for compatibility between different alternatives, resource constraints will be used to indicate the need for specific resources and performance constraint [3]. In this consideration of DSM, the constraints and behaviour of DSM will be defined in accordance to EWS by keeping the integrity of the domain concept.

2.3 Code Generation

In DSM the code is required to be generated from the domain models in order to drive working software application, a database schema or even some documentation [4]. Fully functional executable code can be generated from the domain models itself without any manual intervention. During transformation no manual mapping is required from domain models to code; instead automatic code generation is facilitated by implementing any technology that provides model to text transformations. In Eclipse, Model to Text transformations (M2T)[5] project focuses on code generation and hosts frameworks mostly based templates with an ability of generating text from models.

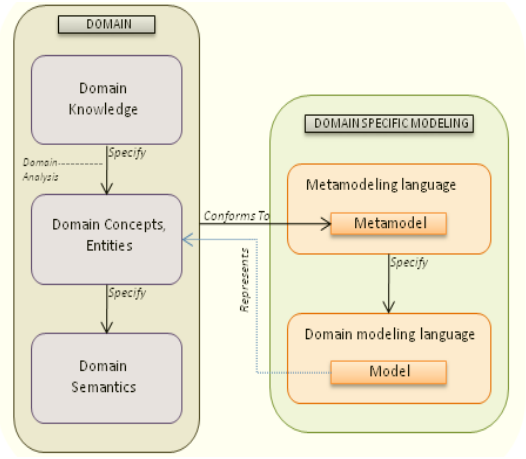

Fig. 2. Conceptual architecture of DSM.

3 Proposed High Level Architecture

In this approach, we stress on providing a new standalone DSM application for a EWS in WTP. Eclipse Rich Client Platform (RCP) will be used to develop it. Fig. 3 illustrates the higher level architecture and the core components of our system can be described as follows:

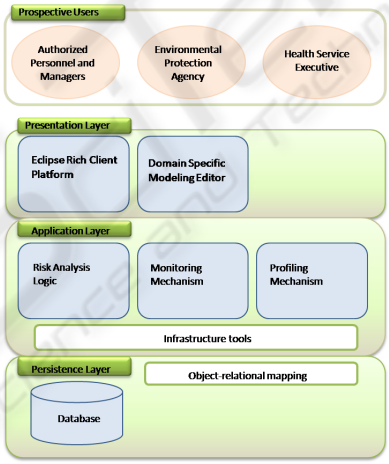

Fig. 3. High level Architecture.

- Prospective users include authorized stakeholders, personnel and managers of WTP, EPA and HSE;
- The presentation layer comprise of RCP platform in order to provide a standalone application. Domain specific editor will serve as user interface for the prospect user to interact with EWS;

- An application layer will provide the core logic for different processes. Risk analysis to calculate the likelihood of vulnerabilities. Monitoring mechanism will assist the users such as plant manager to check, oversee the current status of water treatment utilities. Profiling mechanism will allow the update of physical inventory and to list what exist in specific plant;
- The persisting layer will handles all the logic to save and retrieve the data from data base. In this layer object-relation mapping is performed to transparently maps objects to relational data.

4 Related Work

A useful aspect of DSM is in providing the convenience of identifying the concepts representing the real entities of WTP by utilizing custom graphics within the models. Hence, offering the convenience to think closer in terms of problem domain and eventually providing an effective EWS. The specified domain models can be used to define other models or to configure other systems perhaps in combination with other enabling technologies by providing the domain specific application process interface for EWS. We argue that it is feasible to develop a novel type of software application to provide EWS.

DSM approach has been successfully applied in a vast array of different domains to create applications for a broad collection of programming languages and platforms including many industrial applications [6] such as in insurance sector, mobile phones, and radios. Their comprehensive study comparison is out of the scope of this paper.

The most recent relevant work we have found is on developing a prototyping approach using DSM for describing the earthquake detection algorithms for an earthquake EWS [7],[8],[9].

DSM approaches have been used also for risk and vulnerability modeling in domains such as critical systems engineering [10], grid computing systems security [11]. These approaches are defining the concepts of ”threat” ”risk” and ”vulnerability” in an appropriate manner but do not integrate the concept of early warning signal, which is of important in every EWS.

5 Conclusions and Ongoing Research

This paper proposes the use of a DSM in EWS for drinking water utilities. Our innovative approach consists of providing DSM to model the risk associated for water treatment utilities and to describe the architecture of EWS application. However, there are many technical research challenges that need to be resolved to define the early warning methodologies within the drinking water treatment utilities and their deployment in our domain models along with their constraints. These include the modeling of constraints as well as the behaviour of the entities of water treatment utilities with respect to the rules and techniques involved in risk management. Further different aspects of DSM implementation need to be investigated such as code generation, improved performance, and validity of the models with respect to the domain.

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