Application of business rules approach in clinical trials

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Abstract: *The paper discusses the use of Unified Modelling Language (UML) for business rules modelling. Different techniques of business rule representation in the models reflecting different aspects of a particular system are briefly described. The paper also demonstrates a method of creating a formal business rule specification from system models based on the use of UML. The representation of business rules in natural language is also shown. The prototype software system realising the proposed method and the results of the experiment are presented.*

Key words: *Business rules, business rules modelling, clinical trials*

INTRODUCTION

Most business rules investigations are focused on businesses as selling, banking, insurance, etc. All businesses are performed according to a specific set of business rules [5]. Clinical trials are not widely discussed in the context of business rules approach. Prima facie clinical trials seemed to be comparable to the systems running on business rules. Yet, thorough analysis of clinical trial procedures shows that clinical trials are directly concentrated on business rules [1], [3], [4]. Each trial is performed according to the explicitly expressed set of rules. There are many documents specifying the way clinical trials have to be performed and these documents are the sources of business rules for clinical trials [4]. In order to run clinical trial activities according to the requirements, the following documents have to be analysed: standard operating procedures (SOPs), Good Clinical Practices, applicable regulatory requirements, etc [3].

Some clinical trials are performed repeatedly for different purposes. In this case, the errors discovered in previous trials are resolved in the consequent trials. However, most trials are being designed from zero [2]. Errors in the new designed protocols occur because these are complex documents. The application of business rules approach in clinical trials was proposed recently [4], but the job already done is focused on the trial protocol design improvement. We state that the principles of business rules approach are not only applicable to the design of the clinical trial protocol. Data clarification is performed in accordance with the approved documents that contain rules for distinguishing data discrepancies. As rules, specifying the way particular trial has to be conducted, are stated in different source documents, the general requirement specification for particular trial is not available. Thus, the need for accurate recording and processing of patient data is fundamental to any clinical trial [1]. If data stored on the master data file is incorrect, conclusions of the analyses will also inevitably be incorrect. We assume that UML model representing particular clinical trial may improve clinical trial design. UML model of a clinical trial should be used to automate the steps of business rules discovery from source documents, rules managements and implementation.

The paper is organised as follows. Section 1 introduces the paper. Section 2 is an introduction to clinical trials. Section 3 shortly discusses the use of UML for business rules modelling. Section 4 shows the structure of a part of the business rules repository used to store date of business rules represented in UML Use Case diagrams. Section 5 presents an experimental tool used to transfer business rules from Use Case models to rules repository and create formal rules specification. Section 6 concludes the paper.

INTRODUCTION TO CLINICAL TRIAL

Generally, clinical trials are performed in four phases [1]:

• Phase I clinical trials are performed to determine an acceptable drug dosage;
• Phase II clinical trials are carried out to prove the efficiency of treatment;
• Phase III clinical trials are executed to compare the efficiency and side effects with those of other drugs and placebo;
• Phase IV clinical trials are large-scale epidemiological studies.

When the purpose of the trial is defined, the document used to justify the design and describe the trial procedures in detail is prepared. This document is called a clinical trial protocol. A protocol is the document containing the information relating to the purpose, design and conduct of the trial. A protocol also specifies what activities are to be performed in a trial, what measurements are to be evaluated, how the study will be coordinated, etc. [1]. Generally, protocols define all aspects of the proceeding of a particular clinical trial. Thus, it is a crucial document, and if incomplete, disorganised or incorrect, can prejudice the whole study [3].

The analysis of data gathered during the clinical trial is as important as protocol design, because the obtained results are fundamental to subsequent activities. The main purpose of having well designed forms is to make patient evaluations suitable for statistical analysis, but before performing the analysis all data has to be collected, processed and checked [1].

BUSINESS RULES MODELLING WITH UML

The concept of business rule in this paper is used as stated in [5]: business rule means a statement that defines or constrains some aspect of a particular business. Concept of "business" in this context is used as an abstraction that refers to any subject of any scope to which model driven architecture or UML modelling is or could be applied [5]. This means that, in this paper, a concept business is used to specify any type of activity having its goals, using its own resources, processing some data and achieving some results.

The Unified Modelling Language is a visual language for specifying, constructing and documenting the artefacts of systems. It is a general-purpose modelling language that can be applied to all application domains (e.g., health, finance, telecom, aerospace) and implementation platforms (e.g., J2EE, .NET) [6].

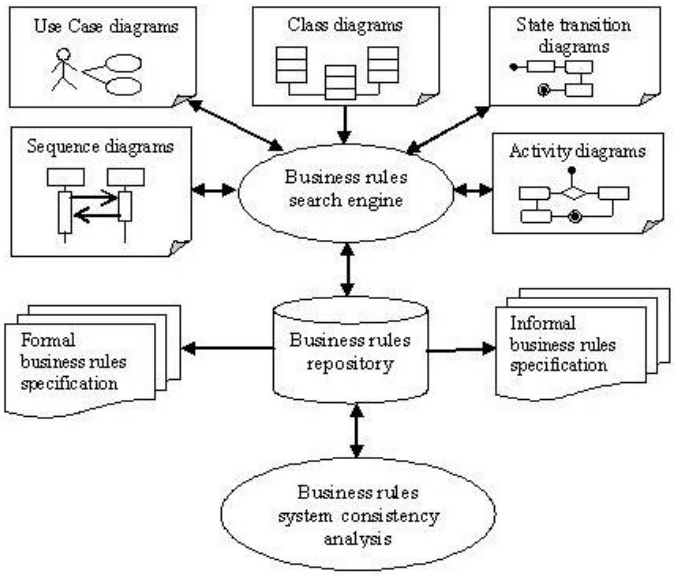

Figure 1. The transformation of business rules from models to business rules specifications

UML diagrams are used to create static and dynamic system models [10]. Structure of the system is described in static system models [7]. The behaviour of the system is described in dynamic system models. UML class diagrams and object diagrams are used to create static system models. UML Use Case, sequence, collaboration, state transition and activity diagrams are used to create dynamic business system models.

Use Case diagrams, sequence diagrams, collaboration diagrams, class diagrams, objects diagrams, state transition diagrams and activity diagrams are used to represent business rules [9]. Since business rules represented in sequence and collaboration diagrams are actually the same, only sequence diagrams are shown in Figure 1. Figure 1 also shows class diagrams rather than representing both class and objects diagrams because business rules presented in these diagrams do not differ. Figure 1 demonstrates the way in which business rules are retrieved from business system model represented by UML. Information about business rules expressed in UML diagrams is transferred to the rule repository for further processing. The structure of the business rules repository and the experimental tool used for business rules transfer are described below.

THE STRUCTURE OF THE BUSINESS RULES REPOSITORY

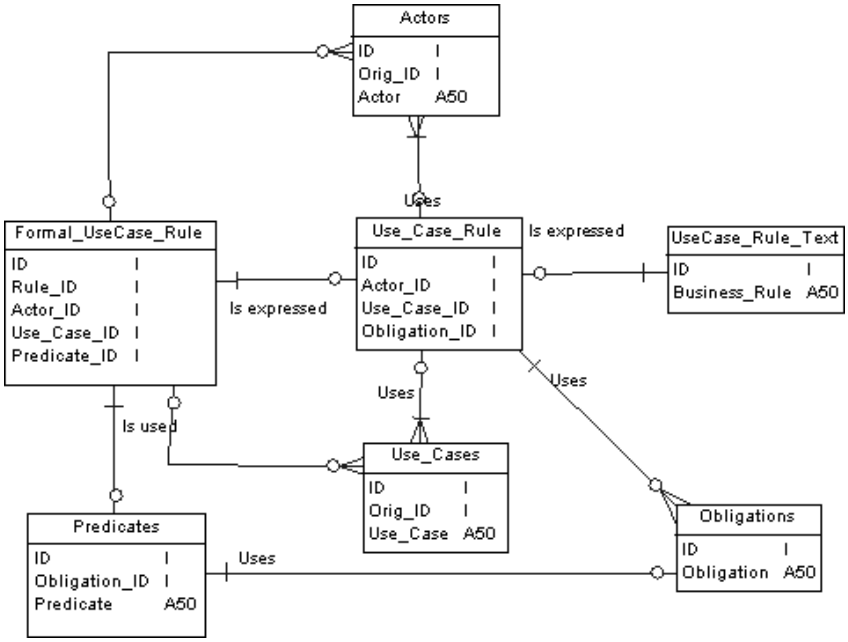

Figure 2. The structural view of a part of the business rules repository for business rules represented in Use Case model

Figure 2 shows only a part of the business rules repository used to store the information of business rules represented by UML use case diagrams [8]. As business rules presented in other business systems models are beyond the scope of this paper, a full business rules repository is not further discussed.

The table "Actors" is used to store the information of actors in the use case model. The purpose of the table "Use Cases" is to store the information of use cases represented in the use case model of the particular business system. The information of business system actor's roles and obligations is stored in the table "Obligations". The table "Predicates" contains the information of predicates that are formed on the basis of actor's roles and obligations. The relationships between business rules components are stored in the table "Use_Case_Rule". The information stored in this table is used to express

business rules formally and informally. Formal business rules expressions are stored in the table "Formal_UseCase_Rules". Business rules expressed in natural language are stored in the table "UseCase_Rule_Text".

EXPERIMENTAL TOOL

Figure 3 presents the architectural view of the experimental tool. A use case model is created using Sybase® PowerDesigner® 9.0 and stored in XML file. Data is copied from XML file to temporal storage. The search for business rules represented in the use case model can be performed directly in XML file, but in order to accelerate the process of business rules search, the data is copied to temporal storage.

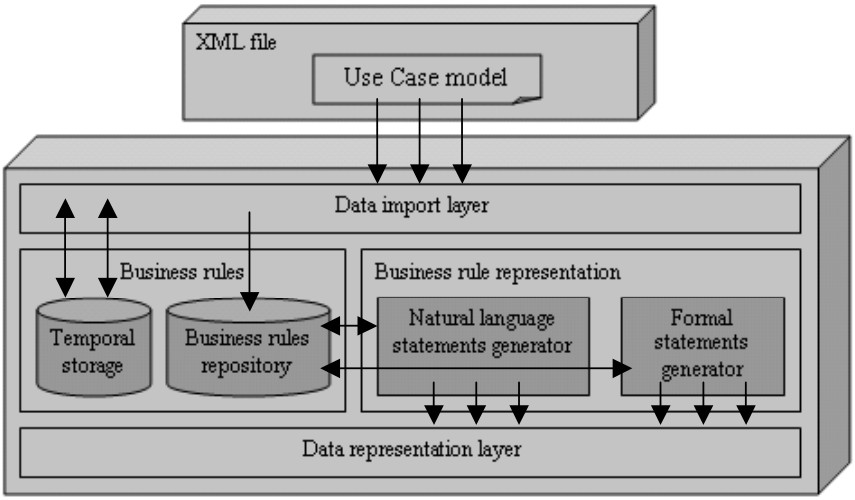

Figure 2. The architectural view of the experimental tool

The following components of business rules are looked for and copied to temporal storage: actors, use cases, relationships between actors and use cases and stereotypes of relations. Stereotypes of relationships are used to specify the roles of actors. Business rules components are connected and business rules are composed in the following step. The roles of business actors are used to form predicates of a form ROLE(ACTOR X, USE CASE Y). Business rules stored in the repository can be expressed in natural language or as first order predicates and represented for the user in a windows-based browse list.

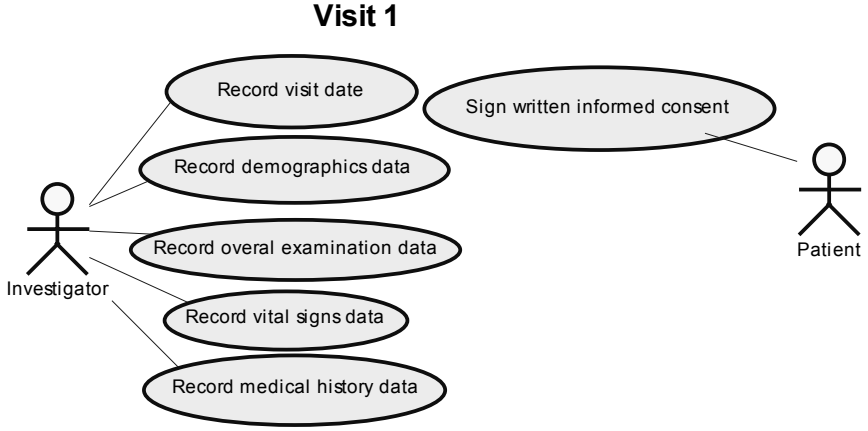

Figure 3. Sample use case model

An experiment showing how rules represented in the use case model can be transformed into constraints for data clarification in clinical trial is presented further. A simplified use case model of the first visit in a clinical trial is presented in Fig 4. The obligations of investigator and patient are represented in the model.

The information regarding the obligations of the investigator and patient described in the use case model in Fig 4 is copied to the rule repository. Rules are expressed as predicates of a form ROLE(ACTOR X, USE CASE Y). Rules are also expressed as constraints which are used for data clarification (Figure 5). Constraints used to find data discrepancies are represented in a form understandable for everyone without a special knowledge. However, rules are actually expressed in the form "Table X record is not null", these are further implemented in a database as a checks to find any incomplete data fields in a database.

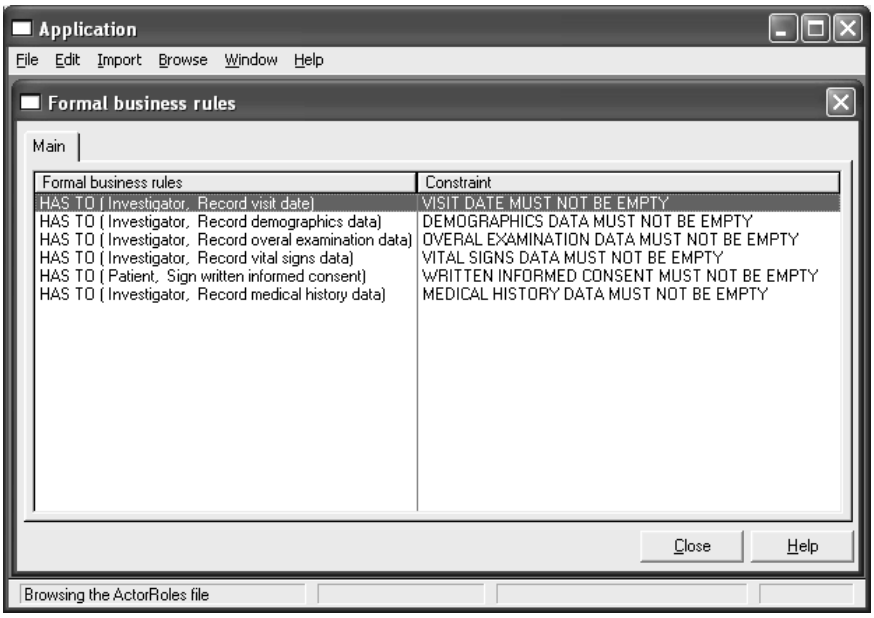

Figure 4. A list of a business rules

The experimental tool for generating rules to validate clinical trial data is limited. Therefore, it is sufficient for generating a part of rules needed to clarify the data collected in clinical trial. This is the initial staged research aimed to demonstrate the feasibility of using the created tool to improve clinical trial data clarification.

CONCLUSIONS AND FUTURE WORK

Business rules approach is generally discussed in the context of commercial systems. The analysis has shown that business rules approach is applicable to clinical trial design and implementation. Since data gathered in clinical trials is full of discrepancies, data clarification has to be performed continuously. Data clarification is performed according to the rules expressed as constraints. The analysis has shown that data clarification rules are not expressed explicitly in clinical trial design. Therefore, we propose to use UML for clinical trial design. The created experimental tool for transferring rules represented in the use case model to rules repository was described. The experiment has demonstrated that

some rules for clinical trial data clarification may be represented in the use case diagrams and translated into constraints that are to be implemented in the clinical trial database. The consistency of business rules represented in different models cannot be ensured using experimental tool and this is the scope of further research. Further research will also focus on the management of business rules represented in other UML diagrams.

REFERENCES

[1] S. Ablett. An introduction to clinical trials. United Kingdom Children's Cancer Center study Group, 2004. URL: http://www.ukccsg.org/public/clinical_trials/01intro.html UKCCSG Data Centre, [retrieved on 2006.04.05].

[2] L. Daniel, R. J. Gennari, M. A. Musen. Knowledge Representation and Tool Support for Critiquing Clinical Trial Protocols. AMIA Annual Symposium, Los Angeles, CA, 2000.

[3] S. Modgil, P. Hammond, J. C. Wyatt, V. Potts. Developing A Knowledge-based Tool for Authoring Clinical Trial Protocols. First European Workshop on computer-based support for clinical guidance and protocols (EWGLP 2000). IOS Press, Amsterdam, Leipzig, Germany, 2000.

[4] K. Nammunil, C. Pickering, S. Modgil, A. Montgomery and others. Design-a-Trial: A Rule-Based Decision Support System for Clinical Trial Design. Knowledge Based Systems, 17/2-4, 2000, p. 121-129.

[5] Object Management Group (OMG). (2002) Business Rules in Models - Request for Information (BRWG RFI1). URL: http://www.omg.org/docs/ad/02-09-13.pdf, [retrieved on 2006.01.15].

[5] Object Management Group (OMG). Unified Modeling Language (UML) Specification: Infrastructure version 2.0. URL: http://www.omg.org/docs/formal/05-07-05.pdf, retrieved on 2006.04.10.

[7] Shen W., Compton K., Huggins J.K. A Toolset for Supporting UML Static and Dynamic Model Checking. // In proceedings of the 26th International Computer Software and Applications Conference (COMPSAC 2002), Prolonging Software Life: Development and Redevelopment, Oxford, England, IEEE Computer Society, 2002, p. 147-152.

[8] O. Vasilecas, E. Lebedys. Business rules repository for business rules represented using UML // In R. Rachev, A. Smrikarov (Eds.). Proc. of the International Conference on Computer Systems and Technologies "CompSysTech ,05", Varna, Bulgaria, 16-17 June. 2004, p. II.5-1 – II.5-6.

[9] O. Vasilecas, E. Lebedys. Repository for Business Rules Represented in UML Diagrams // Izvestia of the Belarusian Engineering Academy, 2005, Vol. 1 (19)/2, p. 187-192.

[10] L. Whitman, B. Huff, A. Presley. Structured models and dynamic systems analysis: The integration of the IDEF0/IDEF3 modeling methods and discrete event simulation. // In the proceedings of the 29th Winter Simulation Conference, Atlanta, GA, 1997, p. 518-524.

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