

Techniques and Tools for Web Requirements in NDT, UWE and WebML

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Abstract: Requirements Engineering (RE) is one of the serious issues for software construction. In the scientific literature we can find several reasons of this affirmation, in spite of this, most of the development process of new software crash due to wrong requirements phase. Several proposals exist for requirements modelling, analysis and elicitation in Software Engineering (SE), however the current market is focusing on the development of Web and mobile applications, specially using Model-Driven methods, this is the reason why we consider it necessary to know the techniques and tools for requirements modelling, analysis and elicitation applied in Model-Driven Web Engineering in order to know their gaps and current trends to propose new solutions. To do this, the most important methods were selected outside the academic area such as NDT, UWE and WebML. A total of 63 publications from ACM, IEEE, Science Direct, DBLP and World Wide Web had been reviewed.

Keywords: Model-driven web engineering, Requirements techniques, Requirements tools, NDT, WebML, UWE.

1. INTRODUCTION

Lately, it has highlighted the victory that Model-Driven Development (MDD) have had for Web engineering (WE), namely Model-Driven Web Engineering (MDWE), this is mainly due to with the use of models it is possible to characterize, the functionality of the application, the needs of the user without ignoring the organizational goals, the business process and from this representation generating the source code. Numerous MDWE methods [2] such as NDT [3], UWE [4] and WebML [5] have been appeared for the development of Web applications by models, but just some of them rigorously complied with the proposal of the Object Management Group (OMG) for Model-Driven Development named Model-Driven Architecture (MDA) [6]. The basic idea of the use of MDA starts from the Computational Independent Model (CIM), in this first layer, the application requirements must be elicited and defined, such that we can generate through model-to-model transformations (M2M) the Platform Independent Model (PIM) to finish in the Platform Specific Model (PSM) with the source code. Unfortunately, most of the MDWE methods barely implements MDA from PIM to PSM leaving aside the requirements (CIM layer) despite of this is a critical phase on which the success of the development

depends directly. This fact can be seen in their support tools *i.e.*, code generation tools and modelling tools.

Requirements are essentially what the application is required to do [1], to obtain them we need techniques for recollection (elicitation), a method to examine them (analysis) and to know how represent them for its implementation (modeling). Requirements elicitation is a technique to collect the requirements; this is the main movement in the Requirements Engineering process [7]. It tries to find out the needs and to collect the appropriate software requirements from the stakeholder's. Therefore, this is a complex process as it decides which techniques should be used in a project, determining, learning, acquiring, discovering the appropriate techniques, so this may negatively influence the development process which results in system failures. Requirements modelling (models) are used when gathering requirements during analysis phase. Whether the development team considers eliciting requirements to be a separate activity, or a part of the analysis phase, this must be a high priority since this is used to discover and clarify the functional requirements for the Web application. According to [8], a requirements model helps to focus on the system's external behaviour, separately from its internal design; the description of the users' and stakeholders' needs with much less ambiguity than in natural language; to define a consistent glossary of terms that can be used by users, developers, and testers; to reduce gaps and inconsistencies in the requirements, to reduce the work needed to respond to requirements changes and to

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plan the order in which features will be developed. Additionally, the requirements models are used as specifications for the designers and developers. Requirements analysis is determining whether the stated requirements are clear, complete, consistent and unambiguous, and to resolve any apparent conflicts.

In MDWE, methods are based on MDA therefore requirements corresponds with the CIM layer, unfortunately, most of the methods starts its development process from the PIM (second MDA layer) to code (passing to PSM layer) leaving aside the CIM (requirements). In this context, we think that MDWE methods should adopt or develop new techniques for its appliance in Web application development from the CIM layer. The adoption of this idea will be useful in order to avoid classic problems presented in Software Engineering like the Web application may be delivered late, it will be may be more costly than the original estimation, end-user and customer will not be satisfied, the Web application may be unreliable and there may be regular system defects [7].

Bearing these considerations in mind, in this work is presented a compilation of techniques and tool's for requirements modelling, analysis and elicitation in the most well-known MDWE methods outside the academic field. Additionally, the tool's used or developed for support this phase on each method is analysed. It is important to highlight that this work is not address to establish a full critic approach since RE is more complex and is sub-divided in another phases like validation, management and so on. But we emphasize on modelling, analysis and elicitation of requirements because these are the starting points in any development process.

The rest of the paper is structured as follows: Section 2 presents requirements concepts used as basis for the analysis detailed in this work. Section 3 describes our analysis of MDWE methods as well as its requirements techniques and tool's. Finally, the conclusion and future work is presented in Section 4.

2. REQUIREMENTS MODELLING, ANALYSIS AND ELICITATION IN MODEL-DRIVEN WEB ENGINEERING METHODS

This section presents the literature basic concepts with regard to requirements modelling, analysis and elicitation focusing in aspects like its definition and the techniques for NDT (Navigational Development

Techniques), UWE (UML-Web Engineering) and WebML (Web Modelling Language) methods.

- Requirements modelling [9] techniques can be used to help deal with the knowledge and reasoning needed in this earlier phase of requirements engineering [10]. As requirements modelling techniques examples we have UML (Unified Modeling Language) Use Cases and BPMN (Business Process Modeling Notation). The purpose of use case is to present a graphical overview of the functionality provided by a system in terms of actors, their goals and any dependencies between those use cases. Also, it is useful to show what system functions are performed for which actor [11]. BPMN is a standard, graphical modeling representation for business processes and is independent of the implementation environment [12].
- Requirements elicitation is used to discover what problems need to be solved [1], and to identify the stakeholders, the objectives that the software system must attain, the tasks that users currently perform and those that they might wish to perform. This phase is often carried out through the application of Interviews, Questionnaires, Brainstorming and Prototyping. Interviews provide an efficient way to collect large amounts of data quickly. The results of interviews, such as the usefulness of the information gathered, can vary significantly depending on the skill of the interviewer [13]. There are fundamentally three types of interviews: unstructured, structured, and semi-structured. Questions must be focused to avoid gathering large amounts of redundant and irrelevant information. They provide an efficient way to collect information from multiple stakeholders quickly, but are limited in the depth of knowledge they are able to elicit. Brainstorming. This is a process where participants from different stakeholder groups engage in informal discussion to rapidly generate as many ideas as possible without focusing on any one in particular. It is important when conducting this type of group work to avoid exploring or critiquing ideas in great detail. It is not usually the intended purpose of brainstorming sessions to resolve major issues or make key decisions. This technique is often used to develop the preliminary mission statement for the project and target system. One

of the advantages in using brainstorming is that it promotes freethinking and expression, and allows the discovery of new and innovative solutions to existing problems [13]. Finally, Prototyping, this technique has been used for elicitation where there is a great deal of uncertainty about the requirements, or where early feedback from stakeholders is required. Prototypes help the system designers to build the information system according the requirements and easy to manipulate for end users. Even so, this is an iterative process and it is also part of the analysis phase of system development life cycle [7].

- Requirements analysis involves end users and systems analysts interacting in an effort to recognize and specify the data and information needed to develop an information system [14]. Recently, Goal-oriented Requirements Engineering (GORE) has become an important technique for this activity due to allow expressing conflict between goals and helps to make decisions that resolve conflicts. During early requirement analysis, the requirements engineer identifies the domain stakeholders and models them as social actors, who depend on one another for goals to be fulfilled, tasks to be performed, and resources to be furnished. Through these dependencies, one can answer why questions, besides what and how, regarding system functionality. Answers to why questions ultimately link system functionality to stakeholder needs, preferences, and objectives [15]. It is important to mention that some of the techniques described previously, such as BPMN and Use Cases, are applied in requirements analysis too.

Considering the definitions presented above, the methods NDT, UWE and WebML are introduced next:

- NDT covers the whole life cycle process in the development of Web applications, including testing or quality assurance phases. The method was proposed by the IWT2 (Ingeniería Web y Testing Temprano) research group from Universidad de Sevilla, Spain. Originally, this method was created only for requirements engineering purposes with regard to Web applications development, gradually it was growing until become a methodology.

- UWE is a method entirely based on the UML (Unified Modelling Language) covers the whole life cycle of the development of Web applications and RIA (Rich Internet Applications). UWE describes a systematic design methodology using exclusively UML techniques, the UML notation and the UML extension mechanisms. Its life cycle is based on MDA and in conjunction with the authors of NDT, proposes a requirements Metamodel named WebRE for model-to-model transformation, from the CIM to PIM layer. UWE emerged from the Ludwig-Maximilians-Universität München. Germany.
- WebML is a visual notation and a methodology for designing Web applications, this method provides graphical and formal specifications for the design process of Web applications. Recently, in 2013 this method (including its visual notation) was extended focusing on the modelling of user interfaces (front-end) and was then proposed at the OMG (Object Management Group) for being a standard, named IFML (Interaction Flow Modelling Language). WebML emerged from thesis students, researchers and partners at Politecnico di Milano within a spinoff. This is an important example from the research addressed to real-world projects.

In the next section is detailed the analysis achieved considering the fundamental concepts described in this section. The method used for the analysis is explained briefly in the following section.

3. THE RESEARCH METHOD

The purpose of this paper is to provide state of the art regarding requirements modelling, analysis and elicitation techniques used by MDWE methods as well as the tool support their offer. The method we used is described as follows: i) Definition of Research Questions (RQ's), ii) Definition of Search Sources, iii) Elaboration of Search String by means of the keywords extracted from the RQ's, iv) Filtering of the Documents Found and v) The Analysis. The research method is based on the Systematic Literature Review proposed by [16].

3.1. Definition of Research Questions (RQ's)

In general, this study aimed to answer the following RQ's:

- Which requirements modelling, analysis and elicitation techniques are currently supported for Model-Driven Web Engineering methods?
- Which methods provide tool support for requirements modelling, analysis and elicitation techniques?

3.2. Definition of Search Sources

With regard to the selection of search sources, in our work we used direct search in CONRICYT (<http://conricyt.mx>), ACM (<http://portal.acm.org>), IEEE (<http://ieeexplore.ieee.org>), Science Direct (<http://sciencedirect.com>), DBLP (<http://informatik.uni-trier.de>) and Google Scholar (<http://scholar.google.com>), used in order to obtain grey literature such as Thesis, Technical Reports, etc. In addition, we look into some of the most representative conferences such as ICWE (International Conference on Web Engineering), International Conference on Web Information System Engineering (WISE) and RE Conference (Requirements Engineering Conference). In accordance with the work of Brereton [17], these libraries were chosen because they are some of the most relevant sources in SE.

3.3. Elaboration of Search String

The structure of the RQ's was used as a basis to extract some keywords, which were then used to search for documents. We initially had the following keywords: Web, engineering, requirements, elicitation, MDWE, method and tools. However, in order to obtain specific results we decided to link Web with the keywords engineering and requirements, requirements with the keyword engineering, and the keyword Web with the keywords *engineering* and *methods*.

3.4. Filtering the Documents Found

The procedure for the analysis of the documents found was defined as follows: first title and abstract of the documents were read, only those that we considered relevant just in the case if some of the terms used in the search strings appeared in the title or the abstract. Then, the introduction and conclusion to those primary studies dealing with specific requirements modelling, analysis and elicitation issues were read. Finally, the whole document was then read.

3.5. The Analysis

This section presents and analyses the results obtained after performing the review. Features (derived

from RQ's) such as RE techniques and tool support are described for the NDT, UWE and WebML methods. We used these methods since there are those approaches that have been constantly being improved by research groups and used in software factories. Moreover, there have been several applications of those methods in real-world projects.

- NDT (Navigational Development Techniques), the RE process consists of three phases (capture, definition, and validation) by means of use case diagrams and a set of textual templates [18]. For requirements elicitation, NDT uses Interviews and Questionnaires. With regard to tool support [19], this is covered by NDT-Suite [20]. NDT hampers the development of a complex Web application, since templates are difficult to complete as they require intensive interviews [21] and they are difficult to maintain due to the use of textual templates for their specification.
- UWE (UML-Web Engineering) [22], since this method is based its development process on MDA [23], the requirements are considered in the CIM layer. This method proposes the use of Interviews, Questionnaires and Checklists for requirements elicitation [21]. A plug-in called Magic UWE was developed to be used with the CASE tool Magic Draw. Requirements elicitation support is missing in this tool.
- WebML (Web Modelling Language) [24]. This method uses UML Use Case and activity diagrams for requirements modelling, with regard to elicitation techniques, the author's states that this approach uses Interviews. However, recently, WebML has implemented the Business Process Modelling Notation (BPMN) through Model-Driven Web application generation, the approach transforms BPMN models into Web application models [25]. With respect to tool support, WebML has WebRatio [26], WebRatio BPM and WebRatio for Mobile devices. WebRatio provides the automatic generation of J2EE code for Web and mobile applications.

4. DISCUSSION

In this subsection we discuss one of the principal reason of what this methods are used outside the academic area in real-world projects, its support for requirements analysis, modelling and elicitation.

UWE and NDT are those methods, which have placed greater importance on RE by defining a set of formal guidelines to be used. In both approaches, the requirements are considered since the early phases of the development process making the development and maintenance of Web applications easier whilst fulfilling the project budget. There is a trend towards the use of interviews, since WebML, NDT and UWE use this technique for requirements elicitation. The techniques presented in this section have advantages and disadvantages, i. e., the use of interviews generates a lot of text, so, in a complex Web application development process is a disadvantage because it is difficult to maintain. This technique could, nevertheless, be extremely useful and comprehensible in the development of simple Web applications. We have seen that different techniques and approaches have different and relative strengths and weaknesses, and may be more or less suited to particular types of situations and environments. Likewise some techniques and approaches are more appropriate for specific activities and the types of information that needs to be acquired during those activities. For requirements modelling, WebML uses BPMN workflow diagrams to represent graphical notation for specifying business processes. However, a lot of the confusion and difficulty in the BPMN community is because some people think that BPM is a kind of SE. Indeed, superficially it looks like SE starts with requirements and the pieces of information are then determined in order to be stored and retrieved from variables, and in the end you have something that can be installed and executed on networked computers. But there is a difference, and that difference is the entire reason that BPM exists, since SE sees BPMN as simply another exercise in converting a drawing (model) into an executable program. With respect to GORE, goals are seen to have substantial promise in aiding the elicitation and elaboration of requirements. This is due to they are often unclear when first were elicited from clients and stakeholders. The introduction of goals offers one way of clarifying requirements [27]. Analyzing requirements in terms of goal decomposition and refinement can be seen as teasing out many levels of requirements statements, each level addressing the demands of the next level [28]. In addition, requirements must eventually lead to design and implementation and, according to [29], goals have been used as an important mechanism for connecting requirements to design.

With regard to tool support, all the methods described in the previous section have a tool support

for its method, NDT it's supported by NDT-Suite; WebML have the tool named WebRatio; and UWE by Magic UWE. For requirements support tool, only NDT and UWE have it. NDT does this using the NDT-Suite, which is a set of tools currently in version 2.3 under the Model-Driven paradigm and offers a solution for Web application development. These tools explore different options that this paradigm can improve such as, development and quality. UWE provides a tool developed for the computer-aided design of Web applications named Magic UWE, which is built as a plug in for Magic Draw 18.0.

Finally, it is important to mention that UWE and NDT implements UML by means of UML profiles and UML Use Cases for modelling and elicitation. According to [30], this is important since UML is a widely accepted standard for software modelling which give some advantages to software developers since they don't have to learn another modelling language for Web application development. But recently, the authors of NDT and UWE combines some ideas (in the context of the MDD) creating a metamodel for requirements specification on which is more sophisticated the generation of conceptual models from requirements named WebRE [31].

5. CONCLUSIONS AND FUTURE WORK

Requirements analysis, modelling and elicitation are fundamental activities in Requirements Engineering and demand the use of certain techniques. Selecting the right techniques has a pertinent influence on the quality of a software system. According to [32], the success of this stage does not depend entirely on the selection of techniques, because, due to the heterogeneity of stakeholders, this process must be carefully handled by effectively applying the appropriate techniques towards the people. This paper has presented a review about the modelling, elicitation and analysis techniques used by NDT, UWE and WebML methods, we analysed its techniques and tools. The review results suggest that elicitation techniques appear to be relatively mature, although new areas of creative requirements are emerging in order to improve current MDWE methods, especially for RIA (Rich Internet Applications) support. For future work, we are collaborating with ProTech I+D, which is a software factory, in order to develop a tool for support RE during its development process. The basic idea is that the tool must be compatible with the WebML approach since this is the one we detected that does not have a well-defined Requirements Engineering

phase, basically is only focused on its development tool WebRatio (used for Web application development and the latest version for mobile application development), thus, we think that we can integrate our tool with its approach for MDWE or to define a Web engineering method from requirements to implementation.

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