Requirements Engineering in the Development Process of Web Systems: A Systematic Literature Review

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Abstract: Requirements Engineering (RE) is the first phase in the software development process during which designers attempt to fully satisfy users' needs. Web Engineering (WE) methods should consider adapting RE to the Web's large and diverse user groups. The objective of this work is to classify the literature with regard to the RE applied in WE in order to obtain the current "state-of-the-art". The present work is based on the Systematic Literature Review (SLR) method proposed by Kitchenham; we have reviewed publications from ACM, IEEE, Science Direct, DBLP and World Wide Web. From a population of 3059 papers, we identified 14 primary studies, which provide information concerning RE when used in WE methods.

Keywords: Web Engineering; Systematic Literature Review; Requirements Engineering; Model-Driven Engineering

1 Introduction

A Web system (WS) is an application that is invoked with a Web browser over the Internet. This application has a set of special features, such as the inclusion of a multidisciplinary team for its development and its large and heterogeneous user community. Web systems are widely accessed by different types of users who have different needs, goals and preferences. These systems must additionally satisfy the needs of many types of stakeholders apart from the users themselves, e.g., the people who maintain the system, the organization that requests the system, or those who fund the system development budget. Special requirements must consequently be considered during the development of Web systems: (i) what information should be provided (content requirements), (ii) which scenarios should be defined in order to provide this information (navigational requirements), (iii) how the user or groups of users should be provided with this information and

(iv) how quality should be evaluated, which is in some cases encompassed in Non-Functional Requirements (NFRs) or named quality attributes, e.g., how to make Web content accessible to people with disabilities [1]. The development process therefore necessitates knowledge and expertise from many different disciplines and requires a team of diverse groups of people with a high degree of expertise in different areas [2], such as developers, designers and so on, thus making this process even more complex and difficult than normal software development. This has led to the appearance of WE methods such as OOH [3], WSDM [4], WebML [5] and UWE [6] which provide different mechanisms that can be used to consider the content, composition, and navigation features of Web systems, including the appropriate steps needed to consider requirements [7].

Bearing these considerations in mind, this paper presents a Systematic Literature Review (SLR) in order to analyze the current state-of-the-art with regard to Requirements Engineering (RE) in Web Engineering (WE), thus revealing the activities that are implemented, such as elicitation, analysis, specification, validation and management. An SLR is a means of identifying, evaluating and interpreting all the available research that is relevant to a particular research question, topic area or phenomenon of interest. It originated in the field of medical research and was successfully adapted to Software Engineering (SE) by Kitchenham [8].

In our previous work [10], we developed an initial SLR in which we began to highlight the importance of considering requirements during the development of Web systems. In the current SLR we have now improved many parts of the paper and have added a lot of new material. For example, one of the weak points of the previous SLR was the search strategy, and this has now been improved. More methods have consequently been added to the review (OOHDM [28] and HERA [38]). What is more, the study has been focused on analyzing the RE activities (elicitation, analysis, specification, validation and management) implemented in each of the WE methods investigated, how the requirements are dealt with as regards RE activities and how these methods have been released into the academic community, with special emphasis on their implementation in industrial projects and the tool support they offer for the entire development process and for RE. We have also analyzed the requirements terminology (terms used to name the special requirements for WS) adopted by each method in a more methodical and comprehensive manner based on the classification previously presented by Escalona and Koch [7].

The remainder of this paper is structured as follows: Section 2 presents those RE and WE concepts that are relevant to the context of this paper. The SLR is detailed in Section 3. The Research Questions are answered in Section 4, in which an analysis and discussion of this work and suggestions for future research are also presented. Finally, our conclusions are provided in Section 5.

2 Requirements and Web Engineering Concepts

Requirements Engineering (RE) is the process of discovering, analyzing, documenting and verifying the services that should be provided by software, along with its operational constraints [84]. Various approaches have been used to define RE activities, such as those proposed in [11, 12], and these activities widely differ from each other for several reasons, e.g., depending on the application domain, the people involved and the organization developing the requirements. However, there are a number of generic activities that commonly appear in all of them, such as elicitation, analysis, specification, validation and management. These are detailed as follows:

- Elicitation, whose goal is to discover what problems need to be solved [12], and to identify the stakeholders, and the objectives that a software system must attain. It is carried out through the application of various techniques [13, 14, 15], such as questionnaires, brainstorming, prototyping and modeling techniques, e.g., goal oriented based methods [16].
- Analysis, which includes the creation of conceptual models or prototypes with which to achieve the completeness of the requirements and deals with understanding an organization's structure, its business rules, goals and tasks, and the data that is needed. [84].
- Specification, which is an integral description of the behavior of the system to be developed. The most widely used techniques are templates, scenarios, use case modeling, and natural language [17].
- Validation. The aim of this phase is to establish whether the requirements elicited provide an accurate representation of the actual *stakeholder* requirements. Some of the techniques employed are reviews and traceability [18], [19].
- Management**,** which consists of recognizing changes through the use of continuous requirements elicitation, and includes techniques for configuration management and version control [20].

After this overview of RE concepts, it is worth noting that the development of WSs involves particular requirements that are different from traditional software requirements, as defined in the seminal work of Escalona and Koch [7], e.g., the authors put forward the argument that Functional Requirements (FRs) for WE are related to three main features of WSs: navigational structure, user interface and personalization capability. An overview of each kind of requirement is provided as follows: i) Content: This is the information that should be presented to users, e.g., in an online bookstore one example might be the information about a "book". ii) Service: The internal functionality with which users are provided. Following the online bookstore example, e.g.: "register a new client". iii) Navigational: The navigational paths the user can follow, e.g., user navigation from the "index page"

to different menu options such as “consult products by category”. iv) Layout: This defines the visual interface for users, such as “a color style”. v) Personalization: Personalization actions to be performed by the Web systems e.g. “show recommendations based on interest in previously acquired books” and vi) Non-Functional: These are related to quality criteria, e.g., “good browsing experience” and “improve efficiency”.

This classification of requirements is used throughout this SLR for the sake of understandability and completeness.

3 The Systematic Literature Review

The objective of this SLR is to summarize the information concerning how RE activities are applied in WE in order to detect avenues for future research.

3.1 Research Questions

According to [8], the question structure is divided into four aspects known as PICO (Population, Intervention, Comparison and Outcomes). The term Population refers to the people, projects and application types affected by the intervention. Intervention concerns the software technology, tool or procedure that generates the outcomes. Comparison refers to another type of intervention – if applicable – while Outcomes are the technological impact on relevant information terms for practical professionals. This PICO strategy has been used as the basis for our research and is use in this context is described as follows:

- Population: the population is composed of designers and developers who request a method in order to obtain more robust process support, and of researchers in the WE field who aim to develop new methods.
- Intervention: this review must search for indications that the development of WSs can be fully supported by a systematic process and a specialized tool.
- Comparison: not applicable.
- Outcomes: the objective is to demonstrate how a systematic process supports the development of WSs and whether or not the process is fully supported with regard to RE activities.

Our research questions (RQ), which are based on the aforementioned strategy, are:

RQ1. - Which of the existing methods for the development of Web systems are based on a systematic process? There are several WE methods for the development of WSs, but not all of them are necessarily based on a systematic method covering all the activities of the development process.

RQ2. -Which RE activities are supported by each method and the techniques used? The RE activities adapted to be applied in WE in each method are studied along with the techniques that they use, e.g., UML Use Cases.

RQ3. - Is there any common terminology with regard to RE that is applied by the existing methods? To detect the way in which the requirements are denominated by each WE method, e.g. "Functional Requirements" can be called "Service Requirements" and "NFRs" can be termed as "Softgoal's", and it is therefore necessary to establish a universal means of denominating Web requirements.

RQ4. – Which methods provide tool support for their development processes? To analyze those WE methods that provide tools covering the development process, including the RE activities.

3.2 Search Strategy

The search strategy should be systematic. According to [8, 9], it is necessary to use search engines by applying a combination of search terms (keywords) extracted from RQ's. Experts should then verify and review the search results. Once the steps to be followed in the search process have been defined, it is necessary to state the resources that are available to conduct the review of primary studies (individual studies contributing to an SLR). The research sources used are repositories with restricted access such as: ACM, IEEE, Science Direct, DBLP Computer Science Bibliography, World Wide Web: Google Scholar. In accordance with Brereton [22], these libraries were chosen because they are some of the most relevant sources in SE. Furthermore, Google Scholar was selected to complete the set of conferences and workshops searched and to seek grey literature in the field (white papers, PhD theses), and the results obtained were then compared with the works found using the search strings.

The structure of the research questions was used as a basis, to extract some keywords, which were then used to search for primary studies. We initially had the following keywords: *Web*, *engineering*, *requirements*, *development*, *method* and *tool*. However, in order to obtain more concrete and specific results in the field, 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*. In this respect, the choice of concatenating "Web" with "engineering" was motivated by our goal, which was to retrieve papers specifically focused on RE in the Web domain. The search string "(Web OR WWW OR World-Wide Web OR Internet) AND engineering" was not therefore considered. The search string was used in all instances, even when examining papers from special issues on Web Engineering. Moreover, a list of synonyms was constructed for each of these keywords. Nevertheless, other words were also added in order to increase the size of potential relevant studies: *system*, *techniques*, *phase*, *and design*. These words were linked with the keywords *Web*, *requirements*, *methods*, *engineering* and *tool*. In order to avoid imprecise results,

we used the SLR proposed by Walia and Carver [23] and the review by Beecham [24] as a basis to create a specific type of string for each search engine (using the list of synonyms), thus making the search as accurate and comprehensive as possible. The search covered is the time period from 2009 to early 2015. This was initially 2014, but we then decided to extend the period to the first months of 2015 in order to obtain better results. Moreover, the corresponding authors of the main texts were e-mailed directly to clarify some particular issues regarding their Web methods, e.g. the authors of NDT and UWE. Finally, the references found in our primary studies and in renowned conferences such as the International Conference on Web Engineering (ICWE) and Web Information Systems and Technologies (WEBIST) were used to search for publications in order to ensure that no major works had been missed.

3.3 Inclusion and Exclusion Criteria

Essentially, only those publications from the RE literature regarding the development of WSs based on a method for specific use in the WE field were considered. Although our research questions are related only to WE methods, this SLR includes the primary studies related to the RE in the Web field and we therefore deemed that at least the part related to the use of one of the RE activities in WE must be present in each primary study, since we assumed that not all methods implement another RE phase. We chose the following inclusion criteria in order to select the relevant publications required to answer our research questions: i) Publication date between 01/01/2009 - 01/01/2015, ii) Requirements phase of WS development process, iii) Explicit mention of WE, iv) Relevance with regard to research questions and v) WE methods with tool support. The exclusion criteria were: i) Topics that do not match the RE activities implemented in Web methods and ii) Duplicated documents from the same study.

3.4 Study Quality Assessment

The place of publication and the diffusion of the methods were used as indicators when performing the quality assessment. The place of publication refers to the journals and conferences in which the primary studies were published (this applies to Google-Scholar which searches for a wider spectrum of papers such as white papers). The diffusion of the methods corresponds to the academic or industrial application of the method, including tool support and whether the tool is a prototype or an industrial-commercial tool. The first search, during which no exclusion criteria were applied, returned a total of 3059 documents of which 70 documents were duplicated. After applying the exclusion criteria (a further review round), 14 documents were eventually considered. It is important to mention that the activity during which publications were searched for was checked by two individual authors of this work in order to verify the quality of the place of publication. The quality assessment was then performed separately to verify the information extracted.

3.5 Data Extraction

The goal of this phase is to design data extraction forms with which to accurately record the information obtained from the primary studies. This form must be designed in such a way that all the information required can be collected in order to fully address the research questions. It was at this point of our SLR that the data extraction was performed. We used a form to store the information extracted from the search results, storing the publication title, the journal or conference/workshop in which the paper was published, the publication date, the main author, the RE techniques, the shortcomings with regard to RE and the tool support.

After quality assessment, the data synthesis was performed. This was done by collating and summarizing the results of the primary studies, which are: *Metamodeling the requirements of Web systems* [31]; *Model transformations from requirements to web system design* [32]; *Requirements engineering for Web Applications - a comparative study* [7]; *Introducing requirements traceability support in model-driven development of web applications* [33]; *The object-oriented hypermedia design model* [30]; *Integrating usability requirements that can be evaluated in design time into Model Driven Engineering of Web Information Systems* [34]; *From task-oriented to goal-oriented Web requirements analysis* [35]; *Transformation techniques in the Model-Driven Development Process of UWE* [36]; *NDT. A Model-Driven Approach for Web requirements* [27]; *A requirement Analysis Approach for Using i* in Web Engineering* [21]; *Web Modeling Language (WebML): a modeling language for designing Websites* [5]; *WSDM: a user centered design method for Web sites* [37]; *Hera: Development of semantic web information systems [38] and Extending a Conceptual Modeling Approach to Web Application Design* [39]. In this respect, it is important to mention that the synthesis of these primary studies was descriptive (non-quantitative) [8, 9] and was carried out by answering the RQ.

4 Data Analysis

This section presents and analyzes the results obtained after subjecting the primary studies to the extraction and data synthesis activities. The selected studies provided relevant evidence with which to satisfactorily answer the four RQs, as described below:

RQ1. - Which of the existing methods for the development of Web systems are based on a systematic process?

The methods extracted from the selected publications were OOWS [25], NDT [27], OOHDM [28, 29, 30], A-OOH [21, 40, 41, 42, 43], UWE [6, 32, 36, 56], WSDM [4, 37, 44], WebML [5, 45, 46, 47], and HERA [38, 48]. Since the A-OOH [54], OOWS [49, 50] and UWE [56] methods have a development process

that is based on Model-Driven Architecture (MDA), a three layer architecture, the process is considered from the first layer, which is the reason why the requirements are considered from the early stages of the development process, thus making the development and maintenance easier, whilst fulfilling the project budget. The other methods, NDT [32] and Hera [38], meanwhile, have a development process that is based on Model-Driven Development (MDD). At this point it is important to highlight the work in [51], which presents a review (not an SLR) describing various MDWE (Model-Driven Web Engineering) methods (methods selected according to the author's own opinion without using selection criteria) that have been proposed, and discusses the advantages and disadvantages of these methods with regard to best practices in WS development. As our work focuses on RE activities and the tool support for development and the terminology used by each one, we did not extract information about the methods presented in the aforementioned review because it contained no relevant information that could be used to answer our research questions.

RQ2. - Which RE activities are supported by each method and the techniques used?

Almost all the methods analyzed in this SLR consider at least one of the RE activities, the exception being HERA since it does not have an explicit requirements phase. UWE, NDT and A-OOH are those methods which have placed greater importance on the RE activities by defining a set of formal guidelines to be used. The only method covering all the RE activities (elicitation, analysis, specification, validation and management) is NDT, which was initially created for the RE for hypertext applications and has been improved over the years to become a full WE method. The methods that do not place very much importance on RE activities are OOHDM and HERA since they only cover requirements specification. Requirements management is also one of the most important activities and one of those least covered, except by NDT [31] and A-OOH which support it by means of change impact analysis (CIA) [52], [43].

With regard to the techniques applied by each RE activity method, we have discovered that the methods use a specific set of technologies (Table 1) and that there would appear to be a trend toward the application of the UML (Unified Modeling Language) Use Cases, since OOWS, WebML, NDT, UWE and OOHDM use this technique in the requirements specification phase. There is also a trend toward the persistence of UML Profiles. The techniques extracted from the methods analyzed in this review are: Use Case Diagrams, a Data Dictionary, Conceptual Maps, the Functional Refinement Tree (FRT), UML-Profiles, Task Diagrams, Textual Templates, a Goal-oriented Requirements Engineering (GORE) modeling language named i*, Activity Diagrams, Interviews, Questionnaires and Checklists. Another technique that is widely accepted is that of Use Case Diagrams, which are used in traditional SE, and it is not surprising that WE methods also use them to model scenarios that may occur, when the user interacts with a WS. Moreover, with regard to UML, UML Profiles have recently

been adopted to provide a generic extension mechanism with which to customize UML models for particular domains, the technology used to do so being the Eclipse Modeling Project [53] by means of ECORE models. These profiles are applied by UWE [31], NDT and A-OOH [54]. Another UML technique that is applied by WebML and UWE is the Activity Diagram**,** which is a complementary technique for use case diagrams that is employed to model the logic captured by a single use case.

Table 1
The Requirements Engineering techniques used by each method

RE Technique	**UWE**	**NDT**	**WebML**	**OOWS**	**OOHDM**	**WSDM**	**A-OOH**
Use Cases	x	x	x	x	x		
Data Dictionary						x	
Conceptual Maps						x	
Functional Refinement Tree (FRT)				x			
UML-Profiles	x	x					x
Task Diagrams				x			
Textual Templates	x	x				x	
*i** Framework							x
Activity Diagrams	x	x	x				
Interviews	x	x					
Questionnaires	x						
Checklists	x	x					

GORE is applied in RE activities, and more specifically the *i** language [16] used by A-OOH [21] which is adapted by using an ECORE metamodel rather than UML-Profiles [54]. The *i** language has proved to be useful for representing: (i) the *stakeholders'* intentions, i.e., their motivations and goals, (ii) dependencies between *stakeholders* in order to achieve their goals, and (ii) the (positive or negative) effects of these goals on each other in order to be able to select alternative designs for the system, thus maximizing goal fulfillment. One of the basic problems with *i** is the growing requirements model (the scalability of the requirements model): when more requirements are set, the model tends to grow too much, and reading it therefore becomes complicated. This problem was recently solved [55] through the implementation of modules, i.e., the equivalent of UML Packages, in order to group the requirements according to two types of requirements (navigational and service). Another GORE technique used in WE is WebURN [57], a notation for early requirements analysis. NDT [27] and WSDM [58], meanwhile, apply Textual Templates for requirements specification. This technique is only applicable when the project is not very large; otherwise textual descriptions will grow significantly, thus making their maintenance and analysis

difficult. This technique can be applied in combination with use case diagrams, which is helpful for the developer depending on the level of granularity of the diagram in question.

The OOWS method uses Task Analysis and the Functional Refinement Tree (FRT) for requirements specification [59, 60]. Task Analysis is a hierarchical representation of which steps have to be performed in a task in order to achieve a goal. Since professionals often perform this, it usually depends on the analyst's experience. The FRT represents a hierarchical decomposition of the business functions of a system that is independent of the actual system structure. The authors of this method are currently working on a technique for the specification of requirements through the use of ontologies in order to solve this drawback.

The Conceptual Maps of Roles and Activities and a Data Dictionary [37, 58] techniques are used by WSDM. They are difficult to maintain and analyze owing to the fact that the requirements are basically defined in textual form. At this point, it is important to highlight the difference between a Data Dictionary and Textual Templates: a Data Dictionary is used to explain the semantics of words, the concepts or the terms that were used during the development process, while a Textual Template is a text structure defined by the methodology used in order to describe a particular functionality of the system that will be created, i.e., in use cases, a template can be added to describe the navigation of the WS, whereas the text descriptions, which are used in use cases, allow the artifact to be enriched, thus making it much easier to understand. Describing navigational requirements by means of textual descriptions is not an easy task owing to the description of alternative navigation paths through the Web system. The last technique is the User Interaction Diagram (UID), which is used by OOHDM to specify the interaction described in a Use Case for validation purposes and to support communication between the designer and users [28, 30, 61].

In summary, these techniques have advantages and disadvantages, e. g, the use of text for requirements specification in a complex development process is a disadvantage, because it is difficult to maintain, although it may nevertheless be extremely useful and comprehensible in the development of a simple Web system. With regard to Task Analysis, this is a set of techniques which is intended to provide a researcher with a complete understanding of what tasks a user really performs, what is needed to carry out those tasks, and what tasks a user should be doing, but this technique can be extremely time and resource consuming.

RQ3. - Is there any common terminology with regard to RE that is applied by the existing methods?

All disciplines needs a mutual terminology, which is required to allow researchers to understand and cooperate with each other, thus providing the basis for an improvement to the research and the reporting of processes in a particular research topic and making the findings from several empirical studies understandable. The research addressing requirements in WE has produced a heterogeneous

terminology for requirements that hinders further progress. A unified vocabulary, which is proposed in [7] (Section 2), is provided to shed light on (i) the expressivity of current methods when considering requirements in WE, and (ii) the correspondences between the custom terms applied to refer to requirements used by each method with the aforementioned classification. An overview of this is shown in Table 2, in which the cell labeled with an "X" indicates that the requirement is not explicitly considered by the method and the last column, labeled "NFRs", indicates that the method denominates non-functional requirements in general as "NFRs". In other words, the method does not use a specific term for each type of non-functional requirements. Of all the methods mentioned in the answer to RQ1, only A-OOH [21], UWE [56], WebML [45], OOWS [62], and NDT [27] cover all the types of requirements mentioned in [7]. However, they use their own terminology to denominate each type of requirement (its custom terms), with the exception of A-OOH, which applies the classification directly [54].

Table 2
Terminology used by each method in order to denominate its requirements

Classification / **Method**	**Content**	**Service**	**Navigational**	**Layout**	**Personalization**	**NFRs**
UWE	Content	Process	Navigation	Presentation	Adaptation	NFRs
NDT	Storage Information	Functional	Interaction	Interaction	Actor	NFRs
WebML	Content	Service	Navigational	Presentation	Personalization	NFRs
WSDM	Content	Functional	Navigational	X	Personalization	Security, Usability
OOWS	Functional	Functional	Navigational	Presentational	Presentation	NFRs
OOHDM	Content	X	Navigational	Layout	X	X
HERA	Content	Service	Navigational	Presentation	Personalization	X
A-OOH	Content	Service	Navigational	Layout	Personalization	Softgoal

Although the methods presented in Table 2 share, in a few cases, a term with the same name from the classification, some of them are used to consider an extra functionality, i.e., NDT includes Navigational and Layout requirements in the concept of Interaction Requirements and OOWS uses Content and Service requirements within FRs [59], [60], [62]. Finally, NFRs are considered in a very general way by basically all the methods. The only methods that consider NFRs in a more detailed form are WSDM [58] and A-OOH [63]: WSDM details Security and Usability NFRs and A-OOH considers the common types of NFRs within the

concept of "Softgoal", which is a general concept that can be used to represent any kind of NFRs in GORE.

RQ4. - Which methods provide tool support for their development processes?

All the methods provide tool support for their development process. NDT is supported by NDT-Suite [26, 27, 64], WSDM has WSDMtool [49, 65], WebML is supported by WebRatio [46, 66], UWE by MagicUWE [67], OOWS uses OlivaNova, OOHDM has OOHDM-WEB, Hera uses two tools, Saxon 7.0 and Sesame, and A-OOH has the WebREd-Tool [69]. With regard to RE activities, only NDT, UWE, OOWS and AOOH have tool support. NDT does this by means of NDT-Suite, UWE provides a Magic Draw plugin, the so-called MagicUWE, OOWS combines OOWS-Suite with the OlivaNova tool (deprecated) and OOWS-Suite [50], and A-OOH is supported by a set of Eclipse plugins [68], WebREd-Tool [40, 69], which won the best software demo award at the ICWE conference [40]. In terms of tool support for specific RE activities, the NDT, OOWS and A-OOH methods implement special techniques, i.e., A-OOH provides traceability support by means of an Eclipse plugin with which the requirements are specified, and when the generation of the conceptual models is performed, a weaving model is created to store the traces among requirements and the conceptual models, which is CIM-PIM in an MDA process [41]. NDT does this by means of the NDT-Suite, using traceability matrices [64]. OOWS uses two tools, the first of which is the open source tool called AGG (Attributed Graph Grammar System) and the second of which is called TaskTracer and is used to generate traceability reports [33]. With regard to the impact of changing a requirement, A-OOH supports CIA [52], which consists of verifying the impact resulting from the change made to any conceptual model after a requirements modification, while the WebREd-tool generates a report containing the requirements affected as the result of a change.

The answers to the RQs have allowed us to establish an analysis accompanied by suggestions for the dissemination of the methods studied in this SLR in the academic and industrial area, along with a list of suggestions for future research.

4.1 Dissemination of the Web Engineering Methods

The dissemination of the different methods is a highly important issue since it assists in the realization of important advances in the standardization of Web system development. The methods must be well known in both the academic world and the software industry. In this respect, it is worth mentioning the support offered by NDT, WSDM, UWE and WebML through their websites because all of them provide everyone who visits their websites with examples, published papers and their respective tools, with the exception of WSDM, which only offers the downloading of published papers because the tool's license is not free. In the particular cases of NDT, UWE and WebML, they provide guided step-by-step

examples with which to study and practice the development of WS using their respective support tools. This confirms why these methods are those most frequently used in academic and industrial projects. It is important to highlight the progress of the WebRatio tool (from WebML) since this has become an international spin-off enterprise and is derived from the definition of the IFML (Interaction Flow Modeling Language), which is the first language designed to express the content, user interaction and control behavior of the front-end of software applications, a standard designed by the OMG (Object Management Group) [70]. Several works have been carried out using this method, such as those presented in [71] and [72]. For more information about WebRatio, the authors' presents some lessons learned in [73].

4.2 Suggestions for Future Research

Empirical studies such as that by Nuseibeh [12] demonstrate that efforts made to provide a detailed business model with which to capture the *stakeholders'* requirements considerably reduce drawbacks in later phases of the development process. This idea will be used as a basis to conclude this analysis with some suggestions for future research: several of the WE methods do not support more than one RE activity, and this deficiency must be resolved, since the main purpose of RE is to facilitate the understanding of the product under development and the ability to manage any changes that occur during the development process. The development of robust tools for MDD covering the MDA life cycle is necessary, since MDD is a current trend (whose advantages have been studied [76]) and most WE methods implement it. The dissemination of the methods is a highly important issue in the standardization of WE. The normalization of the way in which requirements are denominated by each method is therefore necessary, because all disciplines need a mutual terminology, which is required to allow researchers to understand and cooperate with each other, thus providing the basis needed to improve the research area. Finally, although various studies regarding the benefits of MDD in a development process have been conducted [76], only a few of them refer to the WE domain ([51], [74] and [75]), which is why it is necessary to conduct more studies in order to validate and support its potential application.

Conclusions

This work presents the results obtained after carrying out an SLR. The aim was to create a comprehensive review and synthesis of the current state-of-the-art in the literature related to the RE activities in WE. To do this, a total of 3059 papers published in the literature and extracted from the most relevant scientific sources were considered, of which 14 were eventually analyzed in depth. The results of this SLR have shown that WE methods have not been designed to properly address development through the application of RE activities. What is more, they simply place less relevance on it or their corresponding techniques are poorly applied.

The relevance of a detailed and precise specification of requirements is well known; it helps to achieve an agreement with the customer, as regards to software functionality, user friendliness and priorities in the development process. However, the modeling of requirements does not occur in many projects, particularly in the Web domain, mainly owing to its special characteristics, its multidisciplinary development teams and its short time-to-market. Web systems can no longer be considered as common software systems owing to the diversity of users who access these applications. It is therefore necessary to provide solutions within the WE field, in order to specify and develop this type of system by considering the huge heterogeneous user population, their needs and goals. Our future work will include a MDD method guided by the RE activities, into which, techniques will be integrated for the automated generation of Web systems by means of an open source tool.

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