Improving Requirements Specification
in WebREd-Tool by Using a NFR's Classification

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Abstract. In Software Engineering (SE), a system has properties that emerge from the combination of its parts, these emergent properties will surely be a matter of system failure if the Non-Fuctional Requirements (NFRs), or system qualities, are not specified in advance. In Web Engineering (WE) field occurs very similar, but with some other issues related to special characteristics of the Web applications such as the navigation (with the application of the security). In this paper, we improve our Model-Driven tool, named WebREd-Tool, extending the requirements metamodel with a NFRs classification, the main idea is to help the Web application designer with the NFRs specification to make better design decisions and also to be used to validate the quality of the final Web application.

Keywords: Web Engineering, Requirements Engineering, Softgoal, GORE, i-star, A-OOH, NFRs, WebREd-Tool, MDE, MDD.

1 Introduction

Throughout the years, several methods for the development of Web applications (OOWS [1], WebML [2], NDT [3] and UWE [4], A-OOH[5]) have emerged [6], regrettably, only a few offers methodological support for the Requirements Engineering (RE) stage. Nevertheless, the complexity and continuos evolution of the Web applications demands the development of methods and tools (specially) for helping the developer's to perform the RE process [7] in order to improve the Web Engineering (WE) field. In this respect, the developer needs solutions (tool support) that take into account both Functional (FR) and Non-Fuctional (NFR) Requirements from the beginning of the Web application development process, what undoubtedly, will help to assure that the final product corresponds qualitatively to the users expectations. Functional Requirements (FRs) describes

the system services, behavior or functions, whereas Non-Fuctional Requirements (NFRs), also known as quality requirements, specify a constraint in the application to build or in the development process [8].

An effective definition of requirements improves the quality of the final product, in this context, NFRs are critical to the successful implementation of almost every non-trivial software system, this is evidenced by the fact that many documented system failures are directly attributed to the inadequate implementation and maintenance of NFRs [9]. Unfortunately, in most of the Web Engineering approaches, a complete analysis of requirements is performed considering only FRs, thus leaving aside the NFRs until the implementation stage [10]. Following this evidence, there have been many attempts to provide techniques and methods to deal with some aspects of the RE process for the development of Web applications, but there is still a need for solutions which enable the designer to consider both FR and NFRs involved in the Web application development process [11] from the initial stage (requirements stage).

As a fact, requirements are ambiguous during elicitation process, but the introduction of the concept of *goals* helps in dealing with ambiguity and clarifying requirements. In recent years, the inclusion of Goal-oriented Requirements Engineering (GORE) in Web Engineering [7,5,12] offers a better analysis in Web application design due to the fact that requirements are explicitly specified in goal-oriented models, thus supporting developers in evaluating the implementation of certain requirements (FR and NFRs) for desigining successful software and the ability to reason about the software, the organization and the stakeholders goals in the same analysis. This has allowed the stakeholders to choose among the design decisions that can be taken to satisfy the goals and evaluate the implementation of certain requirements in particular (including NFRs). In this field, FRs are related to goals and sub-goals whereas NFRs are named softgoals, commonly used to represent objectives that miss clear-cut criteria, thus, analyzing Non-functional Requirements in terms of goals help in refining, exploring alternatives and resolving conflicts.

This paper is as extension of our recent work [12] about the importance of take into account those components from Requirements Engineering (RE) which are not considered with the necessary emphasis in Web Engineering field such as: Change Impact Analysis (CIA)[13,14], Requirements Traceability (RT) [15] and Non-Functional Requirements Optimization [16]. To this aim, we improve our Model-Driven tool named WebREd-Tool[1] adopting a NFRs classification in order to support the designer to make better design decisions and also to be used to validate the quality of the final Web application. In particular, the novelty of our ongoing work presented in this paper consists of: (i) the conduction of a literature review related to NFRs classification; (ii) the realization of an analysis of the most common Non-Fuctional Requirements used in Web and the

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[1] The WebREd-Tool was the best demo tool and poster winner in the International Conference on Web Engineering 2012 (ICWE), developed in conjunction by the Universidad Autónoma de Sinaloa (Mexico), University of Alicante (Spain) and the Universidad Politécnica de Valencia (Spain) [17].

elaboration of a proposal for a basic classification of Non-Functional Requirements for Web Engineering, to do it, six type of NFRs have been considered due to they are the most commonly used in the Web Engineering field: *Usability*, *Performance*, *Reliability*, *Safety*, *Security* and *Efficiency*; (iii) the integration of NFRs classification in the Web requiremens metamodel used by the WebREd-Tool for requiremens specification, the integration consist in the specialization of the softgoal element from the graphic language used by the WebREd-Tool for Web requirements specification (*i** modeling language [18]).

The main benefit of our approach is that provides specific information about the different NFRs involved during the development process from the initial stage, thus allowing developers to make more informed design decisions for implementing a Web application that fully-satisfies the user expectations. Finally, it is important to mention that the WebREd-Tool is the proof of concept of our Goal-oriented Requirements Engineering (GORE) approach for requirements specification in Web Engineering [6,12].

The rest of the paper is organized as follows: Section 2 presents some related work relevant to the context of this work. Section 3 describes our GORE proposal where is found the contribution of this work. In Section 4, our Model-Driven tool, WebREd-Tool, is shortly described. The specialization of the requirements specification for the NFRs and its application is described in Section 5. Finally, the conclusion and future work is presented in Section 6.

2   Background

Recent studies with regard to Requirement Engineering techniques for the development of Web applications [19] have highlighted that most of the Web Engineering approaches focus on the analysis and design stages and do not give a comprehensive support to the requirements stage (such as WebML [2], OOHDM [20], WSDM [21] or Hera [22]). In some cases, NFRs are considered in a very general manner by almost all the approaches and only two of them, namely NDT and WebML, also provides dedicated tool support, as reviewed in [2] and [3].

Regarding approaches that consider NFRs requirements from early stages of the development process, in [23] the authors propose a metamodel for representing usability requirements for Web applications and in [10] the authors present the state-of-the-art for NFRs in Model-Driven Development (MDD), as well as an approach for considering NFRs into a MDD process from the very beginning of the development process. Chung [24] adopted a goal and process-oriented approach in NFR framework for dealing with Non-Functional Requirements using AND/OR tree. This framework was focused on quality goal satisficing where as Dardenne [25] proposed a goal-based framework with a focus on goal satisfaction. Unfortunately, these approaches are not designed to be used in the Web Engineering field. To the best of our knowledge, the only approaches that use GORE techniques in Web Engineering have been presented in [26,27]. Unfortunately, although these approaches use the *i** modeling framework [18,28] to represent requirements in Web domain, they do not benefit from every *i** feature because

don't use all the expressiveness of the *i** framework to represent the special type of requirements of the Web applications such as the related with navigational issues. To overcome this situation, our previous work [12] adapts the well-known taxonomy of Web requirements presented in [29] for the *i** framework.

To sum up, there have been many attempts to provide techniques and methods to deal with some aspects of the Requirements Engineering process for Web applications. Nevertheless, there is still a need for solutions that considers NFRs from beginning of the Web application development process in order to improve the quality of the Web application perceived by users.

3   A Goal-Oriented Modeling Framework Applied in Web Engineering

This section describes our proposal to specify requirements in the context of the A-OOH (Adaptive Object-Oriented Hypermedia method) Web modeling method [30]. A-OOH is an extension of the OOH (Object-Oriented Hypermedia) [31] method with the inclusion of personalization strategies. This development method is combined with a modeling language named *i** for requirements specificication. The *i** (pronunced *eye-star*) is one of the most widespread goal-oriented frameworks, its has been applied for modeling organizations, business processes, requirements specifications and requirements analysis, among others. As a goal-oriented analysis technique, the *i** framework focuses on the description and evaluation of alternatives and their relationships to the organizational objectives [12].

We shortly describe next an excerpt of the *i** framework which is relevant for the present work. For a further explanation, we refer the reader to [18,28]. Essentially, the *i** framework consists of two models: the strategic dependency (SD) model, to describe the dependency relationships (represented as –▷–) among various actors in an organizational context, and the strategic rationale (SR) model, used to describe actor goals and interests and how they might be achieved. Therefore, the SR model (represented as a dashed circle ⬚) provides a detailed way of modeling the intentions of each actor (represented as a circle ◯), i.e., internal intentional elements and their relationships:

- A goal (elipse ⬭) represents an (intentional) desire of an actor. Interestingly, goals provide a rationale for requirements but they are not enough for describing how the goal will be satisfied. This can be described through means-end links (–▷) representing alternative ways for fulfilling goals.
- A task (hexagon ⬡) describes some work to be performed in a particular way. Decomposition links (—+) are useful for representing the necessary intentional elements for a task to be performed.
- A resource (rectangle ▭) represents some physical or informational entity required for the actor.
- A softgoal (eight-shape ◯) is a goal whose satisfaction criteria is not clearcut. How an intentional element contributes to the satisfaction or fulfillment

of a softgoal is determined via contribution links ($\xrightarrow[\text{hurt}]{\text{help}}$). Possible labels for a contribution link are "make", "some+", "help", "hurt", "some-", "break", "unknown", indicating the (positive, negative or unknown) strength of the contribution.

Even though i^* provides good mechanisms to model actors and relationships between them, it needs to be adapted to the Web Engineering domain to reflect special Web requirements that are not taken into account in traditional requirement analysis approaches. As the A-OOH approach is UML-compliant, we have used the extension mechanisms of UML in order to adapt the i^* modeling framework to the taxonomy of Web requirements (Content, Service, Navigational, Layout, Personalization and Non-Functional Requirements) presented in [29]. To do so, (i) we defined a profile to formally represent the adaptation of each one of the i^* elements with each requirement type from the Web requirements clasification adopted [5]; and (ii) we implemented this profile in an EMF (Eclipse Modeling Framework) metamodel adding new EMF clases according to the different kind of Web requirements: the Navigational, Service, Personalization and Layout requirements extends the Task element and the Content requirement extends the Resource class. It is worth noting that NFRs, until now, can be modeled by directly using the softgoal element. In Figure 1 can be seen an extract of the EMF metamodel for Web requirements specification using the i^* framework. The metamodel has been implemented in the Eclipse [32] IDE (Integrated Development Enviroment).
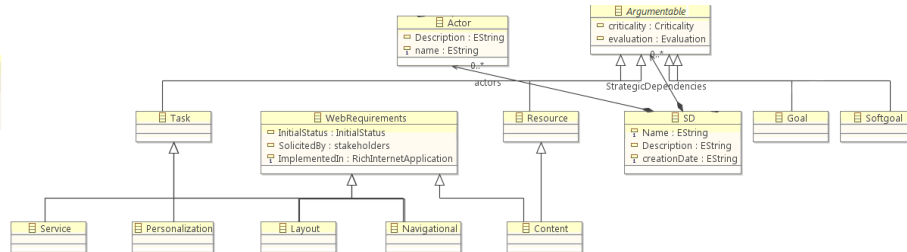

Fig. 1. An overview of the original i^* metamodel implemented in Eclipse (EMF)

The development process of this method is founded in the MDA (Model-Driven Architecture) [11]. MDA is an OMG's standard and consists of a three-tier architecture with which the requirements are specified at the Computational Independent Model (CIM), from there are derived the Web application conceptual models which corresponds with the Platform Independent Model (PIM) of the MDA. Finally, the Web application conceptual models are used to generate the implementation code; this stage corresponds with the Platform Specific Model (PSM) from the MDA standard. A crucial part of MDA is the concept of

transformation between models either model-to-model (M2M) or model-to-text (M2T). With the M2M transformations is possible the transformation from a model in other one. To use the advantages of MDA, our proposal supports the automatic derivation of Web conceptual models from a requirements model by means of a set of M2M transformation rules defined in [6,12].

4   The WebREd-Tool

The WebREd-Tool[2] is a set of Eclipse [32] plugins that have been developed to assist the designer in the early phases of a Web application development process. With the WebREd-Tool, the designer can specify the Web application requirements by using the i^* modelling framework. The WebREd-Tool assists the designer comparing different configurations of functional requirements, while balancing and optimizing non-functional requirements based on the Pareto efficiency [33]. The WebREd-Tool is based on the Model-Driven Development (MDD) paradigm applied in the context of the Web Engineering, this specialization of the MDD is called Model-Driven Web Engineering (MDWE) [11].
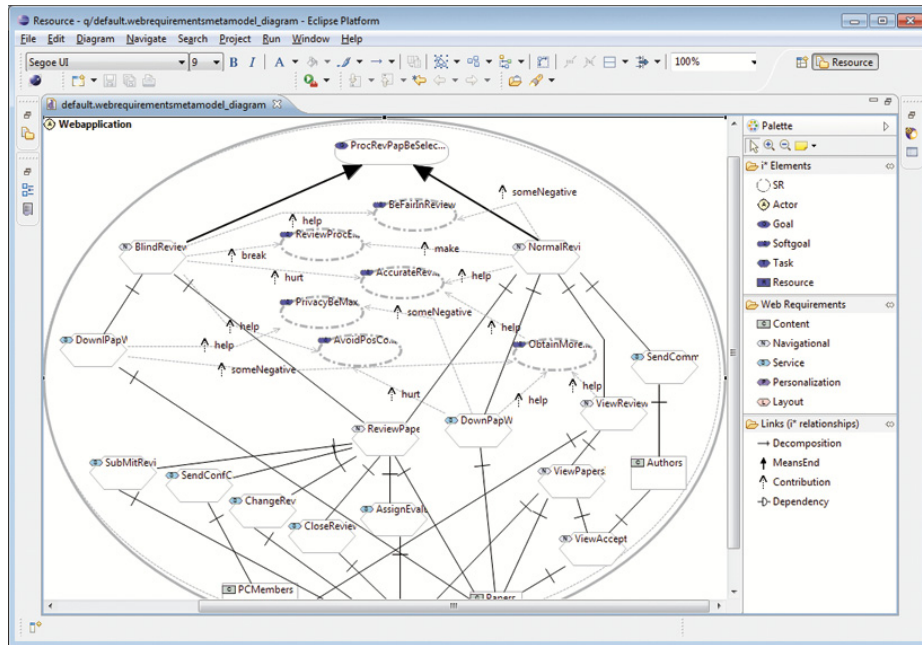

Fig. 2. WebREd-Tool implemented in Eclipse

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[2] http://code.google.com/p/webred/

The tool development consists of three main parts. The first one consists on the implementation of the adapted $i*$ modeling framework for the Web domain. This adaptation was made by defining a EMF (Eclipse Modeling Framework) [34] metamodel and creating a specific class for each type of component of the $i*$ framework (see Figure 1). In the second part, the metamodel was used within the GMF (Graphical Modeling Framework) [35] to create a graphical editor (see Figure 2). With the graphical editor, the designer can specify the Web application requirements in a graphical environment using the $i*$ components such as goals, tasks, softgoals, decomposition, means-end and contribution links and the Web requirements types including service, navigational, content, personalization and layout. The tool-box is shown on the right side of Figure 2, including the aforementioned modeling elements. The third part is the implementation of the Pareto algorithm and, based on it, the visualization of requirement configurations.

The WebREd-Tool provides user support on issues such as Change Impact Analysis [13] and [14], Softgoal optimization [17] and [16], as well as requirements traceability [15] in a Model-Driven Web Engineering context [6]. Further explanation is available at [11] and [17].

Although this work was perceived in the context of the A-OOH method [12], it is in fact a stand-alone, independent approach that can thus be used in any Web Engineering method. Finally, this proposal supports an automatic derivation of Web conceptual models from a requirements model by means of a set of transformation rules, the derivation of the Web application source code is still in development.

5   Softgoal Specialization

It is worth noting that the development of Web applications have some particular requirements that differs from the traditional requirements, especially when it comes to Non-Functional Requirements. These type of requirements are defined and clasified in the seminal work of [36], based on the literature review performed [9], in this work, we propose the definition of six types of NFRs. An overview of each kind of NFR for Web Engineering is described below:

– Usability. Refers to the user's ability to use the Web application without requiring any special training.
– Performance. It is used to describe the best use of the resources, it is related to performance.
– Reliability. Its the capability to maintain the performance of the Web application over the time without losing throwput.
– Safety. It is used in order to ensure that the Web application will do only what it is meant to do.
– Security. Refers to protect all the information managed in the Web applications, including the session management and the user authentication.
– Efficiency. Represents the optimal use of resources, for example the server requests.

This classification of NFRs for Web Engineering is used in order to extend the
$i*$ framework. Specifically, this classification will be used to enrich the expressiveness of the *Softgoal* element from the $i*$ modeling framework. A softgoal
is an objective without clear-cut criteria [28] and can represent Non-Functional
Requirements and relations between Non-Functional Requirements in a goal-oriented modeling context. To this aim, it was necessary to modify the original
Web requirements metamodel (see an extract of the metamodel in Fig. 1) in
order to extend the definition of the *softgoal* element in a similar form as was
done in our previous work [12] to adapt the FRs classification presented in [29]
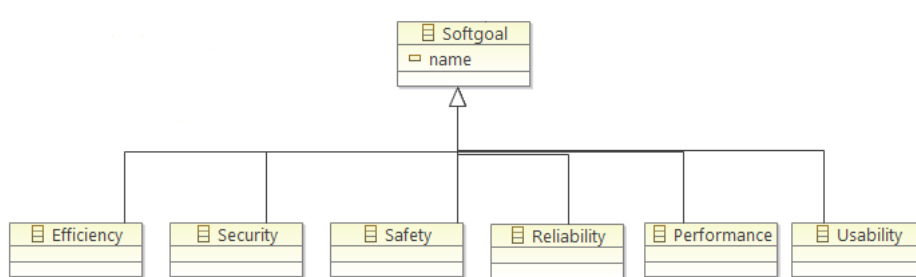(see Fig. 3).

Fig. 3. An overview of the $i*$ metamodel modified with the NFRs taxonomy

Once the $i*$ framework was entended with the softgoal specialization, the
next step consisted in making a re-engineering process in order to build a new
GMF editor, thus integrating new elements to the tool-bar to be able to use the
abstract syntax (metamodel), ie the representation of each one of the elements
to represent the Non-Functional Requirements.

6   Conclusions and Future Work

In this work, we have presented an extension to our goal-oriented RE approach
for the development of Web 1.0 applications named WebREd-Tool. Seeing that
a Web application architecture is composed of a collection of design decisions,
each design decision can help or hinder certain NFRs. Thus, current tools and
methods are focus on expressing components and connectors in the Web application, therefore, design decisions and their relationships with Non-Functional
Requirements are often captured in separate design documentation. This disassociation makes architecture comprehension and architecture evolution harder.
In this work, our proposal offers several advantages such as including the specification of Non-Functional Requirements from the requirements analysis stage
considering the design decisions from the initial stages of the Web application
development process. Since it is supported under a MDA-based process, it reflects the requirements captured in the final product. Future work consists in:

(i) the development of a set of model-to-model transformations test, (iii) the reengineering process in order to verify all the original functions of the WebREd-Tool (requirements traceability, change impact analysis and softgoal optimization) and (iii) the integration of our goal-oriented approach in a full-MDD solution for the development of Rich Internet Applications (RIA's) within the OOH4RIA approach [37].

References

1. Fons, J., Valderas, P., Ruiz, M., Rojas, G., Pastor, O.: Oows: A method to develop web applications from web-oriented conceptual models. In: International Workshop on Web Oriented Software Technology (IWWOST), pp. 65–70 (2003)
2. Ceri, S., Fraternali, P., Bongio, A.: Web modeling language (webml): A modeling language for designing websites. The International Journal of Computer and Telecommunications Networking 33(1-6), 137–157 (2000)
3. Escalona, M.J., Aragón, G.: Ndt. a model-driven approach for web requirements. IEEE Transactions on Software Engineering 34(3), 377–390 (2008)
4. Koch, N.: The expressive power of uml-based web engineering. In: International Workshop on Web-oriented Software Technology (IWWOST), pp. 40–41 (2002)
5. Garrigós, I., Mazón, J.-N., Trujillo, J.: A requirement analysis approach for using i* in web engineering. In: Gaedke, M., Grossniklaus, M., Díaz, O. (eds.) ICWE 2009. LNCS, vol. 5648, pp. 151–165. Springer, Heidelberg (2009)
6. Aguilar, J.A.: A Goal-oriented Approach for Managing Requirements in the Development of Web Applications. PhD thesis, University of Alicante, Spain (2011)
7. Nuseibeh, B., Easterbrook, S.M.: Requirements engineering: a roadmap. In: International Conference on Software Engineering (ICSE), pp. 35–46 (2000)
8. Gupta, C., Singh, Y., Chauhan, D.: Dependency based Process Model for Impact Analysis: A Requirement Engineering Perspective. International Journal of Computer Applications 6(6), 28–30 (2010)
9. Jureta, I.J., Faulkner, S., Schobbens, P.-Y.: A more expressive softgoal conceptualization for quality requirements analysis. In: Embley, D.W., Olivé, A., Ram, S. (eds.) ER 2006. LNCS, vol. 4215, pp. 281–295. Springer, Heidelberg (2006)
10. Ameller, D., Gutiérrez, F., Cabot, J.: Dealing with Non-functional Requirements in Model-Driven Development. In: 18th IEEE International Requirements Engineering Conference, RE (2010)
11. Aguilar, J.A.: A Goal-oriented Approach for the Development of Web Applications: Goal-oriented Requirements Engineering (GORE) and Model-Driven Architecture (MDA) in the Development of Web Applications. LAP LAMBERT. Academic Publishing (2012)

12. Aguilar, J.A., Garrigós, I., Mazón, J.N., Trujillo, J.: An MDA Approach for Goal-oriented Requirement Analysis in Web Engineering. J. UCS 16(17), 2475–2494 (2010)
13. Aguilar, J.A., Garrigós, I., Mazón, J.-N.: Impact analysis of goal-oriented requirements in web engineering. In: Murgante, B., Gervasi, O., Iglesias, A., Taniar, D., Apduhan, B.O. (eds.) ICCSA 2011, Part V. LNCS, vol. 6786, pp. 421–436. Springer, Heidelberg (2011)
14. Aguilar, J.A., Garrigós, I., Mazón, J.-N., Zaldívar, A.: Dealing with dependencies among functional and non-functional requirements for impact analysis in web engineering. In: Murgante, B., Gervasi, O., Misra, S., Nedjah, N., Rocha, A.M.A.C., Taniar, D., Apduhan, B.O. (eds.) ICCSA 2012, Part IV. LNCS, vol. 7336, pp. 116–131. Springer, Heidelberg (2012)
15. Aguilar, J.A., Garrigós, I., Mazón, J.N.: Modelos de weaving para trazabilidad de requisitos web en a-ooh. In: VII Taller sobre Desarrollo de Software Dirigido por Modelos (DSDM), JISBD, Congreso Español de Informatica (CEDI), Valencia, España, SISTEDES, pp. 146–155 (2010)
16. Aguilar, J.A., Garrigós, I., Mazón, J.-N.: A goal-oriented approach for optimizing non-functional requirements in web applications. In: De Troyer, O., Bauzer Medeiros, C., Billen, R., Hallot, P., Simitsis, A., Van Mingroot, H. (eds.) ER Workshops 2011. LNCS, vol. 6999, pp. 14–23. Springer, Heidelberg (2011)
17. Aguilar Calderon, J.A., Garrigós, I., Casteleyn, S., Mazón, J.-N.: WebREd: A model-driven tool for web requirements specification and optimization. In: Brambilla, M., Tokuda, T., Tolksdorf, R. (eds.) ICWE 2012. LNCS, vol. 7387, pp. 452–455. Springer, Heidelberg (2012)
18. Yu, E.: Modelling Strategic Relationships for Process Reenginering. PhD thesis, University of Toronto, Canada (1995)
19. Aguilar, J.A., Garrigós, I., Mazón, J.N., Trujillo, J.: Web Engineering approaches for requirement analysis- A Systematic Literature Review. In: 6th Web Information Systems and Technologies (WEBIST), vol. 2, pp. 187–190. SciTePress Digital Library, Valencia (2010)
20. Schwabe, D., Rossi, G.: The object-oriented hypermedia design model. Communications of the ACM 38(8), 45–46 (1995)
21. De Troyer, O.M.F., Leune, C.J.: Wsdm: A user centered design method for web sites. Comput. Netw. ISDN Syst. 30(1-7), 85–94 (1998)
22. Casteleyn, S., Woensel, W.V., Houben, G.J.: A semantics-based aspect-oriented approach to adaptation in web engineering. In: Hypertext, pp. 189–198 (2007)
23. Molina, F., Toval, A.: Integrating usability requirements that can be evaluated in design time into model driven engineering of web information systems. Adv. Eng. Softw. 40, 1306–1317 (2009)
24. Mylopoulos, J., Chung, L., Nixon, B.: Representing and using nonfunctional requirements: A process-oriented approach. IEEE Trans. Softw. Eng. 18(6), 483–497 (1992)
25. Dardenne, A., van Lamsweerde, A., Fickas, S.: Goal-directed requirements acquisition. In: Selected Papers of the Sixth International Workshop on Software Specification and Design, 6IWSSD, pp. 3–50. Elsevier Science Publishers B.V., Amsterdam (1993)
26. Bolchini, D., Paolini, P.: Goal-driven requirements analysis for hypermedia-intensive web applications, vol. 9, pp. 85–103. Springer (2004)
27. Molina, F., Pardillo, J., Toval, A.: Modelling web-based systems requirements using WRM. In: Hartmann, S., Zhou, X., Kirchberg, M. (eds.) WISE 2008. LNCS, vol. 5176, pp. 122–131. Springer, Heidelberg (2008)

28. Yu, E.: Towards modeling and reasoning support for early-phase requirements engineering. In: RE, pp. 226–235 (1997)
29. Escalona, M.J., Koch, N.: Requirements engineering for web applications - a comparative study. J. Web Eng. 2(3), 193–212 (2004)
30. Garrigós, I.: A-OOH: Extending Web Application Design with Dynamic Personalization. PhD thesis, University of Alicante, Spain (2008)
31. Cachero, C., Gómez, J.: Advanced conceptual modeling of web applications: Embedding operation. In: 21th International Conference on Conceptual Modeling Interfaces in Navigation Design (2002)
32. Eclipse (2012), `http://www.eclipse.org/`
33. Szidarovszky, F., Gershon, M., Duckstein, L.: Techniques for Multiobjective Decision Making in Systems Management. Elsevier (1986)
34. EMF, `http://www.eclipse.org/emf/`
35. GMF, `http://www.eclipse.org/gmf/`
36. Zhang, W., Yang, Y., Wang, Q., Shu, F.: An empirical study on classification of non-functional requirements. In: Proceedings of the 23rd International Conference on Software Engineering & Knowledge Engineering (SEKE 2011). Knowledge Systems Institute Graduate School, Miami Beach (2011)
37. Meliá, S., Martínez, J.J., Mira, S., Osuna, J., Gómez, J.: An eclipse plug-in for model-driven development of rich internet applications. In: Benatallah, B., Casati, F., Kappel, G., Rossi, G. (eds.) ICWE 2010. LNCS, vol. 6189, pp. 514–517. Springer, Heidelberg (2010)