In *Proceedings of Workshops and Doctoral Consortium* (CaiSE'07). Vol. 2, Pages: 853-860.

A Reengineering Framework for Informing Decisions over Requirements Models

Gemma Grau

Universitat Politècnica de Catalunya (UPC).
c/ Jordi Girona 1-3, Barcelona E-08034, Spain.
ggrau@lsi.upc.edu

Abstract. It is a well known fact that the decisions taken in the early stages of the Information Systems Development process, affects the quality of the final product. Because of that, there are many proposals that address the evaluation of the Information System properties at the requirements stages, by using different models and metrics to measure them. However, most of the proposals do not address all the aspects that have to be considered for such analysis: the construction of the models; the link of the models with requirements; the exploration of alternatives, the definition of metrics for evaluating the alternatives; and, the possible reuse of the final model. The main goal of this thesis is to provide a framework for the effective and reliable generation and evaluation of alternatives in order to inform decisions over requirements models. With this aim, we propose a method that addresses Information Systems Development as a Business Process Reengineering practice. The method is based on well-known Requirements Engineering and Business Process Reengineering techniques and uses *i** as its modelling framework.

1. Introduction

It is a well known fact that the decisions taken in the early stages of the Information Systems Development process, affects the quality of the final product. There are several factors that influence the final result, such as the decisions regarding how functional and non-functional requirements are addressed, the architecture design, or the technology adopted. The consideration of such factors at the requirements stages results in the exploration of different alternatives, which evaluation helps the adoption of more informed decisions, reducing the project risks.

The exploration and evaluation of alternative solutions is widely addressed in the literature in the forms of heuristics, patterns, and metrics. However, the context of application and the focus of these proposals it is not always the same. Some of them address requirements gathering and modelling, others the exploration of alternative solutions and, finally, some others focus on the evaluation of the modelled Information Systems. On the other hand, despite that most of the proposals rely on a modelling technique for representing the knowledge about the Information System, there is no common modelling language to conciliate them.

Taking these issues into account, we propose to address the generation and evaluation of alternatives for Information Systems Development as an exercise of Business Process Reengineering. Our arguments for such a claim are twofold. On the one hand, we observe some similarities between the mentioned issues and the ones considered during the Business Process Reengineering phases, being two of them the search for process alternatives and the evaluation of process alternatives [21], [28]. On the other hand, we argue that both activities can be considered two views of the same activity: Business Process Reengineering often require the development or acquisition of an Information System, whilst most of the times Information Systems Development is an activity that seldom takes place from the scratch (e.g., it automates tasks that are already undertaken by humans in an organization, or substitute an existing system that has to be reengineered).

Many studies show that both the content and format of a representation affect problem-solving processes and results [21], thus it is a key point to use a modelling language to support them. Among the several modelling frameworks that can be used, we consider that the *i** framework [28] is particularly adequate because it is linked to both the Business Process Reengineering and the Requirements Engineering fields. The *i** framework is a well consolidated goal-oriented approach that allows to model Information Systems in a graphical way, in terms of actors and dependencies among them. With this constructs, *i** allows the representation of the functional and non-functional goals of the system, as well as the strategic goals of the organization.

The remainder of this paper is organized as follows. In section 2 we explain the proposed solution, the main research issues, and the research method followed. The related work on *i** and Business Process Reengineering is introduced in section 3. In section 4 we present PR*i*M, a Process Reengineering *i**-based Method, which addresses the research issues under consideration. Based on PR*i*M we have abstracted ReeF, a more general Reengineering Framework that allows using different techniques when applying the method. ReeF is explained in section 5 as part of the ongoing work. The future work and the conclusions are presented in sections 6 and 7.

2. Proposed Solution and Research Method

The main goal of this thesis is to provide a framework for the effective and reliable generation and evaluation of requirements models in order to inform decisions in the Information System Development process. More precisely, we are interested in modelling the requirements model with *i** and the use of structural metrics over them. This raises the following research issues:

- How *i** models have to be constructed in order to be a reliable and prescriptive representation of the requirements?
- How can we explore and represent the different alternatives for the new system?
- How can we apply structural metrics to evaluate quality factors over the *i** models?

Due to the similarities between Information Systems development and Business Process Reengineering we propose to address to address these issues within the scope of a reengineering exercise focusing on: the construction of the models; its analysis for improvement; the generation of alternatives; its evaluation using structural metrics; and, finally, the reuse of the resulting model for obtaining the Information System specification.

We remark that most of these aspects have already been addressed in both the Requirements Engineering and the Business Process Reengineering fields [16]. There are several techniques to be applied in each one of these phases, but none of them tackle all the phases at the same level of detail. Based on the analysis of the related work (which is presented in section 4), we determine a set of research issues that focus on: 1) the construction of *i** models, which has to be done in a reliable and systematic way; 2) the search for patterns for the systematic generation of alternatives, focusing on the use and definition of heuristics and guidelines; 3) the use of structural metrics for evaluating alternatives, establishing what kind of properties can be evaluated with structural metrics, which *i** elements affects each property, and how the properties can be defined; and, 4) the definition of an integration framework where techniques in both the Requirements Engineering and the Business Process Reengineering fields that can be adapted to support the generation and evaluation of alternatives.

In order to define such a framework, we established a research method divided in four steps. First, we did an exhaustive review of the existing techniques in order to found out its key points and deficiencies. Based on the study of this techniques and our own experience in *i** modelling [12], we defined the PR*i*M method. Second, we replicated academic case studies in order to validate the results obtained with PR*i*M by comparing them with the expected ones. Third, more literature review was done to abstract ReeF, a general Reengineering Framework that allows using other techniques different from the ones proposed in PR*i*M when applying the method. And, finally, as a fourth step, we will validate the whole framework in industrial case studies.

3. Analysis of the Related Work

In the original proposal of the *i** framework [28], Business Process Reengineering is addressed with the following four activities, which we describe making reference to other works related to *i** and the specific activity:

The construction of an *i model of the process based on intentional concepts.** It is addressed by several works [4], [8], [12], [20], [23], [27], [28]. The final goal of these methods is the requirements gathering for the new Information System, and the main difference between them is in the way the models are constructed. Some of them follow a top-down approach and progressively decompose the intentionality of the actors [4], [8], [12], [28]. This approach implies certain uncertainness, and does not ensure prescriptiveness in the construction of the models. This issue is better addressed in bottom-up approaches [20], [23], [27], but the methods that use existing artefacts for obtaining *i** does not address the non-functional aspects of the Information System and the organizational goals. In [14] we present a deeper comparative analysis of *i** modelling techniques.

The systematic search for process alternatives. It is addressed in [28] by providing alternative manners to decompose each actor goal, which results into a single *i** model containing all the alternatives. Some other proposals tackle this issue by generating different *i** models, one for each alternative. For instance, in [22] organizational patterns are used. Also, the methods proposed in [4], [8], [12] construct two different *i** models that can be viewed as two different alternatives: the social system, only representing human actors; and the socio-technical system, which adds the Information System to the previous one. Although the use of patterns is mentioned in these proposals, no guidelines are provided for applying such patterns. Therefore, more heuristics and guidelines are needed.

The systematic evaluation of process alternatives with respect to stakeholder's interests. It is addressed in three different ways. First, the use of reasoning techniques in order to evaluate the accomplishment of certain properties [4], [28]. Second, the transformation of the *i** model into executable code in order to evaluate its performance [27]. And, third, the application of structural metrics in order to weight certain elements of the *i** models and, based on its structure, compute certain properties [9]. Structural metrics presuppose that *i** models are built in such a way that properties can be measured correctly.

The connection of strategic reasoning with Information System Development. It is done by providing rules that transform *i** models into specifications [8], [26]. For a more exhaustive related work on *i** we refer to the *i** wiki, at [19].

4. Consolidated Work: PR*i*M, a Process Reengineering *i** Method

PR*i*M [11], [18] is a method that addresses Information Systems Development as an exercise of Business Process Reengineering. Hence, the method has been constructed after a rigorous state of the art and our own experience on both Requirements Engineering and Business Process Reengineering techniques [16]. Based on this study, PR*i*M takes as a departing point the four Business Process Reengineering phases proposed in [28], adding a first phase for making explicit the analysis of the current process and an intermediate phase for reengineering the current process before the generation of alternatives (see Fig.1. for an overview of the PR*i*M method). As a result, in PR*i*M we merge several existing techniques with our own proposals, focusing on the research issues previously mentioned:

Phase 1: Analysis of the Current Process. There's a need of understanding the current process before specifying the new one. Several Requirements Engineering techniques can be used for this analysis and, among them, we have chosen Human Activity Modelling [20]. Once the information is obtained, we propose to document the current process using our Detailed Interaction Scripts (DIS). DIS are templates that describe the information of each activity of the current process in a structured manner in order to facilitate further steps of the method.

Phase 2: Construction of the *i Model of the Current Process.** We propose to build the *i** model in two differentiated steps in order to distinguish the functionality performed by the stakeholders (descriptive goals, automatically obtained by applying certain rules over the information in the DIS templates), from their intentionality (prescriptive goals, obtained by applying provided guidelines). This distinction is also proposed in [1], [21], and allows the separation between the functionality needed and the organizational strategy.

Phase 3: Reengineering of the Current Process. Once the *i** model of the current process is built, we analyse it for improvements and, thus, add new goals to the already obtained model. The analysis of the process can be done by using an already existing goal-oriented requirements engineering technique. Therefore, we have adapt the consolidated approach KAOS [7] for supporting the elicitation of the requirements for the new Information System. As both *i** and KAOS are goal-oriented, the relationship between the concepts they provide is easily established.

Phase 4: Generation of Alternatives. For generating the alternatives we propose to add new actors to the model and, then, to reallocate the dependencies between them. New actors can be obtained by adding: the system actor, as proposed in [4], [8], [12]; or several actors according to organizational patterns such as in [22]. Once they are added, reallocation of responsibilities is done by adapting the patterns proposed in [21] where, for each activity of the process, we decide if its dependencies are still satisfied by the current actor or are assigned to another actor.

Phase 5: Evaluation of Alternatives. As process alternatives are modelled as different *i** models, applying the same metric over the different models allows to evaluate them for a certain property. We have extended the proposal in [9] to propose a set of structural metrics [10], where we differentiate between actor-based and dependency-based metrics according to the *i** elements that affect the property under study.

Phase 6: Specification of the New System. Based on the model of the chosen alternative, the specification of the new Information System is generated [8], [26].

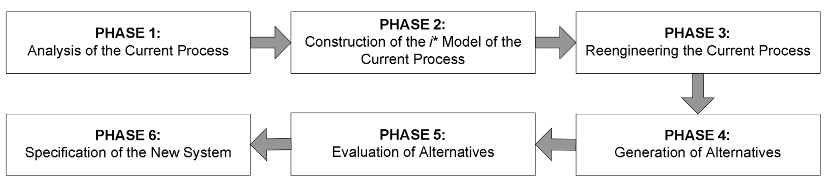

Fig 1. Overview of the PR*i*M method.

The PR*i*M method has been validated by replicating already addressed academic case studies. First, the *Meeting Scheduler* case study, a well-known exemplar that allowed the validation of the applicability of the method by comparing the results obtained with the provided solution, which is presented in [11]. Second, The *eMedia Shop* case study [22] that allowed the validation of the generation and evaluation of alternatives according to the patterns and properties of the problem statement. Finally, the *eLearning System* case study is a large-scale exemplar in which many different organizational alternatives are possible and different kinds of metrics have been applied. An excerpt for the *Execution of a Collaborative Exercise* is presented in [18].

We remark that, for the execution of the case studies, tool support has been essential. In fact, we have used two different tools. In our first stages of research, we use REDEPEND-REACT [13] a VISIO graphical tool that supports the generation and evaluation of alternatives within the *i** framework. As we detected that in graphical tools, the management of the *i** models gets harder as they are more complex, we have developed J-PR*i*M [15], a Java tool that shows the models textually in a hierarchical way and supports all the phases of the method.

5. Ongoing Work: Abstraction and Applicability of PR*i*M

We observe that there are many other methods and techniques that could be used within the context of PR*i*M, either from the Requirements Engineering or from the Business Process Reengineering fields. Thus, it is possible to change some of the techniques used in each of the phases, for instance, to adapt it to a particular domain of application. In order to facilitate this process, we have defined ReeF [17], a Reengineering Framework that uses the Method Engineering approach [3], [24] in order to define a generic set of phases that can be customized by applying other methods, and techniques.

As a first attempt, we have customized ReeF, into SAR*i*M [17], a Software Architecture Reengineering *i**-based Method. In this context, the techniques used in phases 1, 2, 5 and 6 are the same proposed in PR*i*M; in phase 3 we adapt techniques from [5] for the elicitation of requirements for the final software architecture; and, in phase 4, we follow the guidelines proposed in the Scenario-base Software Architecture Reengineering Method [2]. SAR*i*M has been validated for a *Home Mobile Robot* case study.

6. Future Work: Consolidation and Validation of the Results

The method has been validated by replicating existing academic case studies in order to compare the results obtained with the existing ones. As a result, we have solved some of the initial research issues. However, there still some open issues:

- The rules and guidelines provided for the construction of the method had been successfully applied by us, however, in order to validate that the construction of the *i** models is prescriptive, we will execute an empirical experiment involving students and expert *i** modelers.
- From the case studies, we have concluded that it is not possible to evaluate all kind of properties and, so, further work will be directed to: a) explore which kind of properties can be evaluated with structural metrics and establish the boundaries for its application; and, b) provide precise guidelines for defining the metrics by establishing which *i** elements contribute to each property.
- The validation of the framework in real case studies is a crucial point in our research and, thus, we would like to collaborate with industrial partners. If this is not possible, we will validate the approach with real projects undertaken in the university context. For instance, we have already a case study for reengineering an existing application for evaluating the research on our university.

7. Conclusions

The main goal of this thesis is to provide a framework for the effective and reliable generation and evaluation of requirements models in order to inform decisions during the Information Systems Development process. For doing so, we have studied current techniques in the Requirements Engineering and Business Process Reengineering fields in order to identify common interaction points and open research issues. After this study we have defined PR*i*M, an *i** method, which provides guidelines and lineaments for:

Construction of *i models.** In phases 1 and 2 of PR*i*M, steps and guidelines are proposed for constructing the models in a prescriptive way. As the construction of models can be a laborious, time-consuming activity in PR*i*M reuse is achieved at three levels: first, reuse of the already existing models in the organization (if they are available); second, use of the same model through the process in order to avoid arduous model transformations; and, finally, the possibility to reuse the information on the resulting model in order to inform further stages of the development process.

Patterns for the systematic generation of alternatives. In phase 3, new actors are added to the model and the dependencies are reallocated between them. We remark that a similar approach for the reallocation of dependencies when generating alternative *i** models has recently been adopted in [6], giving strength to the proposal.

Provide metrics for evaluating the generated architectures. The structural metrics proposed [10] differentiate among actor-based and dependency-based metrics according to the *i** elements that contribute to a property. They have been applied on a subset of suitable properties related to processes in the case studies (e.g., data privacy, process agility and ease of communication among others).

Provide a framework for integrating those aspects. Wherever is possible PR*i*M makes use of well-know techniques. In order to adapt the method to other contexts, we propose to replace these techniques with similar ones and to adapt the method to other contexts. For doing so, we propose ReeF, a framework that allows using Method Engineering for combining different techniques.

Acknowledgements. This work has been partially supported by the CICYT programme, project TIN2004-07461-C02-01. Gemma Grau work is supported by an UPC research scholarship.

References

1. A.I. Antón, W.M. McCracken, C. Potts. "Goal Decomposition and Scenario Analysis in Business Process Reengineering". In *Proceedings of CAiSE 1994*. LNCS 811, pp. 94-104,.
2. P. Bengtsson, J. Bosch. "Scenario-based Software Architecture Reengineering". In *Proceedings of the5th International Conference on Software Reuse*, pp. 308-317, 1998.
3. S. Brinkkemper, M. Saeki, F. Harmsen. "Assembly Techniques for Method Engineering". In *Proceedings of CAiSE 1998*, LNCS 1413, pp. 381-400, 1998.
4. P. Bresciani, A. Perini, P. Giorgini, F. Giunchiglia, J. Mylopoulos. "TROPOS: An Agent-Oriented Software Development Methodology". *Journal of Autonomous Agents and Multi-Agent Systems*. May 2004. Volume 8, Issue 3.
5. H. de Bruin, H. van Vliet. "Scenario-based Generation and Evaluation of Sofware Architectures". In *Proceedings of the Third International Conference on Generative and Component-Based Software Engineering*, GCSE 2001. LNCS 2186, pp.128-139.
6. V. Bryl, P. Giorgini, J. Mylopoulos. "Designing Cooperative IS: Exploring and Evaluating Alternatives". OTM Conferences (1) 2006. pp. 533-550.

7. A. Dardenne, A. van Lamsweerde, S. Fickas. "Goal-directed Requirements Acquisition", Science of Computer Programming, Volume 20, Issue 1-2 (April 1993), pp. 3-50.
8. H. Estrada, A. Martínez, O. Pastor. "Goal-based business modeling oriented towards late requirements generation". In *Proceedings of the 22nd International Conference on Conceptual Modeling*, 2003. Springer-Verlag, LNCS 2813. pp. 277-290.
9. X. Franch, N.A.M. Maiden. "Modeling Component Dependencies to Inform their Selection", In *Proceedings of the 2nd International Conference on COTS Based Software Systems*, ICCBSS 2003. Springer-Verlag, LNCS 2580. pp. 81-91.
10. X. Franch, G. Grau, C. Quer. "A Framework for the Definition of Metrics for Actor-Dependency Models". In *Proceedings of RE 2004*, pp. 348-349.
11. G. Grau, X. Franch, N.A.M. Maiden. "A Goal Based Round-Trip Method for System Development". *In Proceedings of the 11th International Workshop on Requirements Engineering: Foundation For Software Qualtiy*, REFSQ 2005. pp. 71-86.
12. G. Grau, X. Franch, E. Mayol, C.P. Ayala, C. Cares, M. Haya, F. Navarrete, P. Botella, C. Quer. "R*i*SD: A Methodology for Building *i** Strategic Dependency Models". In *Proceedings of SEKE 2005*. pp. 259-266.
13. G. Grau, X. Franch, N.A.M. Maiden. "REDEPEND-REACT: an Architecture Analysis Tool". In *Proceedings of RE 2005*. pp. 455 - 456.
14. Grau G., Cares, C., X. Franch, Navarrete, F.J.: "A Comparative Analysis of *i** Agent-Oriented Modelling Techniques". In *Proceedings of SEKE 2006*. pp. 657-663.
15. G. Grau, X. Franch, S. Ávila. "J-PR*i*M: A Java Tool for a Process Reengineering *i** Methodology". In *Proceedings of RE 2006*. pp. 352-353.
16. G. Grau. "State of the Art for the Systematic Construction and Analysis of *i** Models for assessing COTS-Based Systems Development". Research Report LSI-06-38-R. Available at: http://www.lsi.upc.edu/~techreps/files/R06-38.zip.
17. G. Grau, Franch, X.: "ReeF: Defining a Customizable Reengineering Framework". To appear in *Proceedings of CAiSE 2007*.
18. G. Grau, X. Franch, N.A.M. Maiden. "PR*i*M: an *i**-based process reengineering method for information systems specification". To appear in *Information and Software Technology*.
19. The *i** wiki at: http://istar.rwth-aachen.de/. Last Accessed: February 2007.
20. S. Jones, N.A.M. Maiden. "RESCUE: An Integrated Method for Specifying Requirements for Complex Socio-Technical Systems". Book chapter in *Requirements Engineering for Sociotechnical Systems*, Idea Group Inc., 2004.
21. G. Katzenstein, F.J. Lerch. "Beneath the Surface of Organizational Processes: A Social Representation Framework for Business Process Redesign". ACM Transactions on Information Systems, Vol.18, No. 4, 2000. pp. 383-422.
22. M. Kolp, P, Giorgini, J. Mylopoulos. "Organizational Patterns for Early Requirements Analysis". In *Proceedings of CAiSE 2003*. Springer-Verlag, LNCS 2681. pp. 617-632.
23. G.C. Neto, A.S. Gomes, J.B. Castro. "Mapeando Diagramas da Teoria da Atividade em Modelos Organizacionais Baseados em *i**". In *Proceedings of the 7th Workshop em Engenharia de Requisitos*, WER 2004. pp: 39-50.
24. J. Ralyté, C. Rolland. "An Approach for Method Reengineering". In Proceedings of ER 2001. LNCS 2224, pp. 471-484.
25. G. Regev, A. Wegmann. "Where do Goals Come from? The Underlying Principles of Goal-Oriented Requirements Engineering". In *Proceedings of RE 2005*. pp. 339-349.
26. V.F.A. Santander, J.F.B. Castro. "Deriving Use Cases from Organizational Modeling". In *Proceedings of RE 2002*. pp 32-39.
27. D. Schmitz, G. Lakemeyer, G. Gans, M. Jarke. "Using PBEL Process Descriptions for Building up Strategic Models for Inter-Organizational Networks". In *Proceedings of the Workshop on Modeling Inter-Organizational Systems*, MIOS 2004. LNCS 3294.
28. E. Yu. *Modelling Strategic Relationships for Process Reengineering*, PhD. thesis, University of Toronto, 1995.