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12th International Conference

on Product Focused Software Development and Process Improvement



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Danilo Caivano
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Second Proceedings: Short Papers, Doctoral Symposium and Workshops

of the

12th International Conference on Product Focused Software Development and Process Improvement – PROFES 2011

20-22 June 2011

Torre Canne (BR) - Italy

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Second Proceedings
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Preface

We would like to welcome you to the 12th International Conference on Product Focused Software Development and Process Improvement, organized by the University of Bari and by the University of Oulu, and held in Torre Canne (BR), Italy.

This year's program comprises several interesting co-located events such as Short Papers, a Doctoral Symposium, two workshops, one on Managing the Client Value Creation Process in Agile Projects (VALOIR) and another on Project and Knowledge Management Trends (PKMT), as well as a tutorial on Establishing and Improving Project Management Using Assessment Models for Process Capability and Organizational Maturity. We have received interesting contributions from all over the world and hope to have put together an interesting program.

We want to thank all of those who have contributed to the set up and running of this year's conference: the authors for submitting their papers, all the committee members for their valuable work in reviewing and selecting the papers and in promoting the conference and its co-located events, the organizing committee together with all the people that helped arrange the events. We also would like to thank all the organizations that have sponsored the conference.

We finally thank all the attendees for allowing a successful conference, and hope you enjoy its high quality co-located events and find the opportunity to share ideas with other researchers and practitioners.

Enjoy your stay in Torre Canne, Italy.

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Empirical investigation on the benefits of using UML in software maintenance

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ABSTRACT
This paper presents a research proposal on how and why we are investigating the benefits of the Unified Modelling Language (UML) in software maintenance tasks. The principal objective is to present the main research questions, along with an explanation of which research methods we propose to use to obtain the answers to these questions in an empirical manner.

Categories and Subject Descriptors
D.2.7 **[Software Engineering]**: Distribution, Maintenance, and Enhancement – *documentation.*

General Terms
Experimentation, design.

Keywords
UML, research methods, empirical studies, software maintenance.

1. INTRODUCTION
The increasing complexity of software projects [14] has led to the emergence of UML [13] as a tool with which to increase the understanding between customer and developer (in the analysis phase), to improve communication among team members [8] and to increase the understanding of how software works (both in the development and the maintenance phases).

However, from an economic point of view, any type of investment must be justified in terms of how much payback there will be at a later stage. This being the case, in the context of software projects, investment in modelling should be justified by benefits, such as improved productivity and improved product quality, which can be seen later during software development or maintenance. This is one of the principal reasons for investigating whether the use of UML can generate important differences that will make the costs involved worthwhile. This is particularly true in the context of software maintenance, which consumes the majority of software development resources, as explained in [10] and [4]: "Maintenance typically consumes 40 percent to 80 percent of software costs. Therefore, it is probably the most important life cycle phase of software" and "60 percent of the budget is spent on software maintenance, and 60 percent of this maintenance is to enhance". Enhancing old software is, therefore, a big business.

The principal goal of this paper is to present a long-term research plan which we propose to develop to investigate whether or not the use of UML provides any benefits in software maintenance tasks (see Section 2). This is a work in progress, and part of the plan is therefore currently being executed while the other part is pending to be dealt with in the future.

2. RESEARCH PLAN
The main goal of our research is to investigate the benefits of modelling in software maintenance tasks. We particularly focus our attention on UML [13] as a modelling language since it is widely used in industry. In order to achieve the goal, three initial research questions have been defined (see Figure 1). The research questions outlined below have been formulated to observe the impact of UML modelling on software maintenance from different perspectives (e.g., from the point of view of software engineers and from empirical data obtained from industrial software projects). Apart from the different perspectives, new insights obtained during the study could also lead to the formulation of new research questions. Several research strategies are employed to address those questions. By considering different angles and conducting multiple research strategies in answering the principal question, we expect to obtain a more comprehensive understanding of the impact of UML modelling on software maintenance.

As our approach for addressing the research questions in this study is empirical in nature, in this section we shall detail the empirical research methods we propose to use to obtain empirical evidence that will allow us to answers the proposed research questions. As suggested in [6], we began collecting the existing empirical evidence through a systematic literature review. We later plan to carry out several empirical studies which will consider the main empirical strategies suggested in [15]: survey [9], interview [12] (as a means to perform surveys), case study [11], and experiment [15].

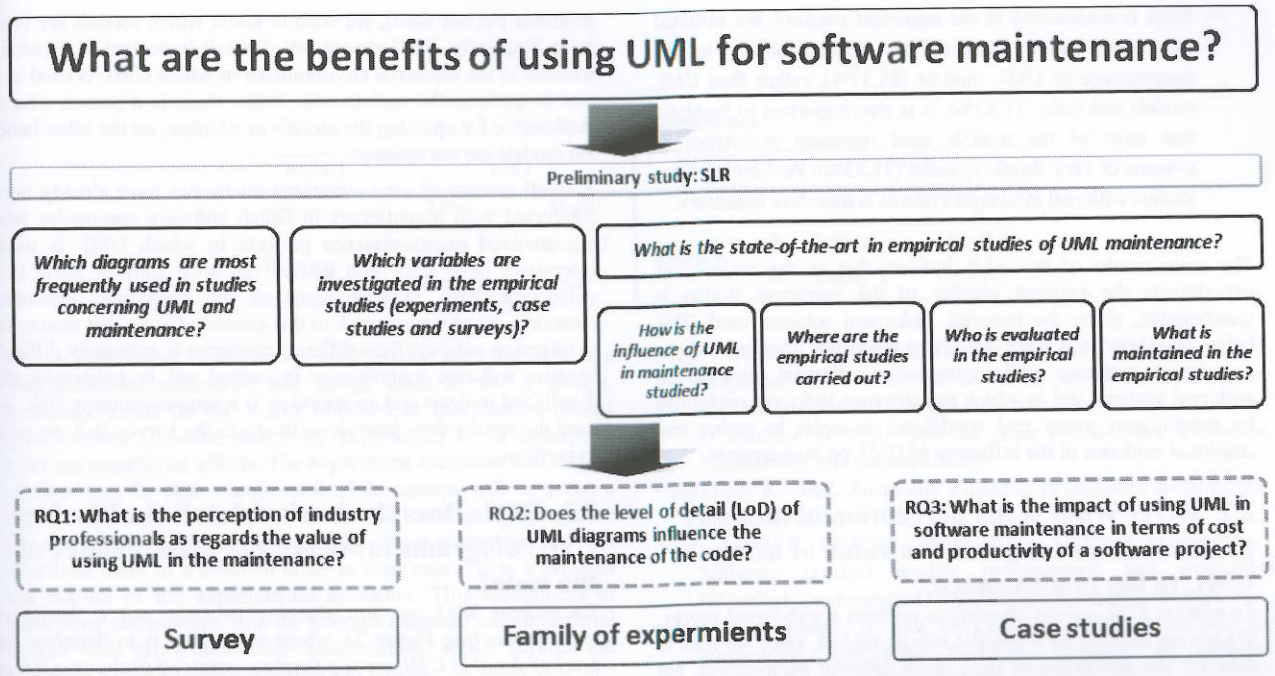

Fig. 1. Research plan.

2.1 Preliminary study: A Systematic Literature Review (SLR)
We began our research by carrying out an SLR [3] to gather the existing empirical evidence with regard to the influence of UML models on software maintenance as seen in six digital sources (Scopus, Science Direct, Wiley InterScience, IEEExplore, ACM, Springer), from 1997 to March 2010. This SLR discovered 53 relevant papers in peer-reviewed journals, conferences, and workshops (which can be found at http://alarcos.esi.uclm.es/SLR-UMLinMaintenance/), and classified them in order to obtain responses to the research questions briefly presented and summarized below (note that the percentages refer to the total number of studies found):

SLR Research Question 1 asked: *Which diagrams are most frequently used in studies concerning UML and maintenance?* The results show a clear ordering which indicates the relative importance that researchers attach to 3 diagram types: class diagrams (32.00% of primary studies), statechart diagrams (27.20%) and sequence diagrams (14.40%). The low occurrence of papers relating to the use case diagrams (6.40%) could be explained by the fact that there are no studies addressing this type of diagrams which are in turn directly related to maintenance tasks.

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SLR Research Question 2 asked: *Which variables are investigated in the empirical studies (experiments, case studies and surveys)?* Most of the studies that were found are experiments (96.7%) which focus their efforts on measuring the understandability of the UML models. The variables which are measured in these papers are thus related to the time (25.7%) and the correctness (11.17%) obtained in the tests by the subjects. There are some more isolated studies which focus on the influence of UML models on maintenance tasks, in which the variables measured are (apart from time) the correctness of the proposed solutions and the quality of the code.

SLR Research Question 3 asked: *What is the state-of-the-art in empirical studies of UML maintenance?* To answer RQ3, an analysis based on different perspectives of the empirical literature in the field is presented. The analysis is presented from the following four perspectives: How, Where, Who and What.

- *How is the influence of UML on maintenance studied?* Most of the studies found present the results of controlled experiments (96.70%). This is a well-known way in which to validate data. However, the field would benefit (in terms of generalizability) from the additional performance of case studies.
- *Where are the empirical studies carried out?* These studies are carried out in a laboratory context (76.92%), so it is also necessary to perform more empirical studies in industrial contexts to corroborate the academic results.
- *Who is evaluated in the empirical studies?* The subjects who performed the tests are mostly students (80.58%). A minority of papers involves academic staff (11.65%) or practitioners (7.77%).

– *What is maintained in the empirical studies?* We obtained that most of the studies are related solely to the maintenance of UML models (88.37%), rather than UML models and code (11.63%). It is also important to highlight that most of the models used represent prototypes of systems or very simple systems (71.83%). Performing more studies with real industrial systems is therefore necessary.

The main results of this SLR indicate that in the majority of experiments the external validity of the empirical studies is questionable, given the material, tasks and subjects used. This being so, there is a need for more empirical studies such as experiments and case studies executed in industrial contexts, i.e. with real systems and in which maintenance tasks are performed by practitioners under real conditions, in order to gather real empirical evidence of the influence of UML on maintenance.

2.2 RQ1: What is the perception of industry professionals as regards the value of using UML in the maintenance?

To address RQ1, we are planning to perform a web-based survey. We are not looking for a specific role as subject, since we wish to discover the perception of UML from different perspectives, but the results will be grouped by roles or groups of roles. The questions in the survey aim to discover what type of documentation is actually being used for maintenance and, whenever UML models are used (it may occur that models are available but not used), we wish to know which models are used most frequently. Furthermore, we deem it important to ascertain whether in the industrial environments in which UML is used as a tool to perform the maintenance tasks, there is a person who is responsible for updating the models or whether, on the other hand, the models are not updated.

A small amount of semi-structured interviews have already been conducted with practitioners in Dutch software companies who are involved in maintenance projects in which UML is used. Interviews have also been carried out with staff in India (via videoconference), because some of the companies contacted outsource maintenance work to this country. Given that managing to interview subjects from different countries is extremely difficult because software maintenance is carried out in geographically distributed projects and an interview is a time-consuming task, we used the results from interviews to create the survey that we wish to perform.

2.3 RQ2: Does the level of detail (LoD) of UML diagrams influence the maintenance of the code?

To address RQ2, we are planning to carry out a family of experiments (see Figure 2), whose main goal is to "*analyze the level of detail in UML models for the purpose of evaluating it with regard to the maintainability of systems from the point of view of the researcher, in the context of students in Computer Science and professionals*".

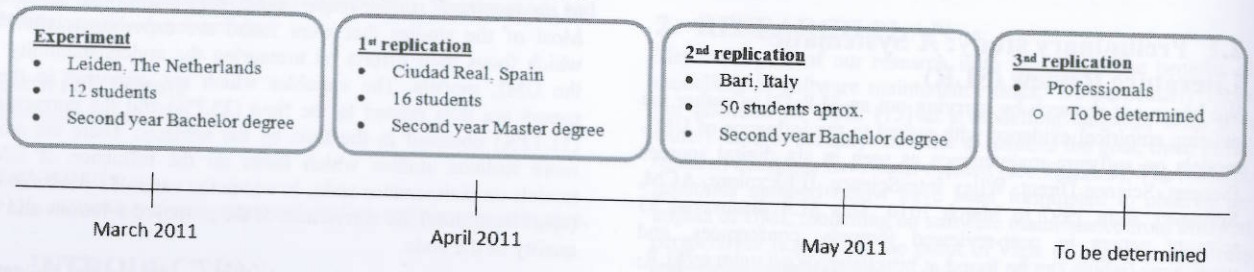

Fig. 2. Chronology of the family of experiments

There are two independent variables: the LoD with two values (low LoD and high LoD) and the diagram domain (A and B). By combining each level of the independent variables we obtain four treatments (see Table 1). The objects of study are software systems (source code + UML models). The UML diagrams considered in this experiment are use case diagrams, sequence diagrams and class diagrams.

As in [8], we considered that the LoD in UML models is defined as the amount of information that is used to represent a modelling element. When the LoD used in a UML model is low, it typically employs only a few syntactic features, such as class-name and associations, without specifying any further facts about the class. When it is high, the model also includes class attributes and operations, association names, association directionality, and multiplicity. In sequence diagrams, where there is a low LoD, the messages among objects have an informal label, and when the LoD is high the label is a method name plus the parameter list. In use case diagrams with a low LoD only actors, use cases and the relations among them are represented in the model, but in a high LoD model there are also extended and included use cases.

The dependent variable is maintainability measured through effectiveness (number of correctly performed modification tasks /number of modification tasks) and efficiency (number of correctly performed tasks/time).

Based on the assumption that the higher the amount of information put into a model, the more is known about the concepts/knowledge described in the model, the hypotheses are: *1) H_{01}: There is no significant difference in subjects' effectiveness when working with UML diagrams modelled using high or low level of detail. H_{11}:¬H_{01}, 2) H_{02}: There is no significant difference of subjects' efficiency when working with UML diagrams modelled using high or low level of detail. H_{11}: ¬H_{02}*

Table 1. Experiment runs

RUN 1		LoD		RUN 2		LoD	
		Low	High			Low	High
Domain	A	Group 1	Group 2	Domain	A	Group 3	Group 4
	B	Group 3	Group 4		B	Group 2	Group 1

Before experiment execution we shall provide the subjects with a background questionnaire and assign them to the 4 groups, randomly based on the marks obtained in the aforementioned questionnaire (blocked design by experience) in an attempt to alleviate experience effects. The experiment execution will consist of two runs. In each round, each of the groups will be given a different treatment. We shall assign the corresponding system (source code + UML models) to each group at random, but will distribute them in a different order in each case. Table 1 presents the outline of the experimental operation. This assignment of treatments corresponds with the selected balanced within factorial design with group-interaction confounding, which permits the lessening of the effects of learning and fatigue.

2.4 RQ3: What is the impact of using UML in software maintenance in terms of the cost and productivity of a software project?

To address RQ3, we are planning to conduct case studies in industrial environments. We cannot, as yet, provide details of the design of this empirical study, because it is still in its early stages. We wish to investigate whether the investment in modelling in maintenance software projects is justified by benefits, such as improved productivity and improved product quality.

We are still in the process of contacting software companies to obtain case studies that fit our purposes (projects using UML in maintenance tasks).

3. ACKNOWLEDGMENTS

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