

MAP-I  
Programa Doutoral em Informática

# Model-Driven Software Engineering

Unidade Curricular em Paradigmas da Computação  
*Paradigms of Computation*  
(UCPC)

DIUM, FEUP

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## Abstract

This document describes a Ph.D. level course, corresponding to a Curriculum Unit credited with 5 ECTS. It corresponds to a joint DIUM-FEUP proposal for UCPC (Paradigms of Computation) in the joint MAP-i doctoral program in Informatics, organized by three portuguese universities (Minho, Aveiro, and Porto).

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## LECTURING TEAM

**DIUM:** João M. Fernandes, Luís S. Barbosa, Alcino Cunha  
**FEUP:** João Pascoal Faria, Ana Paiva

**Coordinator:** João M. Fernandes

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# A. Programmatic Component

## 1. Theme, Justification and Context

### Motivation: Models in Software Engineering

So-called model-driven approaches to software design have gained, in recent years, widespread acceptance in software engineering. This raises a number of questions to the non-initiated, namely:

- what does model-orientation actually mean?
- how does one record models?
- (and above all) why does model-orientation matter?

In classical disciplines, by model one means an abstraction of something of interest. Reality is so complex that any attempt to consider it in full detail is doomed to fail. Scientists and engineers have learnt by experience to deliberately abstract from that part of reality which is not relevant to their current particular perspective. Naturally, features which can be ignored in one particular context may turn up to be essential to another one. In a sense, a balance between sharp observation and economy of thought (and common sense) is what is required in abstract modeling.

These ideas are well expressed in the consensual definition given by J. Rothenberg in “The Nature of Modeling in Artificial Intelligence, Simulation, and Modeling”, John Wiley and Sons, 1989, pp. 75-92,

Modeling, in the broadest sense, is the cost-effective use of something in place of something else for some cognitive purpose. It allows us to use something that is simpler, safer or cheaper than reality for some purpose. A model represents reality for the given purpose; the model is an abstraction of reality in the sense that it cannot represent all aspects of reality. This allows us to deal with the world in a simplified manner, avoiding the complexity, danger and irreversibility of reality.

Concerning how to record abstract models, drawings and diagrams are the most popular choices. However, scientists have learnt that drawings alone are unreliable means of passing knowledge on to future generations and that some kind of formal, unambiguous notation is required. The emergence of mathematical notation from natural language in science and engineering is among the main advances in modern, learned societies.

In an internet site devoted to stimulating youths' interest towards engineering disciplines (<http://www.discoverengineering.org>) one can read: Engineering is the application of math and science to create something of value from our natural resources. The fact that software engineering is not enrolled in the list of engineering branches in the same site (17 as a whole) can lead some to think that the definition is not wide enough to include branches which are more concerned with services than with natural resource transformation, and which might turn up to be less mathdependent. However, when software engineering emerged in the late sixties, the intention was not quite that, cf. the following excerpt of the 1968 NATO conference on the subject, which took place in Garmisch, Germany:

In late 1967 the Study Group recommended the holding of a working conference on Software Engineering. The phrase 'software engineering' was deliberately chosen as being provocative, in implying the need for software manufacture to be based on the types of theoretical foundations and practical disciplines, that are traditional in the established branches of engineering.

So, clearly, it has been always the intention of software engineers to manufacture software from rigorous models of real problems and situations which can be animated, queried and reasoned about. Moreover, so-called model-oriented specification is a formal technique that has been in use for many years in methodologies such as eg. VDM, Z or B. So, model-orientation does matter and has a tradition in formal methods.

More recently, the term model-driven engineering (MDE) was coined to refer to the use of generative and transformational techniques for software engineering where system implementations are (semi-) automatically derived from models or specifications. It consists of systematically using "models" as primary engineering artifacts throughout the production lifecycle, but of course, everything depends on the underlying notion of what a model actually "is".

As mentioned above, mathematical modeling has a well-known tradition in both the exact sciences (e.g. physics, biology) and the social sciences (e.g. economics, sociology). In the context of software engineering, mathematical models are the essence of so-called model-oriented specification, a formal technique which has been in use for many years in methodologies such as e.g. VDM, Z or B. Within MDE, however, the word "model" does not necessarily refer to a piece of mathematics and purports solely the idea of abstracting irrelevant detail from a real problem, so as to make it tractable and machine-processable. Models are therefore regarded as first class entities, as expressed by the adagium "Everything is a Model".

## Approach: what is Model-driven Software Engineering?

We define Model-Driven Software Engineering (or MDSE) as the application of model-driven engineering to software engineering, i.e., it consists of systematically using models as primary engineering artifacts throughout the software engineering lifecycle.

The most common types of models of software systems used today are UML models (with roots in several diagramming notations) and several types of formal models (with stronger roots in mathematics). The current trend in MDSE is accompanied by an increasing convergence between UML models and formal models.

The best known MDE initiative is the Object Management Group (OMG) called Model-Driven Architecture (MDA), which is a registered trademark of OMG. Another related acronym is Model-Driven Development (MDD) which is an OMG trademark. MDA is intended to support model-driven engineering of software systems. A gentle introduction to MDA can be found in the book, “MDA Explained: The Model Driven Architecture – Practice and Promise”, by Anneke Kleppe, Jos Warmer and Wim Bast, from Addison-Wesley, 2003. The basic idea behind the MDA initiative is to use (UML) models not only as analysis and design documents but also as the basis for code generation. The benefits are increased productivity (via automated transformations from models to code as well as between models at different levels of abstraction), portability (with the distinction between Platform Independent Models and Platform Specific Models), interoperability (via PSM bridges) and maintainability (since models are easier to maintain than code). In order to be able to perform those transformations in an automated way, the models have to be of greater rigor and precision. Stronger roots and convergence with more formal notations can be observed in several components of the recent UML 2.0 standard: the Object-Constraint Language (or OCL) has roots in formal specification languages of the VDM and Z family; behavior state machine diagrams are now very close to the more formal SDL notation used in the telecommunication industry; the semantics of activity diagrams is now based on Petri Nets.

However, one should not reduce the more fundamental MDE trend to the MDA initiative. According to Jean Bézivin in his seminal paper “On the Unification Power of Models”,

the MDA initiative is a particular variant of a new global trend called MDE (Model Driven Engineering)

Such is the scope of the present course.

## Course Context

In such a context this course proposes an approach to Software Engineering based on the central role of models, their construction, validation, verification, transformation

and reuse. It seeks to lay the foundations for a sound discipline of Model-driven Software Engineering, instead of adopting a particular formalism, method or notation. It is organized around three main ideas:

- Sound principles - as enounced above
- Eclecticism - several approaches and notations are addressed rather than a single unifying one
- Pragmatism - the course goes beyond first principles into practical application of useful techniques and tools

More specifically, the goal of this course is to address the fundamental concepts and techniques of MDE, without forgetting its realization in the MDA initiative.

Besides the benefits already mentioned in the MDA initiative, the convergence of formal-based and UML-based models and methods, opens the way for automated verification and validation of the models (for earlier defect detection), the development of systems (or parts of systems) that are correct by construction, and the automatic generation of test cases from models for conformity testing of the final system. Existing legacy systems can also benefit from this trend by employing automated reverse-engineering techniques.

MDSE is an area of very active research, where theory and pragmatics, rigor and agility meet to achieve increased quality and productivity in the development of software intensive systems.

## Brief Mention to CMU Related Courses

Carnegie Mellon University offers related courses in the Master of Software Engineering, which act simultaneously as core courses in the PhD Program in Software Engineering:

**Models of Software Systems:** “Scientific foundations for software engineering depend on the use of precise, abstract models for characterizing and reasoning about properties of software systems. This course considers many of the standard models for representing sequential and concurrent systems, such as state machines, algebras, and traces. It shows how different logics can be used to specify properties of software systems, such as functional correctness, deadlock freedom, and internal consistency. Concepts such as composition mechanisms, abstraction relations, invariants, non-determinism, inductive definitions and denotational descriptions are recurrent themes throughout the course.” Topics: foundations; state machines; Z; refinement and abstraction; concurrency (in FSP); model checking; Petri Nets; UML

**Analysis of Software Artifacts:** “Our ability to build, maintain, and reuse software systems relies on our ability to analyze effectively the products of software development. This course will address all kinds of software artifacts - specifications, designs, code, etc. - and will cover both traditional analyses, such as verification and testing, and promising new approaches, such as model checking, abstract execution and new type systems. The focus will be the analysis of function (for finding errors in artifacts and to support maintenance and reverse engineering), but the course will also address other kinds of analysis (such as performance and security). Various kinds of abstraction (such as program slicing) that can be applied to artifacts to obtain simpler views for analysis will play a pivotal role. Concern for realistic and economical application of analysis will also be evident in a bias towards analyses that can be applied incrementally. The course emphasizes the fundamental similarities between analyses (in their mechanism and power) to teach the students the limitations and scope of the analyses, rather than the distinctions that arose historically (static vs. dynamic, code vs. spec). The course will balance theoretical discussions with lab exercises in which students will apply the ideas they are learning to real artifacts.”

### **ACM Computing Classification System subjects covered:**

- D. Software / D.2 SOFTWARE ENGINEERING / D.2.2 Design Tools and Techniques
- D. Software / D.2 SOFTWARE ENGINEERING / D.2.4 Software/Program Verification
- D. Software / D.2 SOFTWARE ENGINEERING / D.2.5 Testing and Debugging
- D. Software / D.2 SOFTWARE ENGINEERING / D.2.11 Software Architectures
- H. Information Systems / H.5 INFORMATION INTERFACES AND PRESENTATION / H.5.2 User Interfaces

## **2. Objectives and Learning Outcomes**

This course aims at introducing a sound approach to the principles, methods and pragmatics of Software Engineering, understood as

... that form of Engineering that applies the principles of computer science and mathematics to achieve cost-effective solutions to software problems  
[CMU/SEI-90-TR-003]

More specifically it intends to cover, both from the foundational and the methodological point of view, the construction, analysis, design, classification, animation, validation and verification of models for software systems at different levels of abstraction and concern. As a second objective the course aims at providing the conceptual tools for the use of models in all phases of the software process, with a particular emphasis on test planning and code generation. The course is not intended as an introductory survey to Model-driven Software Engineering, but as an opportunity of exposing students to cutting-edge research topics in this area, although presented in a coherent and integrated way. It is placed at a similar level and cover overlapping material with advanced modules in doctoral programs at leading academic institutions.

Upon successful completion of this curricular unit, students should be able:

- to explain the need for describing software systems with models, as a way to abstract from the system's complexity and to reason about its properties;
- to clearly differentiate from behavioral/dynamic and informational/structural models;
- to identify the expressiveness and limitations of different modeling frameworks (like UML, VDM, Petri nets, ERDs, DFDs, Problem Frames) and to describe the type of system views they better fit.
- to use models for the activities (analysis, design, implementation, testing, maintenance) associated with the development of large software systems.
- to create, analyze, validate, verify and transform sets of models with the adequate detail for the software system under development, based on a multiple view approach.
- to describe/implement model transformations for automating the software process, namely to generate final code from the models.

### **3. Course Contents**

#### **1. Principles of model-driven software engineering**

This first course unit is intended to provide a motivation and context for MDSE and introduce its main principles. Topics to be addressed include, but are not restricted to a notion of abstraction, model quality, process vs. product, cost effectiveness, reuse, patterns, selection of modeling frameworks based on the modelling purpose, model consistency, model continuity, views and multiview approaches and modeling complexity.

## 2. Models

This is a central unit in the course whose purpose is to study several modelling frameworks in Software Engineering. Such study encompasses, for each case, foundations, associated methodologies and modeling notations. Models to be considered in this unit are classified with respect to

- the degree of mathematical precision involved, leading to a basic distinction between formal and semi-formal (often referred to as visual) models;
- their purpose, distinguishing between functional, data and control/dynamic/behavioral models;
- the underlying computation model, distinguishing between state-oriented, activity-oriented, structure-oriented, data-oriented, and heterogeneous;
- their domain of application, to capture functional or non-functional properties.

The Unified Model Language (UML) will be adopted as a representative of a semi-formal modeling framework. As the OMG specification states, UML is “a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system”. Although in itself it does not specify any methodological or design process, its role as a (collection of inter-related of) semi-formal notations in supporting software development, from business processes or global architectures down to database schema, and reusable software components, became more and more fundamental, almost a de facto standard, to the whole Software Engineering discipline. Topics to be addressed include: UML diagrams; OCL; action semantics and executable UML; extensibility mechanisms; UML meta-model. On the formal side, on the other hand, the course will cover both

- state-oriented (e.g. VDM and Spec#), and
- behavior-oriented methods (e.g. Petri nets and temporal logics)

A last topic to be addressed in this unit concerns model integration, within UML and between UML and other modeling frameworks.

## 3. Model Quality

If a project uses poor models, it risks encountering problems such as misunderstanding, building the wrong product, large testing effort and ultimately a low quality product. Hence, assuring the quality of models is of key importance for completing projects successfully in a MDSE approach. This course unit is concerned with model quality analysis and enforcement. In particular, the following topics will be considered:

- Quality attributes, e.g., completeness, consistency, non-ambiguity, conciseness, adequacy, esthetics, verifiability, maintainability, compliance



- Quality metrics
- Quality strategies, e.g., constructive and analytical

#### 4. Model Verification and Validation

As a follow-up of the unit on model quality, this course unit introduces the principles and techniques that can be used to promote and analyze aspects of software quality during the software development life-cycle. The unit reviews the state of the art in software verification and validation, associated to the correct development of models (get the model right) and the analysis of their soundness, adequacy and general sensibleness (get the right model) , respectively. Particular topics to be covered include: V&V in the Software Engineering life-cycle; models for reasoning about software; classification, expression and enforcing of properties; static and dynamic analysis.

The emphasis is placed on practical static analysis techniques and tools to perform model based verification and validation of software, in terms of assigned invariants, pre- and post-conditions. These include both model checking (explicit vs. symbolic, timed, stochastic) and theorem proving (firstorder, higher-order), as well as their integration. It also presents an overview of dynamic analysis techniques, based on model prototyping, and a comparison with its static counterpart, although a deeper coverage will be left for the model-based testing unit. At this stage it is not pertinent to choose the exact tools to use in the course. Nevertheless, likely candidates are model checkers such as SMV, SPIN, Uppaal or PRISM, and theorem provers such as the Larch prover, PVS or HOL.

#### 5. Model Transformation

This course unit covers the fundamental issue of model transformation within the two basic types of models considered in the course — visual (like UML) and formal (like VDM, Petri nets or ASM). Particular emphasis will be placed on the following topics:

- Stepwise refinement of both function-, data- and behavior-oriented models.
- Transformation of analysis models into design models making explicit the envisaged software architecture.
- Transformation of platform independent into platform specific models.
- Code generation (i.e., transformation of design models into code), especially for behavior-intensive systems, and its current limitations
- Coupled software transformations understood as the simultaneous transformation of several models preserving consistency relations holding between them. This area has strong connections to the viewupdate problem, i.e, the ability to translate updates on a view of a data source into updates on the data source itself, which is extremely relevant in MDSE.

- Model constraints (vulg. invariants, “business rules”) and their role in model transformation, i.e., principles for reasoning about constraints, including constraint logics and calculi that make these logics operational.

#### 6. **Model-based Testing**

Model-based testing, a fundamental issue in MDSE, is a software testing technique in which test cases are derived (semi-)automatically from a model of the system under test (SUT). It allows checking the conformity between the implementation and the model of the SUT, introducing more systematization and automation into the testing process. This course unit will start by explaining the model-based testing process and its phases. Existing techniques to support each phase of the testing process will be reviewed. In particular, it will present techniques for

- Input data generation.
- Test case generation.
- Checking test coverage and adequacy.
- Dealing with the state explosion problem.
- Checking conformity between the model and an implementation.

At the end of this unit, the students should be able to apply model-based testing to a medium size software system selecting among the existing techniques the ones considered more adapted for the kind of model used.

#### 7. **Re-engineering**

This unit will introduce techniques for the reverse engineering of software systems, with a particular emphasis on code slicing and strategic programming. The reverse engineering of the user interface code of software written in Java/Swing will be used as a case study.

#### 8. **Case-study**

A challenging case study will be proposed in each instantiation of this course. This unit has a double purpose: not only to act as a case study discussion in strict sense but also to raise a research challenge in Software Engineering. For the previous edition (07/08) of MAP-i, the chosen area was human-computer interaction. In the 08/09 edition, a different case study will be selected.

## 4. **Teaching Methods and Student Assessment**

The course is organized around a number of lectures with the double purpose of covering the contents and introducing research challenges. Specific lecture notes for each course unit will be written.

- 50% based on written assignments (e.g., a research paper analysis) proposed on the end of each course unit.
- 50% based on an individual survey monograph.

## 5. Basic Bibliographic References

- Berard B, Bidoit M, Finkel A, Laroussinie F, Petit A, Petrucci L, Schnoebelen P. *Systems and Software Verification: Model-Checking Techniques and Tools*, Springer, 1999.
- Bjorner D. *Software Engineering (Abstraction and Modelling; Specification of Systems and Languages; Domains, Requirements and Software Design)*, Springer, 2006.
- Clarke EM, Grumberg O, Peled DA. *Model Checking*. MIT Press, 2000.
- Douglass BP. *Real Time UML: Advances in the UML for Real-Time Systems*, Addison Wesley, 2004.
- Fitzgerald J, Larsen PG, Mukherjee P, Plat N, Verhoef M. *Validated Designs for Object-oriented Systems*, Springer, 2005.
- Jensen K, Kristensen LM. *Coloured Petri Nets: Modeling and Validation of Concurrent Systems*, Springer, 2008. To appear.
- Kleppe A, Warmer J, Bast W. *MDA Explained: The Model Driven Architecture – Practice and Promise*, Addison-Wesley, 2003.
- Stevens P, Pooley R. *Using UML: Software Engineering with Objects and Components*, Addison-Wesley, 2000.
- Utting M, Legeard M. *Practical Model-Based Testing: A Tools Approach*, Morgan Kaufmann, 2007.
- Wieringa RJ. *Design Methods for Reactive Systems: Yourdon, Statemate, and the UML*, Morgan Kaufmann Publishers, 2003.

## B. Lecturing Team

### 1. Team Presentation

This course is supported by a team involving researchers from both the University of Porto, FEUP (João Pascoal Faria and Ana Paiva), and the University of Minho, DI/CCTC (João M. Fernandes, Luís Soares Barbosa, and Alcino Cunha). This course was offered in the first edition of the MAP-i programme and was attended by 15 students.

All team members are working, and have worked actively in the past few years, on topics that are directly related to the subjects covered by this course, as detailed below.

### 2. Coordinator

The coordinator of the unit is João M. Fernandes.

### 3. Short Presentation of Team Members

In the sequel we introduce a brief presentation of each team member, which includes, for each of them, up to 5 key publications related to the scientific area in which this course is proposed. **All CVs are supplied in separate PDF documents.**

**João M. Fernandes** is associate professor at the Department of Informatics of Minho University, and a researcher member of CCTC. His scientific research activities are centered around the areas of systems modelling and development of software for embedded systems. In the systems modelling area, his interests lie on the usage of the UML and High-level Petri nets, as specification notations for highly complex software systems, and in studying and applying model-driven development approaches. In the embedded software area, his attention focus on issues related to the methodological approach to follow, namely the requirements capture, the software process model, the methods used for development, and the transition between phases. He is a co-founder and regular editor for the International Workshop Series on Model-based Methodologies for Pervasive and Embedded Software (MOMPES). He is a funding member of the IFIP Working Group 10.2 (Embedded Systems). In 2002/03, he was a postdoctoral researcher at TUCS (Turku, Finland), and in 2006/7 he was an invited assistant professor at University of Aarhus (Denmark).

Key Publications:

- Machado RJ, Fernandes JM, Monteiro PA, Rodrigues H. Transformation of UML

Models for Service-Oriented Software Architectures, 12th IEEE International Conference on the Engineering of Computer Based Systems (ECBS 2005), Greenbelt, Maryland, USA, pp. 173-182, IEEE Computer Society Press, Apr/2005.

- Machado RJ, Ramos I, Fernandes JM. Specification of Requirements Models, Engineering and Managing Software Requirements, Aurum A., Wohlin C. (eds.), chap. 3, pp. 47-68, Springer, Jul/2005.
- Machado RJ, Fernandes JM, Monteiro PA, Rodrigues H. Refinement of Software Architectures by Recursive Model Transformations, 7th International Conference on Product Focused Software Process Improvement (PROFES 2006), Amsterdam, The Netherlands, LNCS 4034, pp. 422-428, Springer, Jun/2006.
- Fernandes JM, Lilius J, Truscan D. Integration of DFDs into a UML-based Model-Driven Engineering Approach, Software and Systems Modeling (SoSyM) 5(4):403-428, Springer, Dec/2006.
- Fernandes JM, Jørgensen JB, Tjell S. Requirements Engineering for Reactive Systems: Coloured Petri Nets for an Elevator Controller, 14th Asia-Pacific Software Engineering Conference (APSEC 2007), Nagoya, Japan, IEEE Computer Society Press, pp. 294-301, Dec/2007.

**Luis Soares Barbosa** is associate professor at the Department of Informatics of Minho University, and a researcher member of CCTC. His research area is program semantics and calculi applied to systems understanding and rigorous software construction. In particular, most of his work has been devoted, concerns the development of formal models and calculi for software components, services and architectures. Since 2003 he has been the coordinator of a FCT project on Program Understanding and Re-engineering as well as of a cooperation project with School of Mathematics of Peking University on Formal Models for Software Components. From 1990 to 2004 he coordinated, as an invited lecturer, a Seminar on Systems Design at the Faculty of Engineering of the University of Bristol, UK. He was also an invited lecturer in Mathematics and Computer Science PhD programs at Tartu University, Estonia (2003), and Peking University, China (2006).

#### Key Publications:

- Sun M, Naixiao Z, Barbosa LS. On Semantics and Refinement of UML Statecharts, Proc. of 2nd IEEE Int. Conf. on Software Engineering and Formal Methods, Cuelar J, Liu Z (eds), pp. 164-173, IEEE Computer Society Press, 2004.
- Cruz A, Barbosa LS, Oliveira JN. From Algebras to Objects: Generation and Composition, Journal of Universal Computer Science 11(10):1580-1612, 2005.

- Barbosa LS, Sun M, Aichernig BK, Rodrigues N. On the Semantics of Componentware: a Coalgebraic Perspective, in Mathematical Frameworks for Component Software: Models for Analysis and Synthesis, He J, Liu Z (eds), Series on Component-Based Software Development, World Scientific, 2006.
- Rodrigues N, Barbosa LS. Program Slicing by Calculation, Journal of Universal Computer Science 12(7):828-848, 2006.
- Barbosa LS, Oliveira JN. Transposing Partial Components: an Exercise on Coalgebraic Refinement, Theoretical Computer Science 365(1-2):2-22, 2006.

**Alcino Cunha** is assistant professor at the Department of Informatics of Minho University, and a researcher member of CCTC. He received his Ph.D. degree in 2005. His general research areas are program calculation, functional programming, data refinement, and coupled software transformation, where he has developed extensive work, partially documented in the 5 selected publications mentioned below

Key Publications:

- Cunha A, Pinto JS. Point-free program transformation. Fundamenta Informaticae, 66(4):315-352, 2005.
- Cunha A, Pinto JS, Proença J. A framework for point-free program transformation. In A. Butterfield, C. Grelck, and F. Huch, editors, Selected Papers of the 17th International Workshop on Implementation and Application of Functional Languages, volume 4015 of LNCS, pp. 1–18. Springer-Verlag, 2006
- Cunha A, Oliveira JN, Visser J. Type-safe Two-level Data Transformation. 14th International Symposium on Formal Methods (FM 2006), Hamilton, Ontario, Canada, LNCS 4085, pp. 284-299, Springer, Jul/2006.
- Cunha A, Visser J. Transformation of Structure-Shy Programs - Applied to XPath Queries and Strategic Functions. Partial Evaluation and Program Manipulation (PEPM 2007), Nice, France, pp. 11-20, ACM Press, Jan/2007.
- Berdaguer P, Cunha A, Pacheco H, Visser J. Coupled Schema Transformation and Data Conversion for XML and SQL. Practical Aspects of Declarative Languages (PADL 2007), Nice, France, LNCS 4354, pp. 290-304, Springer, Jan/2007.

**Ana Paiva** is assistant professor at Engineering Faculty of Porto University. She has been developing research work on model-based GUI testing in collaboration with Foundation of Software Engineering research group within Microsoft Research. She had the opportunity to extend Microsoft's model-based testing tool, Spec Explorer, in order to make it more adapted for GUI testing. She had to face with several problems concerned with the implementation and automation of the model-based testing process. In particular, she developed a method for modeling GUIs, a technique to cope with the

state space explosion problem, and a tool to map model actions with simulated user actions on a GUI implementation for checking conformity between the GUI model and its implementation. She is a member of the CYTED network on software verification and validation (REVVIS). Her input will be valuable specially in modeling techniques, model-based testing and in case study construction.

**João Pascoal de Faria** is assistant professor at the Department of Electrical and Computer Engineering of FEUP, and a researcher at INESC Porto. He has active research work in the area of model-based testing (one of the major topics of the program proposed), based both on formal models and UML models, since 2003. He has more than 10 years of experience in teaching and supervising students' projects in object oriented analysis and design with UML and previous notations, and a 4-year experience in teaching Software Testing. He has a 10-year experience in the development and maintenance of a rapid application development (RAD) tool between 1989 and 1999 that is still in use, and currently has a strong interest in combining formal and traditional methods for rapid and rigorous application development. He is the proposal coordinator of a research project currently submitted to FCT on An Automated Model-based User Interface Testing Environment.

Key Publications (together with Ana Paiva):

- Paiva A, Faria JP, Vidal R. Specification-based Testing of User Interfaces, 10th Design Specification and Verification of Interactive Systems Workshop (DSV-IS 2003), Funchal, Portugal, LNCS 2844, pp. 139-153, Springer, Jun/2003.
- Paiva A, Faria JP, Vidal R. Automated Specification-based Testing of Interactive Components with AsmL, QUATIC 2004, Porto, Oct/2004.
- Paiva A, Faria JP, Vidal R, Tillmann N. Modeling and Testing Hierarchical GUIs, 12th International Workshop on Abstract State Machines (ASM 2005), Paris, France, pp. 329-344, Mar/2005.
- Paiva A, Faria JP, Vidal R, Tillmann N. A Model-to-implementation Mapping Tool for Automated Model-based GUI Testing, 7th International Conference on Formal Engineering Methods (ICFEM 2005), Manchester, UK, LNCS 3785, pp. 450-464, Springer, Nov/2005.
- Paiva A, Faria JP, Vidal R. Towards the Integration of Visual and Formal Models for GUI Testing, 3rd Workshop on Model Based Testing (MBT 2007) at ETAPS 2007, Braga, Portugal, 2007.

# CURRICULUM VITÆ

João M. Fernandes

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## Academic degrees, Institutions, Fields of study:

- PhD, U.Minho, Informatics / Computer Engineering, May/2000.
- MSc, U.Minho, Informatics / Computing Science, Jul/1994.
- Licenciatura (5-year degree), U.Minho, Systems and Informatics Engineering, Sep/1991.

**Current position, Institution:** Associate Professor, U.Minho, since Oct/2007.

## Previous positions, Institutions:

- Visiting Assistant Professor, Aarhus Universitet, Dep. Computer Science, Denmark, Sep/2006-Jun/2007.
- Invited Assistant Professor, Universidade do Algarve, Faculty of Sciences and Technology, Faro, Portugal, Sep/2004-Jun/2006.
- Post-doctoral Researcher, TUCS, Turku, Finland, Sep/2002-Feb/2003.
- Vice-president of the Engineering Degrees Council, U.Minho, Oct/2004-Sep/2006.
- Director of the 5-year degree in Systems and Informatics Engineering, U.Minho, Jun/2004-Sep/2006.
- Assistant Professor, U.Minho, May/2000–Oct/2007.
- Assistant, U.Minho, Jul/1994–May/2000.
- Teaching Assistant, U.Minho, Nov/1991–Jul/1994.
- Junior Assistant, U.Minho, 1989/90.

**Main research area:** Software Engineering

**Other scientific interests:** Embedded Computing, Systems Modelling

## Organisation of international scientific conferences:

1. Industry Liaison Committee Chair, IEEE Second International Symposium on Industrial Embedded Systems (SIES 2007), Costa da Caparica (Lisbon), Portugal, Jul/2007
2. Editor and organiser, Workshop series on Model-based Methodologies for Pervasive and Embedded Software (MOMPES); 5 editions, 2004-2008. Proceedings published by IEEE Computer Society Press, since 2006.
3. Organising Committee Co-chair, 5th IFIP International Conference on Distributed and Parallel Embedded Systems (DIPES 2006), Braga, Portugal, Oct/2006. Proceedings published in IFIP series, Springer.
4. Organising Committee Co-chair and Finance chair, 3rd IEEE International Conference on Application of Concurrency to System Design (ACSD 2003), Guimarães, Portugal, Jun/2003. Proceedings published by IEEE Computer Society Press.
5. Program Committee Member of several international conferences and workshops: QUATIC, SIES, SPAC, TeaConc, MOMPES, REC, CPN, DIPES, ICESS, ETFA, DSOA, CONTROLO.
6. Reviewer for several international conferences and the following journals: IEEE Transactions on Software Engineering, IEEE Software, IEEE Computer, IEEE Transactions on Industrial Electronics, Software and Systems Modeling (Springer), Nordic Journal of Computing, "Integration, the VLSI Journal" (Elsevier), Energy (Elsevier).

## Most relevant publications (2004-7):

1. Monteiro MP, Fernandes JM, An Illustrative Example of Refactoring Object-oriented Source Code with Aspect-oriented Mechanisms, Software: Practice and Experience 38(4):361–96, Wiley. doi 10.1002/spe.835.
2. Fernandes JM, Jørgensen JB, Tjell S; Requirements Engineering for Reactive Systems: Coloured Petri Nets for an Elevator Controller, 14th Asia-Pacific Software Engineering Conference (APSEC 2007),



- Nagoya, Japan, IEEE Computer Society Press, pp.~294--301, Dez/2007. doi: 10.1109/APSEC.2007.81.
3. Fernandes JM, Machado RJ, Teaching Embedded Systems Engineering in a Software-Oriented Computing Degree, 37th Annual ASEE/IEEE Frontiers in Education Conference (FIE 2007), Milwaukee, WI, USA, Oct/2007. doi 10.1109/FIE.2007.4417949.
  4. Mashkoo A, Fernandes JM, Deriving Software Architectures for CRUD Applications: The FPL Tower Interface Case Study, 2nd International Conference on Software Engineering Advances (ICSEA 2007), Cap Esterel, France, IEEE Computer Society Press, Aug/2007. doi 10.1109/ICSEA.2007.25.
  5. Ribeiro OR, Fernandes JM, Translating Synchronous Petri Nets into PROMELA for Verification of Behavioural Properties, 2nd IEEE International Symposium on Industrial Embedded Systems (SIES 2007), Costa da Caparica, Portugal, IEEE, Jul/2007. doi 10.1109/SIES.2007.4297344.
  6. Fernandes JM, Tjell S, Jørgensen JB, Ribeiro OR, Designing Tool Support for Translating Use Cases and UML 2.0 Sequence Diagrams into a Coloured Petri Net, 6th International Workshop on Scenarios and State Machines (SCESM 2007), within the 29th International Conference on Software Engineering (ICSE 2007), Minneapolis, MN, USA, IEEE Computer Society Press, May/2007. doi: 10.1109/SCESM.2007.1.
  7. Fernandes JM, Machado RJ, A Two-Year Software Engineering M.Sc. Degree designed under the Bologna Declaration Principles, 1st International Conference on Software Engineering Advances (ICSEA 2006), Tahiti, French Polynesia, IEEE Computer Society Press, Oct-Nov/2006. doi: 10.1109/ICSEA.2006.13.
  8. Fernandes JM, Machado RJ, Monteiro PA, Rodrigues H, A Demonstration Case on the Transformation of Software Architectures for Mobile Applications, From Model-Driven Design to Resource Management for Distributed Embedded Systems, Kleinjohann B, Kleinjohann L, Machado RJ, Pereira C, Thiagarajan PS (eds.), Springer, IFIP 225, pp. 235--44, Oct/2006, ISBN 0-387-39361-7.
  9. Fernandes JM, Lilius J., Truscan D., Integration of DFDs into a UML-based Model-Driven Engineering Approach, Software and Systems Modeling (SoSyM) 5(4):403--28, Springer, Dec/2006. doi: 10.1007/s10270-006-0013-0.
  10. Duarte FJ, Fernandes JM, Machado RJ, Business Modeling in Process-Oriented Organizations for RUP-based Software Development, Reference Modeling for Business Systems Analysis, Fettke P, Loos P (eds.), Idea Group, Hershey, Pennsylvania, USA, chap. 5, pp. 98--117, Oct/2006.
  11. Machado RJ, Fernandes JM, Monteiro PA, Rodrigues H, Refinement of Software Architectures by Recursive Model Transformations, 7th International Conference on Product Focused Software Process Improvement (PROFES 2006), Münch J, Vierimaa M (eds.), Amsterdam, The Netherlands, Springer, LNCS 4034, pp. 422--8, Jun/2006. doi: 10.1007/11767718\_38.
  12. Monteiro MP, Fernandes JM, Towards a Catalogue of Refactorings and Code Smells for AspectJ, Transactions on Aspect-Oriented Software Development I, Springer, Rashid A, Aksit M (eds.), LNCS 3880, pp. 214--58, Mar/2006. doi: 10.1007/11687061\_7.
  13. Monteiro MP, Fernandes JM, Refactoring a Java Code Base to AspectJ: An Illustrative Example, 21st IEEE International Conference on Software Maintenance (ICSM 2005), Budapest, Hungary, IEEE Computer Society Press, pp. 17--26, Sep/2005. doi: 10.1109/ICSM.2005.75.
  14. Machado RJ, Fernandes JM, Integration of Embedded Software with Corporate Information Systems, From Specification to Embedded Systems Application, Rettberg A, Zanella MC, Rammig FJ (eds.), pp. 169--78, Springer, Aug/2005. doi: 10.1007/11523277\_17.
  15. Machado RJ, Ramos I, Fernandes JM, Specification of Requirements Models, Engineering and Managing Software Requirements, Aurum A., Wohlin C. (eds.), chap. 3, pp. 47--68, Springer, Jul/2005. doi: 10.1007/3-540-28244-0\_3.
  16. Machado RJ, Fernandes JM, Monteiro PA, Rodrigues H, Transformation of UML Models for Service-Oriented Software Architectures, 12th IEEE International Conference on the Engineering of Computer Based Systems (ECBS 2005), Greenbelt, Maryland, USA, pp. 173--82, IEEE Computer Society Press, Apr/2005. doi: 10.1109/ECBS.2005.73.
  17. Ribeiro OR, Fernandes JM, Pinto L, Model Checking Embedded Systems with PROMELA, 12th IEEE International Conference on the Engineering of Computer Based Systems (ECBS 2005), Greenbelt, Maryland, USA, IEEE Computer Society Press, pp. 378--85, Apr/2005. doi: 10.1109/ECBS.2005.53.
  18. Monteiro MP, Fernandes JM, Towards a Catalog of Aspect-Oriented Refactorings, 4th International Conference on Aspect-Oriented Software Development (AOSD 2005), Tarr P (ed.), Chicago, Illinois, USA, ACM Press, pp. 111--22, Mar/2005. doi: 10.1145/1052898.1052908.
  19. Fernandes JM, Duarte FJ, A Reference Framework for Process-Oriented Software Development Organizations, Software and Systems Modeling (SoSyM) 4(1):94--105, Springer, Feb/2005. doi: 10.1007/s10270-004-0063-0.
  20. Machado RJ, Fernandes JM, A Multi-level Design Pattern for Embedded Software, Design Methods and Applications for Distributed Embedded Systems, Kleinjohann B, Gao GR, Kopetz H, Kleinjohann L, Rettberg A (eds.), pp. 247--56, Kluwer Academic Publishers, Boston, Massachusetts, USA, Aug/2004.
  21. Fernandes JM, Lilius J, Functional and Object-Oriented Views in Embedded Software Modeling, 11th IEEE Int. Conference on the Engineering of Computer Based Systems (ECBS 2004), Brno, Czech Republic, pp. 378--87, IEEE Computer Society Press, May/2004. doi: 10.1109/ECBS.2004.1316722.

22. Truscan D, Fernandes JM, Lilius J, Tool Support for DFD-UML Model-based Transformations, 11th IEEE International Conference on the Engineering of Computer Based Systems (ECBS 2004), Brno, Czech Republic, IEEE Computer Society Press, pp. 388–97, May/2004. doi: 10.1109/ECBS.2004.1316723.
23. Fernandes JM, Duarte FJ, Using RUP for Process-Oriented Organisations, 5th International Conference on Product Focused Software Process Improvement (PROFES 2004), Bomarius F, Iida H (eds.), Kansai Science City, Japan, Springer, LNCS 3009, pp. 348–62, Apr/2004.

#### **PhD and MSc supervisions:**

1. PhD in Information Systems, Francisco José Monteiro Duarte, Automated Information Systems Generation for Process-Oriented Organizations. Started in Oct/2006.
2. PhD in Informatics, Óscar Rafael da Silva Ferreira Ribeiro. Animation and Validation of Reactive Software from Scenario-Based Models. Started in Apr/2005.
3. PhD in Informatics, Miguel Jorge Tavares Pessoa Monteiro, Refactorings to Evolve Object-Oriented Systems with Aspect-Oriented Concepts. Finished in Jul/2005.
4. MSc in Informatics, Paula Alexandra Fernandes Monteiro, Model-based Transformations for Pervasive Software Architectures. Finished in May/2006.
5. MSc in Informatics, Óscar Rafael da Silva Ferreira Ribeiro, Model Checking of Petri Nets for Embedded Systems. Finished in Jul/2005.
6. MSc in Informatics, Francisco José Monteiro Duarte. Process-Oriented Software Engineering. Finished in Jul/2002.

#### **Funded projects:**

1. UMinho Principal Researcher, SOFTAS: Software Development with Aspects, Set/2005-Dez/2007. Programme FCT (POSI/EIA/60189/2004). Partners: FCT-UNL (coordination; Ana M. Moreira), U.Minho, IP Beja, IP Castelo Branco, LINCIS, NAV.
2. Researcher, uPAIN: Ubiquitous Solutions for Pain Monitoring and Control in Post-Surgery Patients, Jan/2005-Feb/2008. Programme AdI/Ideia 2004 (AdI/IDEIA/70/2004/3.1B/00364/007). Partners: U.Minho (coordination; Ricardo J. Machado e Armando Pinto de Almeida), Hospital da Senhora da Oliveira de Guimarães, MobiComp - Computação Móvel.
3. Researcher, STACOS: Standard-Based Cooperative Software, Jan/2004-Abr/2007. Programme FCT Sapiens 2002 (POSI/CHS/48875/2002). Partners: U.Minho (coordination; Ricardo J. Machado), FCUL, INESC-ID, IDITE-Minho, LINCIS, ATX Software.
4. Researcher, PPC-VM: Portable Parallel Computing based on Virtual Machines, Mar/2004-Feb/2007. Programa FCT Sapiens 2002 (POSI/CHS/47158/2002). Partners: U.Minho (coordination; João L. Sobral).
5. Principal Researcher, METHODES: Methodologies and Tools for Developing Embedded Systems, Fev/2002-Jan/2006. Programme FCT Sapiens 2001 (POSI/CHS/37334/2001). Partners: U.Minho, ISEP, IDITE-Minho.

#### **Courses taught in the last 2 years:**

In the academic year 2007/08, at U.Minho, I was responsible for one undergraduate the MAP-i course on “Model-Driven Software Engineering” (15 students) and one graduate course on “Requirements Engineering and Management” (15 students). I was also involved in lecturing one undergraduate course on “Computing System” (around 330 students).

In the academic year 2006/07, I was on a sabbatical leave at the Dep. of Computer Science at University of Aarhus, Denmark, as an invited assistant professor. I had no teaching duties in that period.

# CURRICULUM VITÆ

## I Personal Data

*Name:* **Luís Manuel Dias Coelho Soares Barbosa**  
*Date of birth:* 1962.02.04  
*E-mail:* lsb@di.uminho.pt  
*URL:* www.di.uminho.pt/~lsb/  
*Affiliations* FME (Formal Methods Europe Association)  
EATCS (European Association for Theoretical Computer Science)

## II Academic Data

- Licenciatura (5-year degree), U.Minho, Systems and Informatics Engineering, 1988.
- PhD in Informatics, area of *Foundations of Computing*, U. Minho, 2001.

## III Current Position

- Assistant Professor, School of Engineering, U. Minho, since 2001 (with tenure since 2006).
- Deputy Head of Department, Informatics Department, U. Minho, since 2002.

## IV Previous Positions

- Invited Lecturer, *Department of Engineering Mathematics*, Bristol University, UK (1992 – 2004).
- Teaching Assistant, Informatics Department, U. Minho (1992–2001)
- Software engineer at EID (Empresa de Investigação e Desenvolvimento de Electrónica), Caparica

## V Reserach

**Main Research Area.** Program semantics and calculi applied to systems understanding and software construction.

*Application area:* Software *components, services* and *architectures*  
*Focus:* Architectural *understanding* and *re-engineering* of legacy software. *Global computing*.  
*Foundations:* *Coalgebra* theory and coinductive reasoning. *Relational calculus*  
*Method:* Systems analysis and construction *by calculation*

## Other Scientific Interests.

- Formal design methods and software prototyping.
- Functional programming. Reactive programming.
- Mathematical modelling and proof. Problem solving. Applications to computer science education in the context of the 'information society'.

## VI PhD Supervisions

### VI.1. – Concluded

- *Sun Meng*, on *Coalgebra Theory and its Application to Component Software*. Co-supervision with *Dr. Bernhard Aichernig* (IIST/UNU, Macau) and *Prof. Zhang Naixiao* (School of Mathematical Sciences, Peking University, China), concluded on 12 November 2004.

### VI.2. – On-going

- *Marco António Castro Barbosa*, on *A Refinement Calculus for Software Components and Architectures*, started on February 2003.
- *Nuno Miguel Feixa Rodrigues*, on *Generic Software Slicing Applied to the Architectural Reconstruction of Legacy Systems*, started April 2005.
- *João Fernando Peixoto Ferreira*, on *Algorithmic Problem Solving: Principles and Applications* cosupervision with *Prof. Roland Backhouse* (School of Computer Science and Information Technology, University of Nottingham, UK), started December 2005.
- *Alexandra Martins Silva* on *Service-oriented Computing: Foundations and Calculi*. Co-supervision with *Prof. J. J. M. M. Rutten* (CWI and Vrije Universiteit Amsterdam, Amsterdam), started May 2006.

## VII Coordination of Funded Projects

### 2005 – 2008

Coordinator of the Portuguese Hub of LERNET, ALFA Network for Joint European - Latin American PhD Programme in **Language Engineering and Rigorous Software Development**.

### 2005 – 2008

Coordinator of **Formal Foundations for Component-based Programming**, Technological and Scientific Cooperation between Portugal and the P. R. of China (contract GRICES-00342).

### 2003 – 2006

Principal researcher of **Program Understanding and Re-engineering: Calculi and Applications** — PURE. FCT (contract POSI/CHS/44304/2002).

## VIII Other Scientific Activities

- Member of the *Steering Committee* of FACS (*Formal Aspects of Component Software* workshop series), since 2006.
- *Satellite Events Co-Chair* of ETAPS'07, Braga, Portugal, 2007.
- *Co-Chair* (with Bernhard Aichernig, Univ. Graz, Austria) of OPENCERT'07 (I International Workshop on Foundations and Techniques for Open Source Software Certification), ETAPS'07, Braga, April, 2007.
- *Co-Chair* (com Peter Gorm Larsen, EC Aarhus) of *II Overture Workshop*, at *International Conference on Formal Methods 2006* (FM'06), McMaster University, Canada, 2006.
- *Co-Chair* (com Zhiming Liu, UNU-IIST, Macau) of FACS'05 (II International Workshop on Formal Aspects of Component Software), Macau, 2005.
- Member of Assessment Panel of *XI Concurso CLEI-UNESCO de Tesis de Maestria* a Latin-American prize for MSc Thesis in Computer Science supported by *Centro Latinoamericano de Estudios en Informática* and UNESCO, Peru, 2004.

- *Program Committe* member of several international conferences and workshops, including AMAST, ICFEM, COORDINATION, FINCO, FOCLASA , SBMF , CMCS, ICTAC, SBLP, among others.

## IX Tutorials and Invited Lectures at International Conferences

- Invited Tutorial at *Second International Colloquium on Theoretical Aspects of Computing* — ICTAC'04. Hanoi, Vietnam. 17-21 October, 2005. Theme: *Coinductive Reasoning By Calculation*.
- Invited Lecture at *Third International Symposium on Formal Methods for Components and Objects* — FMCO'04. Lorentz Center, Leiden University. 2-5 November, 2004. Theme: *A Perspective on Component Refinement*.
- Invited Tutorial at *VI Brazilian Symposium on Programming Languages*. Pontifícia Universidade Católica do Rio de Janeiro, Brasil. 5-7 Junho, 2002. Theme: *Coalgebraic Structures in Program Construction*.

## X Collaboration in PhD Programs external to U. Minho

- **University of Tartu** (Estonia): Doctoral Program in Mathematics and Computer Science, course on *Models and Calculi for Software Components*. 8-12 December, 2003 (12 hours).
- **Peking University** (China): Doctoral Program in Mathematics (School of Mathematical Sciences), course on *Coinduction: Calculi and Applications*. 22 September to 4 October, 2006 (30 horas).

## XI Selected Publications (2004-2006)

### XI.1. – Book chapters

- (1) L. S. Barbosa, M. Sun, B. K. Aichernig, and N. Rodrigues. On the semantics of componentware: a coalgebraic perspective. In Jifeng He and Zhiming Liu, editors, *Mathematical Frameworks for Component Software: Models for Analysis and Synthesis*, Series on Component-Based Development. World Scientific, 2006.
- (2) L. S. Barbosa and M. H. Martinho. Modelling is for reasoning. In C. Haines, P. Galbraith, W. Blum and S. Khan, editors, *Mathematical Modelling: Education, Engineering and Economics*, Horwood Publishing, ISBN 1-904275-20-6, (no prelo) 2006.
- (3) L. S. Barbosa. A perspective on component refinement. In F. S. de Boer, M. Bonsangue, S. Graf, and W.-P. de Roever, editors, *Revised Lectures from the Third International Symposium on Formal Methods for Components and Objects*, pages 23–48. Tutorial Series of Springer Lect. Notes Comp. Sci. (3657), 2005.

### XI.2. – Journal Papers

- (4) L. S. Barbosa and J. N. Oliveira. Transposing partial coalgebras: An exercise on coalgebraic refinement. *Theoretical Computer Science, Elsevier*, 365 (1-2), pp 2-22, 2006.
- (5) P. R. Ribeiro, L. S. Barbosa, and M. A. Barbosa. Generic Process Algebra: A Programming Challenge. *Journal of Universal Computer Science*, Special Issue with Selected papers from Xth SBLP, M. Bigonha (Guest Editor), 12 (7), pp 922-937, 2006.
- (6) N. Rodrigues and L. S. Barbosa. Program Slicing by Calculation. *Journal of Universal Computer Science*, Special Issue with Selected Papers from Xth SBLP, M. Bigonha (Guest Editor), 12 (7), 828-848, 2006.
- (7) A. M. Cruz, L. S. Barbosa, and J. N. Oliveira. From Algebras to Objects: Generation and Composition. *Journal of Universal Computer Science*, Special Issue on *Compositional Construction and Reasoning Techniques for Software*, F. Arbab and J. Kok (Guest Editors), 11 (10), pages 1580–1613, December, 2005.

- (8) M. Sun and L. S. Barbosa. Components as coalgebras: the refinement dimension. *Theoretical Computer Science, Elsevier*, 351, pp 276-294, 2005.
- (9) M. A. Barbosa and L. S. Barbosa. A relational model for component interconnection. *Journal of Universal Computer Science*, 10(7):808–823, July 2004.

### **XI.3. – Conference Papers**

- (10) M. A. Barbosa, L. S. Barbosa and J. F. C. Campos. Towards a Coordination Model for Interactive Systems Proc. of FMIS'06, Macau, Outubro, 2006. *Elect. Notes in Theor. Comp. Sci.*, Elsevier (in print).
- (11) M. A. Barbosa and L. S. Barbosa. Configurations of Web Services Proc. of FOCLASA'04, Bonn, Julho, 2006. *Elect. Notes in Theor. Comp. Sci.*, Elsevier (in print).
- (12) M. A. Barbosa and L. S. Barbosa. An orchestrator for dynamic interconnection of software components In I. Cerna and I. Linden, editors, *2nd International Workshop on iMethods and Tools for Coordinating Concurrent, Distributed and Mobile Systems (MTCoord'06)*, Bologna, Itália, Junho, 2006. *Elect. Notes in Theor. Comp. Sci.*, Elsevier (in print).
- (13) M. Sun, L. S. Barbosa, and Z. Naixiao. On refinement of software architectures. In Dang Van Hung and Martin Wirsing, editors, *2nd International Colloquium on Theoretical Aspects of Computing (ICTAC'05)*, pages 469–484, Hanoi, Vietnam, September 2005. *Springer Lect. Notes Comp. Sci.* (3722).
- (14) N. Rodrigues and L. S. Barbosa. Component identification through program slicing. In L. S. Barbosa and Z. Liu, editors, *Proc. of FACS'05 (2nd Int. Workshop on Formal Approaches to Component Software)*, UNU-IIST, Macau, October 2005. *Elect. Notes in Theor. Comp. Sci.*, 160, pages 291–304, Elsevier.
- (15) Nuno F. Rodrigues and Luís S. Barbosa. Architectural prototyping: From CCS to .net. *Electr. Notes Theor. Comput. Sci.*, Elsevier, 130:151–167, 2005.
- (16) M. Sun, Z. Naixiao, and L. S. Barbosa. On semantics and refinement of UML statecharts: A coalgebraic view. In J. Cuellar and Z. Liu, editors, *Proc. of 2nd IEEE Int. Conf. on Software Engineering and Formal Methods*, pages 164–173, Beijing, China, September 2004. IEEE Computer Society Press.
- (17) M. A. Barbosa and L. S. Barbosa. Specifying software connectors. In K. Araki and Z. Liu, editors, *1st International Colloquium on Theoretical Aspects of Computing (ICTAC'04)*, pages 53–68, Guiyang, China, September 2004. *Springer Lect. Notes Comp. Sci.* (3407).
- (18) M. Sun, B. K. Aichernig, L. S. Barbosa, and Z. Naixiao. A coalgebraic semantic framework for component based development in UML. In L. Birkedal, editor, *Proc. Int. Conf. on Category Theory and Computer Science (CTCS'04)*, volume 122, pages 229–245. *Elect. Notes in Theor. Comp. Sci.*, Elsevier, 2005.
- (19) M. Sun and L. S. Barbosa. On refinement of generic software components. In C. Rettray, S. Maharaj, and C. Shankland, editors, *10th Int. Conf. Algebraic Methods and Software Technology (AMAST)*, pages 506–520, Stirling, August 2004. *Springer Lect. Notes Comp. Sci.* (3116). *Best Student Co-authored Paper Award*.

## Europass Curriculum Vitae

### Personal information

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**Cunha Manuel Alcino Pereira**

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Portuguese

13, July, 1973

### Work experience

- Aux. Prof.

*Dates:* since 2005

*Employer:* University of Minho, Portugal

*Sector:* Dept. of Informatics

*Position held:* Auxiliary Professor

*Main activities:* teaching & research

- Lecturer

*Dates:* 1997-05

*Employer:* University of Minho, Portugal

*Sector:* Dept. of Informatics

*Position held:* Assistant lecturer

*Main activities:* teaching & research

### Education and training

- Ph.D.

*Year:* 2005

*Academic degree:* Philosophy Doctor

*Institution:* Dept. of Informatics, University of Minho, Portugal

- Lic.

*Year:* 1996

*Academic degree:* Licenciatura

*Institution:* Dept. of Informatics, University of Minho, Portugal

### Technical skills

- Domain of specialization

Computer science

- Areas of research

Program calculation, Functional programming, Polytypic programming, Data refinement, Coupled software transformation

### Participation in research projects

- PURé

2003-06, *Program Understanding and Re-engineering: Calculi and Applications*, FCT research project POSI/CHS/44304/2002.

## Relevant Publications

### INTERNATIONAL JOURNALS

- Alcino Cunha and Jorge Sousa Pinto.  
Point-free program transformation.  
*Fundamenta Informaticae*, 66(4):315–352, 2005.  
Special Issue on Program Transformation

### INTERNATIONAL CONFERENCES

- Pablo Berdaguer, Alcino Cunha, Hugo Pacheco, and Joost Visser.  
Coupled schema transformation and data conversion for XML and SQL.  
In M. Hanus, editor, *Proceedings of the 9th International Symposium on Practical Aspects of Declarative Languages*, volume 4354 of *LNCS*, pages 290–304. Springer-Verlag, 2007
- Alcino Cunha and Joost Visser.  
Transformation of structure-shy programs - applied to XPath queries and strategic functions.  
In *Proceedings of the ACM SIGPLAN 2007 Workshop on Partial Evaluation and Program Manipulation*. ACM Press, 2007.  
To appear
- Alcino Cunha and Joost Visser.  
Strongly typed rewriting for coupled software transformation.  
In *Proceedings of the 7th International Workshop on Rule-Based Programming*, ENTCS. Elsevier, 2006.  
To appear
- Alcino Cunha, José Nuno Oliveira, and Joost Visser.  
Type-safe two-level data transformation.  
In J. Misra, T. Nipkow, and E. Sekerinski, editors, *Proceedings of the 14th International Symposium on Formal Methods*, volume 4085 of *LNCS*, pages 284–299. Springer-Verlag, 2006
- Alcino Cunha, Jorge Sousa Pinto, and José Proença.  
A framework for point-free program transformation.  
In A. Butterfield, C. Grelck, and F. Huch, editors, *Selected Papers of the 17th International Workshop on Implementation and Application of Functional Languages*, volume 4015 of *LNCS*, pages 1–18. Springer-Verlag, 2006
- Alcino Cunha.  
Automatic visualization of recursion trees: a case study on generic programming.  
*Electronic Notes in Theoretical Computer Science*, 86(3), 2003.  
Selected papers of the 12th International Workshop on Functional and (Constraint) Logic Programming
- Alcino Cunha and Orlando Belo.  
Integrating agent based information outsourcing techniques on data warehousing systems.  
In *Proceedings of the IEEE Systems, Man, and Cybernetics Conference*, pages 1025–1030. IEEE Press, 1999

### OTHER PAPERS AND POSTERS

- Manuel Barbosa, Alcino Cunha, and Jorge Sousa Pinto.  
Recursion patterns and time-analysis.  
*ACM SIGPLAN Notices*, 40(5):45–54, 2005
- Alcino Cunha and Jorge Sousa Pinto.  
Making the point-free calculus less pointless.  
In *Proceedings of the 2nd APPSEM II Workshop*, pages 178–179, 2004
- Alcino Cunha, José Barros, and João Saraiva.  
Deriving animations from recursive definitions.  
In *Draft Proceedings of the 14th International Workshop on the Implementation of Functional Languages (IFL'02)*, 2002



- Alcino Cunha and José Neves.  
A game-theoretic approach to the socialization of utility-based agents.  
In *Proceedings of the 3rd International Conference on Multi-agent Systems*, pages 413–414.  
IEEE Press, 1998
- Alcino Cunha and Orlando Belo.  
Resource allocation on agent meta-societies.  
In E. Costa and A. Cardoso, editors, *Progress in Artificial Intelligence*, volume 1323 of *LNAI*,  
pages 343–348. Springer-Verlag, 1997

#### THESES AND DISSERTATIONS

- Alcino Cunha.  
*Point-free Program Calculation*.  
PhD thesis, Department of Informatics, University of Minho, 2005

#### Personal skills and competences

- Mother tongue Portuguese
- Other languages English

# CURRICULUM VITAE

## Personal Data:

*Name:* Ana Cristina Ramada Paiva Pimenta

*Date of Birth:* 24/12/72

*Place of Birth:* Amarante

*Nationality:* Portuguese

*Marital Status:* Married

*Address:* Rua Dr. Joaquim Pires de Lima, nº 213, 3º Dir,  
4200-350 Porto, Portugal

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*Institucional Address:* Rua Dr. Roberto Frias, s/n 4200-465 Porto, Portugal

*Institucional Phone:* +351 22 508 1523

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---

## Education:

- PhD degree in Electrical and Computers Engineering at Engineering Faculty of Porto University (FEUP). Thesis under the title: "Automated Specification-based Testing of Graphical User Interfaces", February 2007.

This dissertation addresses the GUI testing problem. The goal is to introduce more systematization and automation into the GUI testing process by applying specification-based testing methods. The use of formal specifications allows the automatic generation of test cases containing not only the input data but also the outcomes expected. Specification-based testing methods have been applied for API testing but are insufficiently developed for GUI testing. Some of the specific challenges posed by GUI testing are addressed in this research work.

This work has been developed in collaboration with the Foundations of Software Engineering research group within Microsoft Research from which it has received an unconditional financial support.

- M.Sc degree in Electrical and Computers Engineering at Engineering Faculty of Porto University (FEUP) with Very Good as final classification – (95-97). Thesis under the title: "3D acquisition system based on a structured light technique".

This thesis describes a structured light acquisition system based on a structured light technique. The system has a programmable multi-stripe liquid crystal light valve mounted in a conventional projector under computer control, with which it is possible to project several different patterns of light and a camera, displaced from the projector, to see the scene.

- Degree in Systems and Informatics Engineering at Minho University of Portugal – (90-95).

---

**Attended courses:**

- “VDM++/UML”, 18 of June - 22 of May, 2001, given by Peter Gorm Larsen, IFAD.
- “Formalware Engineering - Formal Methods for Engineering Software”, 24-28 September, 2001, Udine (Italy), coordinated by: E. Börger (University of Pisa, Italy), F. Honsell and S. Martini (University of Udine, Italy).

---

**Professional experience**

- Assistant Professor at Engineering Faculty of Porto University since February 2007.
- Assistant Lecture at Electrical and Computers Engineering Department of Engineering Faculty of Porto University since 1999.
- Assistant Lecture at Informatics’ Engineering Department of the Engineering Superior Institute of Porto (ISEP), (4/1997 - 10/1999).
- Researcher at INEB - Biomedical Engineering Institute, (9/1996 - 3/1998).
- Internship at the company “Integral Vision”, in Bedford, England (4/4/95 - 4/10/95).

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**Research Interests**

- Formal Methods.
- Specification-based testing.
- User Interface modelling and testing.
- Model-checking.
- Software engineering.

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**Principal Published Conference Papers:**

- "Model-based user interface testing with Spec Explorer and ConcurTaskTrees", in Proceedings of the 2<sup>nd</sup> International Workshop on Formal Methods for Interactive Systems, José L. Silva, José Creissac Campos, Ana C. T. Paiva, 2007.
- "Reverse Engineered Formal Models for GUI Testing", in Proceedings of the 12<sup>th</sup> International Workshop on Formal Methods for Industrial Critical Systems, Ana C. R. Paiva, João Pascoal Faria, Pedro Mendes, Berlin, Germany, July 1-2, 2007.
- "Towards the Integration of Visual and Formal Models for GUI Testing", in Proceedings of the Third Workshop on Model Based Testing (MBT'07), Ana C. R. Paiva, João P. Faria, Raul M. Vidal, Braga, Portugal, 2007.
- “Modeling and Testing Hierarchical GUIs”, in Proceedings of the 12th International Workshop on Abstract State Machines, ASM'05 – Ana Cristina Paiva, Nikolai Tillmann, João Pascoal Faria, Raul Moreira Vidal, 2005.

- “A Model-to-implementation Mapping Tool for Automated Model-based GUI Testing”, in Proceedings of the 7th International Conference on Formal Engineering Methods, ICFEM'05 – Ana Cristina Paiva, João Pascoal Faria, Nikolai Tillmann, Raul Moreira Vidal, 2005.
- “Automated Specification-based Testing of Interactive Components with AsmL”, in proceedings of the 5th edition of the international conference QUATIC (Quality: the bridge to the future in ICT) – Ana Cristina Paiva, João Pascoal Faria, Raul Moreira Vidal, 2004.
- "Specification-based Testing of User Interfaces", in Proceedings of the 10th Workshop on Design, Specification and Verification of Interactive Systems, DSV-IS'03, Funchal, Madeira, Ana C. Paiva, João P. Faria, Raul M. Vidal, 4-6 de Junho, 2003.
- "3-D Surface Characterization Using a Structured-Light Technique", magazine of the Electronic and Telecommunications department of the university of Aveiro, Vol.3 nº 2, pp. 173-179, Jorge A. Silva, Ana C. Paiva, André Restivo, Aurélio Campilho, J. Pontes, 2000.

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### **Supervising experience:**

#### **PhD**

- Pedro Mendes, "Automatic Testing of Graphical User Interface Based on UML Behavioural Models", started 2008 (co-supervision with João Pascoal Faria).

#### **MSc**

- Rodrigo Moreira, "Development of a Visual GUI Modelling Front-end", (September 07 – April 08).
- Hugo Pereira, "Impact analysis of the introduction of formal specification methods in a software project", started February 08.

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### **Research Projects:**

- Membership of the YES!VV project – Independent Verification and Validation of software (Oct 2007 to July 2008). Project financial supported by ADI related to the programme PRIME.

The objective of the FEUP members involved in the project is to write a report with the state of the art about formal methods for requirements analysis and benchmarking of those methods. At the end of the project, a report review based on the results achieved during the development of the project.

- Membership of the IVY project – "A model-based usability analysis environment". Project financial supported by FCT, POSI/EIA/56646/2004 (July 2005 to June 2008).

The objective is to develop a model based tool for the analysis of interactive systems designs. The tool will act as a front end to the SMV

model checker, creating an abstraction layer where models of interactive systems can be developed and analysed.

- Membership of the CYTED REVVIS network – the goal of this project is to create an Iberia-Latin-American network focused on I&D innovation on software verification and validation for exchange of knowledge among different research groups.

11<sup>th</sup> April, 2008

Ana Cristina Ramada Paiva Pimenta

# CURRICULUM VITAE

## João Carlos Pascoal de Faria

### 1. Personal data

**Full name:** João Carlos Pascoal de Faria

**National identity card:** 3703791, Porto, 17-3-2004

**Birth place and date:** Matosinhos, 19-10-1959

**Nationality:** Portugal

**Institutional address:** Faculdade de Engenharia da Universidade do Porto,  
Rua Dr. Roberto Frias, s/n, 4200-465 Porto, PORTUGAL.

**Home address:** R. de Serralves, nº 635, 1º Esquerdo, 4150 Porto, Portugal

**Fiscal identity number:** 169795381, Porto, 6º bairro

**Contact data:** Telephone: 225081523, E-mail: [jpf@fe.up.pt](mailto:jpf@fe.up.pt) , Url:  
<http://www.fe.up.pt/~jpf>

### 2. Academic degrees

**Licentiate (5 years):** Electrical Engineering - Digital Systems and Computers, Faculty of Engineering of the University of Porto (FEUP), classification 18 (1985).

**PhD:** Electrical and Computer Engineering, FEUP, approved by unanimity, *Data-driven Active Rules for the Maintenance of Integrity Constraints and Derived Data in Interactive Database Applications* (1999).

### 3. Previous and current scientific and/or professional activities

**Lecturer at FEUP (December 1985-):** He is currently Assistant Professor at the Informatics Section of the Department of Electrical and Computer Engineering of the Faculty of Engineering of the University of Porto (FEUP), where he is since December 1985. He teaches currently several subjects on software engineering, software testing, object-oriented analysis and design with UML, enterprise application development, and software project management. He conducts scientific research work and supervision on the integration of formal and semi-formal methods in software engineering, namely in model-base software testing. He is a member of the Scientific Council of the Master Course on Informatics Engineering and a member of the Scientific Council of FEUP. He represents FEUP in the "Comissão Sectorial para a Qualidade nas Tecnologias de Informação e Comunicações (CS03)" of the "Conselho Nacional para a Qualidade" (CNQ).

**Researcher at INESC Porto (October 1985-):** He is a researcher at INESC-Porto, in the field of Software Engineering and Information Systems, in the Information and Communication Systems Unit. From 1989 to 1999 he was responsible for the development and maintenance of a rapid application development tool (SAGA), still in use in Portugal.

**Novabase-Saúde (August 2000 - February 2002):** In Novabase-Saúde he was responsible for innovation in the Development Unit, where he participated in the CSI (development of a hospital management system) and SIIMS (definition of the future hospital management systems of the Ministry of Health) projects.

**Sidereus (March 2002 - November 2002) -** He worked with Sidereus as Software Architect in database auditing projects and in the development of *Costumer Relationship Management* system in Microsoft .Net technology.

#### 4. Area of scientific work

Software Engineering.

#### 5. Domain of specialization

**Domain of specialization (PhD):** Rapid application development tools.

**Present research interests:** Model based software testing. Integration of formal and semi-formal methods in software engineering. Model driven software engineering.

#### 6. Supervising experience

Role	Student	Thesis	Program	Period and status
Co-supervisor	Ana Cristina Ramada Paiva	Automated Specification-based Testing of User Interfaces	PhD in Electrical and Computer Engineering	Concluded February 2007
Co-supervisor	Maria Clara dos Santos Pinto Silveira	Requirements Reuse in the Development and Adaptation of Software Products	PhD in Electrical and Computer Engineering	Concluded April 2006
Supervisor	António Miguel Rosado da Cruz	Automatic Generation of User Interfaces from Rigorous Domain and Use Case Models	PhD in Informatics Engineering	Started January 2007
Supervisor	Pedro Miguel Mendes	Automatic Testing of Graphical User Interfaces Based on UML Behavioral Models	PhD in Informatics Engineering	Started January 2007
Co-supervisor	Pedro Castro Henriques	Strategic Planning and Architecture Definition of the SIERS – Information	MSc in Informatics Engineering	Started November 2006

		System of the National Healthcare Regulation Board		
Supervisor	Vagner David Pinto Morais	Web-based build, configuration, integration and testing tool for a grid application	MSc in Electrical and Computer Engineering	Started November-2006
Supervisor	Rui Jorge Reis Gomes	Testing Voice Interfaces	MSc in Informatics Engineering	Concluded May 2007
Supervisor	Paulo Alexandre Fernandes	Data Source Independence and Change Management in Network Diagrams Editors	MSc in Electrical and Computer Engineering	Concluded February 2007
Supervisor	Sara Campos de Araújo	Security in the Circulation of Clinical Data	MSc in Communication Networks and Services	Concluded June 2007, waiting final exam
Supervisor	Firmino Oliveira da Silva	System and Platform Integration for the Management of Customer Information	MSc in Information Management	Concluded March 2005

## 7. Participation in research and development projects

Project name	Institution(s)	Role	Dates
SIFO - Fibber Optics Integrated Systems	INESC Porto	Design of and ISDN (Integrated Services Digital Network) integrated circuit	October 1985- June 1986
"Autarquias" (Information Systems for Local Authorities)	INESC Porto	Responsible for the development of several modules, tool migration, and technology transfer	October 1987 - February 1991
SAGA (Rapid Application Development Tool)	INESC Porto	Project manager	1989-1999 (tool still in use in 2007)



SCOPE (Sistema da Comunidade Portuária Electrónico)	INESC Porto, others	UML training. Test and certification planning.	2005-2006
IVY - A model-based usability analysis environment, POSI/EIA/56646/2004	Minho University, FEUP, INESC Porto	Analysis of alternative modelling notations.	July 2005 - June 2008
REVVIS - Reunião de Especialistas em Verificação e Validação de Software (*)	Several (CYTED network, Portugal, Spain and Latin America)	Verification and validation of user interfaces, particularly model-based GUI testing and usability evaluation (with Ana Paiva, Raul Vidal, João Falcão e Cunha and Lia Patrício from FEUP)	2007-2009
YES!VV - Demonstration of the Independent Software Verification & Validation Technology	FEUP, Critical Software, Efacec	Leader of scientific consultancy team from FEUP (with Ana Paiva)	2007-2008
AMBER i-Test - An Automated Model-based User Interface Testing Environment. (submitted to FCT)	FEUP, Critical Software	Coordinator	2007-2009

## 9. Publications (recent)

- "REVERSE ENGINEERED FORMAL MODELS FOR GUI TESTING"  
Ana C. R. Paiva, João C. P. Faria, Pedro M. C. Mendes  
12th International Workshop on Formal Methods for Industrial Critical Systems (FMICS 2007). July 1-2, 2007, Berlin, Germany (*accepted*)
- TOWARDS THE INTEGRATION OF VISUAL AND FORMAL MODELS FOR GUI TESTING  
Ana C. R. Paiva, João C. P. Faria, Raul F. A. M. Vidal  
MBT'06 - Third Workshop on Model Based Testing, 31 March - 1 April 2007, Braga, Portugal (satellite workshop of ETAPS 2007)
- A METHODOLOGY FOR AUDITING E-VOTING PROCESSES AND SYSTEMS USED AT THE ELECTIONS FOR THE PORTUGUESE PARLIAMENT  
J. Falcão e Cunha, M. Jorge Leitão, J. Pascoal Faria, A. Pimenta Monteiro, M. Antónia Carravilla  
Electronic Voting 2006 - The 2nd International Workshop on Electronic Voting, 2-4 August 2006, Vienna, Austria

- WIKI BASED REQUIREMENTS DOCUMENTATION OF GENERIC SOFTWARE PRODUCTS  
Clara Silveira, João Pascoal Faria, Ademar Aguiar, Raul Vidal  
AWRE'05 - The Tenth Australian Workshop on Requirements Engineering, 22 November 2005, Melbourne, Australia (*best paper award*)
- A MODEL-TO-IMPLEMENTATION MAPPING TOOL FOR AUTOMATED MODEL-BASED GUI TESTING  
Ana C. R. Paiva, João C. P. Faria, Nikolai Tillmann, Raul F. A. M. Vidal  
ICFEM 2005 - Seventh International Conference on Formal Engineering Methods, 1-4 November 2005, Manchester, UK
- MODELING AND TESTING HIERARCHICAL GUIs  
Ana C. R. Paiva, João C. P. Faria, Raul F. A. Moreira, Nikolai Tillmann  
ASM 2005 - 12th International Workshop on Abstract State Machines, March 8-11, 2005, Paris, France
- AUTOMATED SPECIFICATION-BASED TESTING OF INTERACTIVE COMPONENTS WITH ASML  
Ana C. R. Paiva, João Pascoal Faria, Raul Moreira Vidal  
QUATIC'2004 (Conferência sobre Qualidade nas Tecnologias de Informação e Comunicação), Porto, 18-20 October, 2004
- SPECIFICATION-BASED TESTING OF USER INTERFACES  
Ana Cristina Paiva, João Pascoal Faria, Raul Moreira Vidal  
The 10th DSV-IS Workshop (Design Specification and Verification of Interactive Systems), Funchal, Madeira, 4-6 June, 2003
- MÉTODOS FORMAIS NA ESPECIFICAÇÃO DE INTERFACES COM O UTILIZADOR: A LINGUAGEM VDM++ E O TRATAMENTO DE EVENTOS  
Ana Cristina Paiva, João Pascoal Faria, Raul Moreira Vidal, José Nuno Oliveira  
Actas da 3ª Conferência da Associação Portuguesa de Sistemas de Informação, 2002
- REGRAS ACTIVAS DIRIGIDAS PELOS DADOS PARA A MANUTENÇÃO DE RESTRIÇÕES DE INTEGRIDADE E DADOS DERIVADOS EM APLICAÇÕES INTERACTIVAS DE BASES DE DADOS  
João Pascoal Faria  
FEUP, September 1999 (PhD thesis)
- DATA-DRIVEN ACTIVE RULES FOR THE MAINTENANCE OF DERIVED DATA AND INTEGRITY CONSTRAINTS IN USER INTERFACES TO DATABASES  
João Pascoal Faria, Raul Moreira Vidal  
Proceedings do XIV Simposium Brasileiro de Bases de Dados - SBBD'99, Florianópolis, Santa Catarina, Brasil, October 1999

## 10. Communications (recent)

Oral communications by invitation

- *Rapid and rigorous application development: vision and challenges*, CAPSI 2004 - Conference of the Portuguese Information Systems Association, Panel "Model-Based Rapid Development", IST, Lisboa, 4 November 2004

- *Integration of formal and semi-formal models: the case of UML and VDM++*, First Portuguese Software Engineering Congress, Coimbra, April 2004
- Rigorous Modelling and Formal Specification in VDM++ and UML: A case study", Informatics Engineering Journey, Instituto Politécnico da Guarda, 28 May 2003
- "Software Quality Mangement: managing the quality of the software process and product", BEST Summer Course on Quality Control Systems, FEUP, 19 September 2002

## 11. Language

Language	Reading	Writing	Conversation
Portuguese	Excelent	Excelent	Excelent
English	Excelent	Good	Good
French	Basic	Basic	Basic

Porto, 4 July 2007