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Applying UML and Patterns

An Introduction to Object-Oriented Analysis and Design and the Unified Process

UML和模式应用

面向对象分析和设计及统一过程导论

（第二版·影印版）

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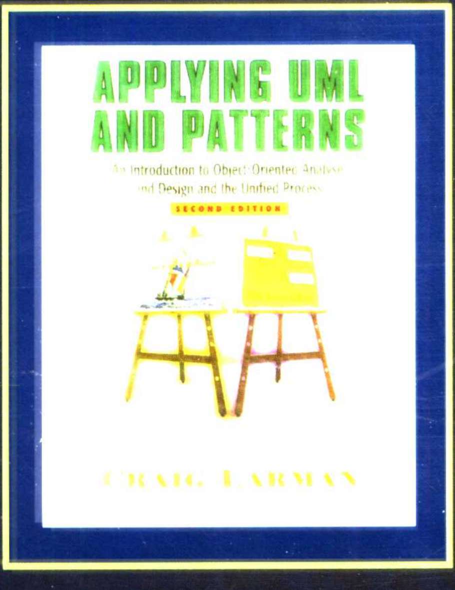
APPLYING UML AND PATTERNS
An Introduction to Object-Oriented Analysis and Design and the Unified Process
SECOND EDITION
CRAIG LARMAN

"经常有人问我，介绍面向对象设计的最好的书是什么。迄今为止，《UML和模式应用》这本书是我最好的选择。"

——Martin Fowler，
《UML Distilled》与《重构》作者

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For Julie

Without your support, this would not have been possible.

For Haley and Hannah

Thanks for putting up with a distracted Daddy, again!

"This edition contains Larman's usual accurate and thoughtful writing. It is a very good book made even better."

—**Alistair Cockburn**, author, *Writing Effective Use Cases* and *Surviving OO Projects*.

"People often ask me which is the best book to introduce them to the world of OO design. Ever since I came across it *Applying UML and Patterns* has been my unreserved choice."

—**Martin Fowler**, author, *UML Distilled* and *Refactoring*.

"This book makes learning UML enjoyable and pragmatic by incrementally introducing it as an intuitive language for specifying the artifacts of object analysis and design. It is a well written introduction to UML and object methods by an expert practitioner."

—**Cris Kobryn**, key contributor to UML 1.x specifications, and chair of the UML Revision Task Force and UML 2.0 Working Group.

"Too few people have a knack for explaining things. Fewer still have a handle on software analysis and design. Craig Larman has both."

—**John Vlissides**, author, *Design Patterns* and *Pattern Hatching*.

FOREWORD

Programming is fun, but developing quality software is hard. In between the nice ideas, the requirements or the "vision," and a working software product, there is much more than programming. Analysis and design, defining how to solve the problem, what to program, capturing this design in ways that are easy to communicate, to review, to implement, and to evolve is what lies at the core of this book. This is what you will learn.

The Unified Modeling Language (UML) has become the universally-accepted language for software design blueprints. UML is the visual language used to convey design ideas throughout this book, which emphasizes how developers really apply frequently used UML elements, rather than obscure features of the language.

The importance of patterns in crafting complex systems has long been recognized in other disciplines. Software design patterns are what allow us to describe design fragments, and reuse design ideas, helping developers leverage the expertise of others. Patterns give a name and form to abstract heuristics, rules and best practices of object-oriented techniques. No reasonable engineer wants to start from a blank slate, and this book offers a palette of readily usable design patterns.

But software design looks a bit dry and mysterious when not presented in the context of a software engineering process. And on this topic, I am delighted that for his second edition, Craig Larman has chosen to embrace and introduce the Unified Process, showing how it can be applied in a relatively simple and low-ceremony way. By presenting the case study in an iterative, risk-driven, architecture-centric process, Craig's advice has realistic context; he exposes the dynamics of what really happens in software development, and shows the external forces at play. The design activities are connected to other tasks, and they no longer appear as a purely cerebral activity of systematic transformations or creative intuition. And Craig and I are convinced of the benefits of iterative development, which you will see abundantly illustrated throughout.

So for me, this book has the right mix of ingredients. You will learn a systematic method to do Object-Oriented Analysis and Design (OOA/D) from a great teacher, a brilliant methodologist, and an "OO guru" who has taught it to thousands around the world. Craig describes the method in the context of the Unified Process. He gradually presents more sophisticated design patterns—this will make the book very handy when you are faced with real-world design challenges. And he uses the most widely accepted notation.

I'm honored to have had the opportunity to work directly with the author of this major book. I enjoyed reading the first edition, and was delighted when he asked me to review the draft of his second edition. We met several times and exchanged many e-mails. I have learned much from Craig, even about our own process work on the Unified Process and how to improve it and position it in various organizational contexts. I am certain that you will learn a lot, too, in reading this book, even if you are already familiar with OOA/D. And, like me, you will find yourself going back to it, to refresh your memory, or to gain further insights from Craig's explanations and experience.

In an iterative process, the result of the second iteration improves on the first. Similarly, the writing matures, I suppose; even if you have the first edition, you'll enjoy and benefit from the second one.

Happy reading!

Philippe Kruchten
Rational Fellow
Rational Software Canada
Vancouver, BC

PREFACE

Thank you for reading this book! This is a practical introduction to object-oriented analysis and design (OOA/D), and to related aspects of iterative development. I am grateful that the first edition was received as a popular introduction to OOA/D throughout the world, translated into many languages. Therefore, this second edition builds upon and refines—rather than replaces—the content in the first. I want to sincerely thank all the readers of the first edition.

Here is how the book will benefit you.

Design robust and maintainable object systems.

First, the use of object technology has proliferated in the development of software, and mastery of OOA/D is critical for you to create robust and maintainable object systems.

Follow a roadmap through requirements, analysis, design, and coding.

Second, if you are new to OOA/D, you are understandably challenged about how to proceed through this complex subject; this book presents a well-defined roadmap—the Unified Process—so that you can move in a step-by-step process from requirements to code.

Use the UML to illustrate analysis and design models.

Third, the Unified Modeling Language (UML) has emerged as the standard notation for modeling; so it is useful for you to be conversant in it. This book teaches the skills of OOA/D using the UML notation.

Improve designs by applying the "gang-of-four" and GRASP design patterns.

Fourth, design patterns communicate the "best practice" idioms and solutions that object-oriented design experts apply in order to create systems. In this book you will learn to apply design patterns, including the popular "gang-of-four" patterns, and the GRASP patterns which communicate fundamental principles of responsibility assignment in object design. Learning and applying patterns will accelerate your mastery of analysis and design.

Learn efficiently by following a refined presentation.

Fifth, the structure and emphasis in this book is based on years of experience in training and mentoring thousands of people in the art of OOA/D. It reflects that experience by providing a refined, proven, and efficient approach to learning the subject so your investment in reading and learning is optimized.

Learn from a realistic exercise.

Sixth, it exhaustively examines a single case study—to realistically illustrate the entire OOA/D process, and goes deeply into thorny details of the problem; it is a realistic exercise.

Translate to code.

Seventh, it shows how to map object design artifacts to code in Java.

Design a layered architecture.

Eighth, it explains how to design a layered architecture and relate the graphical user interface layer to domain and technical services layers.

Design a framework.

Finally, it shows you how to design an object-oriented framework and applies this to the creation of a framework for persistent storage in a database.

Objectives

The overarching objective is this:

> Help students and developers create object designs through the application of a set of explainable principles and heuristics.

By studying and applying the information and techniques presented here, you will become more adept at understanding a problem in terms of its processes and concepts, and designing a solid solution using objects.

Intended Audience

This book is an *introduction* to OOA/D, related requirements analysis, and to iterative development with the Unified Process as a sample process; it is not meant as an advanced text. It is for the following audience:

- Developers and students with experience in an object-oriented programming language, but who are new—or relatively new—to object-oriented analysis and design.
- Students in computer science or software engineering courses studying object technology.
- Those with some familiarity in OOA/D who want to learn the UML notation, apply patterns, or who want to sharpen and deepen their analysis and design skills.

Prerequisites

Some prerequisite knowledge is assumed—and necessary—to benefit from this book:

- Knowledge and experience in an object-oriented programming language such as Java, C#, C++, or Smalltalk.
- Knowledge of fundamental object technology concepts, such as class, instance, interface, polymorphism, encapsulation, interfaces, and inheritance.

Fundamental object technology concepts are not defined.

Java Examples

In general, the book presents code examples in Java or discusses Java implementations, due to its widespread familiarity. However, the ideas presented are applicable to most—if not all—object-oriented programming languages.

Book Organization

The overall strategy in the organization of this book is that analysis and design topics are introduced in an order similar to that of a software development project running across an "inception" phase (a Unified Process term) followed by three iterations (see Figure P.1).

1. The inception phase chapters introduce the basics of requirements analysis.
2. Iteration 1 introduces fundamental OOA/D and how to assign responsibilities to objects.
3. Iteration 2 focuses on object design, especially on introducing some high-use "design patterns."
4. Iteration 3 introduces a variety of subjects, such as architectural analysis and framework design.

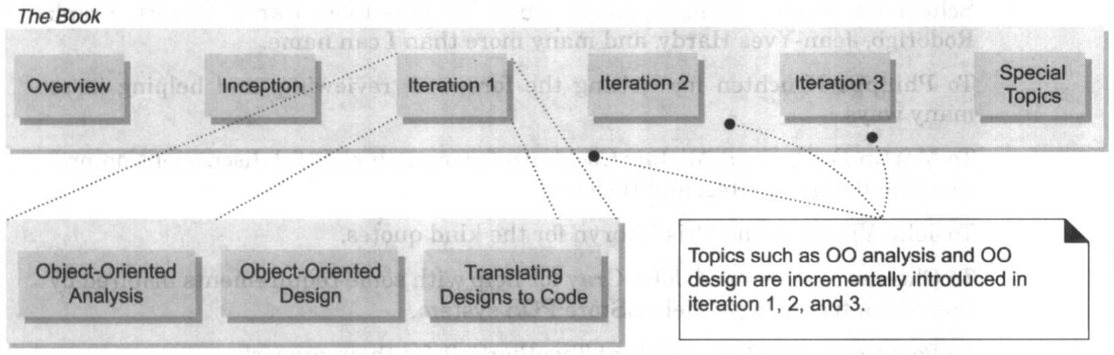
The Book
Overview
Inception
Iteration 1
Iteration 2
Iteration 3
Special Topics
Object-Oriented Analysis
Object-Oriented Design
Translating Designs to Code
Topics such as OO analysis and OO design are incrementally introduced in iteration 1, 2, and 3.

Figure P.1. The organization of the book follows that of a development project.

Web-Related Resources

- Please see www.craiglarman.com for articles related to object technology, patterns, and process.
- Some instructor resources can be found at www.phptr.com/larman.

Enhancements to the First Edition

While retaining the same core as the first edition, the second is refined in many ways, including:

- Use cases are updated to follow the very popular approach of [Cockburn01].
- The well-known Unified Process (UP) is used as the example iterative process within which to introduce OOA/D. Thus, all artifacts are named according to UP terms, such as Domain Model.
- New requirements in the case study, leading to a third iteration.

- Updated treatment of design patterns.
- Introduction to architectural analysis.
- Introduction of Protected Variations as a GRASP pattern.
- A 50/50 balance between sequence and collaboration diagrams.
- The latest UML notation updates.
- Discussion of some practical aspects of drawing using whiteboards or UML CASE tools.

Acknowledgments

First, a very special thanks to my friends and colleagues at Valtech, world-class object developers and iterative development experts, who in some way contributed to, supported, or reviewed the book, including Chris Tarr, Michel Ezran, Tim Snyder, Curtis Hite, Celso Gonzalez, Pascal Roques, Ken DeLong, Brett Schuchert, Ashley Johnson, Chris Jones, Thomas Liou, Darryl Gebert, Frank Rodorigo, Jean-Yves Hardy, and many more than I can name.

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Thanks to Paul Becker at Prentice-Hall for believing the first edition would be a worthwhile project, and to Paul Petralia and Patti Guerrieri for shepherding the second.

Finally, a special thanks to Graham Glass for opening a door.

About the Author

Craig Larman serves as Director of Process for Valtech, an international consulting company with divisions in Europe, Asia, and North America, specializing in e-business systems development, object technologies, and iterative development with the Unified Process.

Since the mid 1980s, Craig has helped thousands of developers to apply object-oriented programming, analysis, and design, and assisted organizations adopt iterative development practices.

After a failed career as a wandering street musician, he built systems in APL, PL/I, and CICS in the 1970s. Starting in the early 1980s—after a full recovery—he became interested in artificial intelligence (having little of his own), natural language processing, and knowledge representation, and built knowledge systems with Lisp machines, Lisp, Prolog, and Smalltalk. He plays bad lead guitar in his part-time band, the *Changing Requirements* (it used to be called the *Requirements*, but some band members changed...).

He holds a B.Sc. and M.Sc. in computer science from Simon Fraser University in Vancouver, Canada.

Contact

Craig can be reached at clarman@ieee.org and www.craiglarman.com. He welcomes questions from readers and educators, and speaking, mentoring, and consulting enquiries.

Typographical Conventions

This is a **new term** in a sentence. This is a *Class* or *method* name in a sentence. This is an author reference [Bob67]. A language independent scope resolution operator "--" is used to indicate a class and its associated method as follows: *ClassName--methodName*.

Production Notes

The manuscript of this book was created with Adobe FrameMaker. All drawings were done with Microsoft Visio. The body font is New Century Schoolbook. The final print images were generated as PDF files using Adobe Acrobat Distiller, from PostScript generated by an AGFA driver.

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