UML by Example

This step-by-step introduction to object-oriented software development is suitable for pedagogical training as well as for practicing software engineers seeking to add rigor to their techniques. The author presents seven complete case studies and several smaller examples documented in UML, derived from small software projects developed for and delivered to real users. These make use of a bridge process that instantiates generic aspects of software methods including iteration and traceability. The process and case studies are preceded by an overview of the object-oriented modeling artifact in UML on which the remainder of the book relies.

The bridge process presents a systematic approach for developing analysis models and unfolding these incrementally and iteratively through to design models and implementation. The process could be viewed as one instantiation of the unified software development process and has the potential of being scalable to large software problems. It also provides a model for organizing deliverables obtained throughout different phases of the software life cycle.

These case studies provide a medium for experimental use and act as templates that can be tailored by readers to fit their specific needs and circumstances.

Ghinwa Jalloul is Assistant Professor of Computer Science at the American University of Beirut, Lebanon, and the head of a parliamentarian committee of Information Technology at the Lebanese Parliament. In addition to her dedication to teaching and the development of academic programs, she is the founder of the Information and Technology Society in Lebanon and is widely published by a number of international forums.
UML by Example

Ghinwa Jalloul

American University of Beirut, Lebanon
To my family

Thank you. Your support, care, and understanding have made this work possible.

Love, Ghinwa
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Preface

This book is meant to serve pedagogical and practical purposes by presenting a process called Bridge, which instantiates generic aspects of software methods including iteration and traceability. It also presents seven case studies documented in Unified Modeling Language (UML). The process and case studies are preceded by an overview of object-oriented modeling artifacts that act as a background for developing the concepts in the process and for presenting the case studies.

The book is appealing for a variety of readers because it provides a comprehensive view of modeling artifacts and how they fit together in an iterative context to provide working solutions. The approach that it adopts has the advantage of cutting down the learning curve and of bridging the gap between theory and practice. Readers will learn from the experience of other developments. The underlying theme is that a considerable amount of learning is achieved through practical applications of the theories involved; teaching object-oriented development could be made more effective by relying on documented practices.

This book is adequate for an introduction to object-oriented software development for pedagogical, training, and practical purposes. The first part is appropriate for a course on object-oriented development, whereas the second part on the case studies provides the meat for technical training. In addition, we believe that novices in practical contexts would benefit from this book, which cuts down the learning curve. Software engineers seeking to add rigor to their techniques would also find this book useful.
The introductory chapter describes modeling artifacts on which the remainder of the book relies. The artifacts are expressed in UML. This chapter relies heavily on examples derived from a large number of case studies, which makes it useful for readers interested in getting a quick introduction on object-oriented and UML modeling concepts, artifacts, and notation.

The bridge process and accompanying case studies present and disseminate instances of applications of principles and practice of object-oriented development. These also illustrate the use of UML for expressing software models and how these models can be mapped to implementations.

The bridge process presents a systematic approach for developing analysis models and unfolding these, incrementally and iteratively, on through to design models and implementation. The process could be viewed as one instantiation of the unified software development process and has the potential of being scalable to large software problems. It also provides a model for organizing deliverables obtained throughout different phases of the software life cycle and acts as a background for detailing the development of two case studies.

The detailed case studies provide packages that students and instructors can use for pedagogical and training advantage. In serving pedagogical and training purposes, the detailed specifications of two case studies demonstrate how solutions can be reached systematically and how generic aspects in developing software can be instantiated. Consequently, these agree with the observation that the primary barriers to valid development could be controlled and their effects diminished.

Because many elements of development are driven by the expertise of developers, rather than laboring to produce detailed solutions throughout, the book asserts that there is "no silver bullet," so the remaining case studies are presented as reached by developers. These as-is case studies provide a basket for experimental use and act as potentially replicable practices that can be exploited by readers after suitable tailoring to fit their specific needs and circumstances.

WHY THIS BOOK

A key challenge of writing this book was the identification of an interesting range of software solutions to practical software problems. Also, the size of the problems was yet another challenge that required much attention. Case studies typically emerge from real-world examples or model the same. Real problems are large and complex, which makes them inappropriate to use for explaining concepts, not to mention that detailed documents on such models are of commercial value that is not publicly available. To give the case studies in this book real flavor, some of the case studies were developed for small businesses and advanced versions of the described versions are now operational. Also, we chose to present small problems that can be modeled and presented within the context of a single book and can be used to relay object-oriented development concepts. Despite their size, the solutions are enticing because these cover all phases of development.
Another challenge is the method of development and presentation of the case studies to maximize the benefit. This has motivated the development of the bridge process model. Methodologies and processes are generic, leaving many decisions to the expertise and judgment of involved workers. By and large, these provide general directives leaving many details undefined, which prevents the immediate application of methodology by working through an example. One generic aspect is iteration. None of the existing methodologies or processes specify when or how iteration is to be performed. Another generic aspect is achieving traceability among various deliverables of the development process. Because of the complexity of deliverables, stepwise traceability could be tedious, and the iteration through the deliverables to ensure correctness of the final product is uncontrollable. Whereas for educational or training purposes, a presentation of a case study would have to explain the role of these deliverables, and how these trace from one another and contribute to the complete development.

These challenges were identified as a result of our experience in teaching object-oriented development for more than five years; we found that learning by example is one theme whose potential is hard to achieve in the context of object-oriented development. There is a lack of thorough case studies and modeling examples, which has been expressed as a need in several occasions and in various object-oriented contexts. The published examples are by and large classical in the sense that they focus on the same problems. Additionally, these are presented to demonstrate the use of notation or a single concept independent of the context of development. In teaching object-oriented software engineering, the lack of thorough case studies proved to be a severe discrepancy when we needed to demonstrate how the concepts could be utilized collaboratively throughout development. Because object-oriented models are based on a variety of interrelated artifacts that have temporal and iterative dependencies, presenting concepts independently fell short of relaying the role and contribution of the artifact to the development process.

We hope that we have been able to address these key challenges in writing this book.

CONTENTS

The book consists of seven chapters organized into three parts. The first chapter is the introduction to modeling artifacts, the second chapter introduces the bridge process, and the remaining chapters contain the case studies. Following is the outline of the book.

Part I: Introduction

This part introduces object-oriented modeling artifacts and the layout and the approaches that will be followed in presenting the detailed case studies.
• **Chapter 1: Modeling Concepts, Artifacts, and Relations**
  This chapter introduces modeling concepts and artifacts including use cases, classes, objects, subsystems, state diagrams, and activity diagrams. The objective is to familiarize readers with object-oriented modeling artifacts and set the framework for the remainder of the book.

• **Chapter 2: Bridge: A Systematic Process Model**
  This chapter describes a multidimensional, multiliteral process for developing software. The process organizes deliverables of the analysis, design, and implementation phases into the inception, elaboration, and construction phases. Based on this organization the process allows for specification of requirements in terms of the three dimensions of system architecture: use case model, object model, and software architecture model. It involves continual incremental unfolding of these models, in which each increment contributes to solve the problem and in many ways with the involvement and the judgment of the analyst. The process relies heavily on dynamic modeling, in particular, and activity diagrams to achieve traceability among requirements’ artifacts. Gradually it gives a comprehensive multidimensional analysis, design and implementation models integrated into the inception, and elaboration and construction phases of development.

**Part II: Detailed Case Studies**

• **Chapter 3: Reservations Online: Case Study 1**
  Work on this case study was motivated by an anticipated need of travel agencies to improve their sales by making their products, namely tours, directly accessible to their client base. Customers as well as travel agents and their employees would be able to view data on tours and to make reservations if desired. The current development focuses on travel agencies but it could be viewed as one instantiation of a general application framework that handles reservations in general, such as hotel, car, and so forth.

• **Chapter 4: Web Page Maker: Case Study 2**
  Work on this case study was motivated by the need to provide a tool to simplify the development of personal web pages and it was requested by an ISP for its clients. The case study is detailed based on the bridge process.

**Part III: As-is Case Studies**

This part presents a suite of case studies as they were developed. The presentation of these case studies follows the same layout described in the introduction.

• **Chapter 5: Simulating a Robot Arm: Case Study 3**
  This case study provides a design for simulating a robot arm.
• **Chapter 6: Math Tutor: Case Study 4**
  Math tutor is an application that educates and trains students in lower level classes in mathematics. The application supports three levels (low, medium, and high) of competency, where each level contains several stages that students have to complete to move across levels.

• **Chapter 7: Distribution Case: Case Study 5**
  This case study was developed for a reseller of goods. The company obtains its products from a vendor and resells them to a customer. The basic requirement is a database to keep track of specific information concerning the various vendors, customers, and warehouses, as well as a product database.

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