"Anyone doing UML modeling, learning UML, reading UML, or building UML tools should have this latest edition. (I own all editions.) There is lots of good, useful information; generally, just enough to be useful, but not too much to be dry. It's a must-have reference for my bookshelf!"

—Jon Kern
Modeler

"This is a great starting point for learning the fundamentals of the UML."

—Scott W. Ambler
Author of *Agile Modeling*

"An eminently sensible description of UML and its usage, with enough humor to hold one's attention. 'The swimming metaphor no longer holds water' indeed!"

—Stephen J. Mellor
Coauthor of *Executable UML*

"This is the perfect book for those who want to use the UML but aren't interested in reading thick UML reference books and research papers. Martin Fowler selects all the critical techniques needed to use the UML for design sketches, freeing the reader from complex and rarely used UML features. Readers will find no shortage of suggestions for further reading. He gives the reader advice based on experience. It's a concise and readable book covering the essential aspects of the UML and related object-oriented concepts."

—Pavel Hruby
Microsoft Business Solutions

"Like all good software developers, Fowler improves his product with each iteration. This is the only book I consider when teaching a class involving UML or if asked to recommend one that can be used to learn it."

—Charles Ashbacher
President/CEO, Charles Ashbacher Technologies

"More books should be like *UML Distilled*—concise and readable. Martin Fowler selects the parts of UML that you need, and presents them in an easy to read style. More valuable than a mere description of the modeling language, however, is the author's insight and experience in how to use this technique to communicate and document design."

—Rob Purser
Purser Consulting, LLC.

本书的评价

"*UML Distilled* remains the best introduction to UML notation. Martin's agile and pragmatic approach hits the sweet spot, and I wholeheartedly recommend it!"

—Craig Larman
Author of *Applying UML and Patterns*

"Fowler cuts through the complexity of UML to get users started quickly."

—Jim Rumbaugh
Author and originator of UML

"Martin Fowler's *UML Distilled* is an excellent way to get started with UML. In fact for most users, *UML Distilled* contains all you need to apply UML successfully. As Martin points out, UML can be used in many ways, but the most common is as a widely recognized notation for sketching designs. This book does an excellent job of distilling the essence of UML. Highly recommended."

—Steve Cook
Software Architect
Microsoft Corporation

"Short books on UML are better than long books on UML. This is still the best short book on UML. In fact, it's the best short book on many subjects."

—Alistair Cockburn
Author and President, Humans and Technology

"The book is immensely useful, readable, and—one of its great virtues—delightfully concise for the immense scope of its subject. If you only buy one book on UML, this should be it."

—Andy Carmichael
BetterSoftwareFaster, Ltd.

"If you're using UML, this book should never be out of reach."

—John Crupi
Distinguished Engineer, Sun Microsystems
Coauthor of *Core J2EE™ Patterns*

Chapter 1

Introduction

What Is the UML?

The Unified Modeling Language (UML) is a family of graphical notations, backed by single meta-model, that help in describing and designing software systems, particularly software systems built using the object-oriented (OO) style. That's a somewhat simplified definition. In fact, the UML is a few different things to different people. This comes both from its own history and from the different views that people have about what makes an effective software engineering process. As a result, my task in much of this chapter is to set the scene for this book by explaining the different ways in which people see and use the UML.

Graphical modeling languages have been around in the software industry for a long time. The fundamental driver behind them all is that programming languages are not at a high enough level of abstraction to facilitate discussions about design.

Despite the fact that graphical modeling languages have been around for a long time, there is an enormous amount of dispute in the software industry about their role. These disputes play directly into how people perceive the role of the UML itself.

The UML is a relatively open standard, controlled by the Object Management Group (OMG), an open consortium of companies. The OMG was formed to build standards that supported interoperability, specifically the interoperability of object-oriented systems. The OMG is perhaps best known for the CORBA (Common Object Request Broker Architecture) standards.

The UML was born out of the unification of the many object-oriented graphical modeling languages that thrived in the late 1980s and early 1990s. Since its appearance in 1997, it has relegated that particular tower of Babel to history. That's a service I, and many other developers, am deeply thankful for.

Ways of Using the UML

At the heart of the role of the UML in software development are the different ways in which people want to use it, differences that carry over from other graphical modeling languages. These differences lead to long and difficult arguments about how the UML should be used.

To untangle this, Steve Mellor and I independently came up with a characterization of the three modes in which people use the UML: sketch, blueprint, and programming language. By far the most common of the three, at least to my biased eye, is **UML as sketch**. In this usage, developers use the UML to help communicate some aspects of a system. As with blueprints, you can use sketches in a forward-engineering or reverse-engineering direction. **Forward engineering** draws a UML diagram before you write code, while **reverse engineering** builds a UML diagram from existing code in order to help understand it.

The essence of sketching is selectivity. With forward sketching, you rough out some issues in code you are about to write, usually discussing them with a group of people on your team. Your aim is to use the sketches to help communicate ideas and alternatives about what you're about to do. You don't talk about all the code you are going to work on, only important issues that you want to run past your colleagues first or sections of the design that you want to visualize before you begin programming. Sessions like this can be very short: a 10-minute session to discuss a few hours of programming or a day to discuss a 2-week iteration.

With reverse engineering, you use sketches to explain how some part of a system works. You don't show every class, simply those that are interesting and worth talking about before you dig into the code.

Because sketching is pretty informal and dynamic, you need to do it quickly and collaboratively, so a common medium is a whiteboard. Sketches are also useful in documents, in which case the focus is communication rather than completeness. The tools used for sketching are lightweight drawing tools, and often people aren't too particular about keeping to every strict rule of the UML. Most UML diagrams shown in books, such as my other books, are sketches. Their emphasis is on selective communication rather than complete specification.

In contrast, **UML as blueprint** is about completeness. In forward engineering, the idea is that blueprints are developed by a designer whose job is to build a detailed design for a programmer to code up. That design should be sufficiently complete in that all design decisions are laid out, and the programmer should be able to follow it as a pretty straightforward activity that requires little thought. The designer may be the same person as the programmer, but usually the designer is a more senior developer who designs for a team of programmers. The inspiration for this approach is other forms of engineering in which professional engineers create engineering drawings that are handed over to construction companies to build.

Blueprinting may be used for all details, or a designer may draw blueprints to a particular area. A common approach is for a designer to develop blueprint-level models as far as interfaces of subsystems but then let developers work out the details of implementing those details.

In reverse engineering, blueprints aim to convey detailed information about the code either in paper documents or as an interactive graphical browser. The blueprints can show every detail about a class in a graphical form that's easier for developers to understand.

Blueprints require much more sophisticated tools than sketches do in order to handle the details required for the task. Specialized CASE (computer-aided software engineering) tools fall into this category, although the term CASE has become a dirty word, and vendors try to avoid it now. Forward-engineering tools support diagram drawing and back it up with a repository to hold the information. Reverse-engineering tools read source code and interpret from it into the repository and generate diagrams. Tools that can do both forward and reverse engineering like this are referred to as **round-trip** tools.

Some tools use the source code itself as the repository and use diagrams as a graphic viewport on the code. These tools tie much more closely into programming and often integrate directly with programming editors. I like to think of these as **tripless** tools.

The line between blueprints and sketches is somewhat blurry, but the distinction, I think, rests on the fact that sketches are deliberately incomplete, highlighting important information, while blueprints intend to be comprehensive, often with the aim of reducing programming to a simple and fairly mechanical activity. In a sound bite, I'd say that sketches are explorative, while blueprints are definitive.

As you do more and more in the UML and the programming gets increasingly mechanical, it becomes obvious that the programming should be automated. Indeed, many CASE tools do some form of code generation, which automates building a significant part of a system. Eventually, however, you reach the point at which all the system can be specified in the UML, and you reach **UML as programming language**. In this environment, developers draw UML diagrams that are compiled directly to executable code, and the UML becomes the source code. Obviously, this usage of UML demands particularly sophisticated tooling. (Also, the notions of forward and reverse engineering don't make any sense for this mode, as the UML and source code are the same thing.)

Model Driven Architecture and Executable UML

When people talk about the UML, they also often talk about **Model Driven Architecture** (**MDA**) [Kleppe et al.]. Essentially, MDA is a standard approach to using the UML as a programming language; the standard is controlled by the OMG, as is the UML. By producing a modeling environment that conforms to the MDA, vendors can create models that can also work with other MDA-compliant environments.

MDA is often talked about in the same breath as the UML because MDA uses the UML as its basic modeling language. But, of course, you don't have to be using MDA to use the UML.

MDA divides development work into two main areas. Modelers represent a particular application by creating a **Platform Independent Model** (**PIM**). The PIM is a UML model that is independent of any particular technology. Tools can then turn a PIM into a **Platform Specific Model** (**PSM**). The PSM is a model of a system targeted to a specific execution environment. Further tools then take the PSM and generate code for that platform. The PSM could be UML but doesn't have to be.

So if you want to build a warehousing system using MDA, you would start by creating a single PIM of your warehousing system. If you then wanted this warehousing system to run on J2EE and .NET, you would use some vendor tools to create two PSMs: one for each platform. Then further tools would generate code for the two platforms.

If the process of going from PIM to PSM to final code is completely automated, we have the UML as programming language. If any of the steps is manual, we have blueprints.

Steve Mellor has long been active in this kind of work and has recently used the term **Executable UML** [Mellor and Balcer]. Executable UML is similar to MDA but uses slightly different terms. Similarly, you begin with a platform-independent model that is equivalent to MDA's PIM. However, the next step is to use a Model Compiler to turn that UML model into a deployable system in a single step; hence, there's no need for the PSM. As the term *compiler* suggests, this step is completely automatic.

The model compilers are based on reusable archetypes. An **archetype** describes how to take an executable UML model and turn it into a particular programming platform. So for the warehousing example, you would buy a model compiler and two archetypes (J2EE and .NET). Run each archetype on your executable UML model, and you have your two versions of the warehousing system.

Executable UML does not use the full UML standard; many constructs of UML are considered to be unnecessary and are therefore not used. As a result, Executable UML is simpler than full UML.

All this sounds good, but how realistic is it? In my view, there are two issues here. First is the question of the tools: whether they are mature enough to do the job. This is something that changes over time; certainly, as I write this, they aren't widely used, and I haven't seen much of them in action.

A more fundamental issue is the whole notion of the UML as a programming language. In my view, it's worth using the UML as a programming language only if it results in something that's significantly more productive than using another programming language. I'm not convinced that it is, based on various graphical development environments I've worked with in the past. Even if it is more productive, it still needs to get a critical mass of users for it to make the mainstream. That's a big hurdle in itself. Like many old Smalltalkers, I consider Smalltalk to be much more productive than current mainstream languages. But as Smalltalk is now only a niche language, I don't see many projects using it. To avoid Smalltalk's fate, the UML has to be luckier, even if it is superior.

One of the interesting questions around the UML as programming language is how to model behavioral logic. UML 2 offers three ways of behavioral modeling: interaction diagrams, state diagrams, and activity diagrams. All have their proponents for programming in. If the UML does gain popularity as a programming language, it will be interesting to see which of these techniques become successful.

Another way in which people look at the UML is the range between using it for conceptual and for software modeling. Most people are familiar with the UML used for software modeling. In this **software perspective**, the elements of the UML map pretty directly to elements in a software system. As we shall see, the mapping is by no means prescriptive, but when we use the UML, we are talking about software elements.

With the **conceptual perspective**, the UML represents a description of the concepts of a domain of study. Here, we aren't talking about software elements so much as we are building a vocabulary to talk about a particular domain.

There are no hard-and-fast rules about perspective; as it turns out, there's really quite a large range of usage. Some tools automatically turn source code into the UML diagrams, treating the UML as an alternative view of the source.

That's very much a software perspective. If you use UML diagrams to try and understand the various meanings of the terms *asset pool* with a bunch of accountants, you are in a much more conceptual frame of mind.

In previous editions of this book, I split the software perspective into specification (interface) and implementation. In practice, I found that it was too hard to draw a precise line between the two, so I feel that the distinction is no longer worth making a fuss about. However, I'm always inclined to emphasize interface rather than implementation in my diagrams.

These different ways of using the UML lead to a host of arguments about what UML diagrams mean and what their relationship is to the rest of the world. In particular, it affects the relationship between the UML and source code. Some people hold the view that the UML should be used to create a design that is independent of the programming language that's used for implementation. Others believe that language-independent design is an oxymoron, with a strong emphasis on the moron.

Another difference in viewpoints is what the essence of the UML is. In my view, most users of the UML, particularly sketchers, see the essence of the UML to be the diagrams. However, the creators of the UML see the diagrams as secondary; the essence of the UML is the meta-model. Diagrams are simply a presentation of the meta-model. This view also makes sense to blueprinters and UML programming language users.

So whenever you read anything involving the UML, it's important to understand the point of view of the author. Only then can you make sense of the often fierce arguments that the UML encourages.

Having said all that, I need to make my biases clear. Almost all the time, my use of the UML is as sketches. I find the UML sketches useful with forward and reverse engineering and in both conceptual and software perspectives.

I'm not a fan of detailed forward-engineered blueprints; I believe that it's too difficult to do well and slows down a development effort. Blueprinting to a level of subsystem interfaces is reasonable, but even then you should expect to change those interfaces as developers implement the interactions across the interface. The value of reverse-engineered blueprints is dependent on how the tool works. If it's used as a dynamic browser, it can be very helpful; if it generates a large document, all it does is kill trees.

I see the UML as programming language as a nice idea but doubt that it will ever see significant usage. I'm not convinced that graphical forms are more productive than textual forms for most programming tasks and that even if they are, it's very difficult for a language to be widely accepted.

As a result of my biases, this book focuses much more on using the UML for sketching. Fortunately, this makes sense for a brief guide. I can't do justice to the UML in its other modes in a book this size, but a book this size makes a good introduction to other books that can. So if you're interested in the UML in its other modes, I'd suggest that you treat this book as an introduction and move on to other books as you need them. If you're interested only in sketches, this book may well be all you need.

How We Got to the UML

I'll admit, I'm a history buff. My favorite idea of light reading is a good history book. But I also know that it's not everybody's idea of fun. I talk about history here because I think that in many ways, it's hard to understand where the UML is without understanding the history of how it got here.

In the 1980s, objects began to move away from the research labs and took their first steps toward the "real" world. Smalltalk stabilized into a platform that people could use, and C++ was born. At that time, various people started thinking about object-oriented graphical design languages.

The key books about object-oriented graphical modeling languages appeared between 1988 and 1992. Leading figures included Grady Booch [Booch, OOAD]; Peter Coad [Coad, OOA], [Coad, OOD]; Ivar Jacobson (Objectory) [Jacobson, OOSE]; Jim Odell [Odell]; Jim Rumbaugh (OMT) [Rumbaugh, insights], [Rumbaugh, OMT]; Sally Shlaer and Steve Mellor [Shlaer and Mellor, data], [Shlaer and Mellor, states]; and Rebecca Wirfs-Brock (Responsibility Driven Design) [Wirfs-Brock].

Each of those authors was now informally leading a group of practitioners who liked those ideas. All these methods were very similar, yet they contained a number of often annoying minor differences among them. The same basic concepts would appear in very different notations, which caused confusion to my clients.

During that heady time, standardization was as talked about as it was ignored. A team from the OMG tried to look at standardization but got only an open letter of protest from all the key methodologists. (This reminds me of an old joke. Question: What is the difference between a methodologist and a terrorist? Answer: You can negotiate with a terrorist.)

The cataclysmic event that first initiated the UML was when Jim Rumbaugh left GE to join Grady Booch at Rational (now a part of IBM). The Booch/Rumbaugh alliance was seen from the beginning as one that could get a critical mass of market share. Grady and Jim proclaimed that "the methods war is over—we won," basically declaring that they were going to achieve standardization "the Microsoft way." A number of other methodologists suggested forming an Anti-Booch Coalition.

By OOPSLA '95, Grady and Jim had prepared their first public description of their merged method: version 0.8 of the *Unified Method* documentation. Even more significant, they announced that Rational Software had bought Objectory and that therefore, Ivar Jacobson would be joining the Unified team. Rational held a well-attended party to celebrate the release of the 0.8 draft. (The highlight of the party was the first public display of Jim Rumbaugh's singing; we all hope it's also the last.)

The next year saw a more open process emerge. The OMG, which had mostly stood on the sidelines, now took an active role. Rational had to incorporate Ivar's ideas and also spent time with other partners. More important, the OMG decided to take a major role.

At this point, it's important to realize why the OMG got involved. Methodologists, like book authors, like to think that they are important. But I don't think that the screams of book authors would even be heard by the OMG. What got the OMG involved were the screams of tools vendors, all of which were frightened that a standard controlled by Rational would give Rational tools an unfair competitive advantage. As a result, the vendors energized the OMG to do something about it, under the banner of CASE tool interoperability. This banner was important, as the OMG was all about interoperability. The idea was to create a UML that would allow CASE tools to freely exchange models.

Mary Loomis and Jim Odell chaired the initial task force. Odell made it clear that he was prepared to give up his method to a standard, but he did not want a Rational-imposed standard. In January 1997, various organizations submitted proposals for a methods standard to facilitate the interchange of models. Rational collaborated with a number of other organizations and released version 1.0 of the UML documentation as their proposal, the first animal to answer to the name Unified Modeling Language.

Then followed a short period of arm twisting while the various proposals were merged. The OMG adopted the resulting 1.1 as an official OMG standard. Some revisions were made later on. Revision 1.2 was entirely cosmetic. Revision 1.3 was more significant. Revision 1.4 added a number of detailed concepts around components and profiles. Revision 1.5 added action semantics.

When people talk about the UML, they credit mainly Grady Booch, Ivar Jacobson, and Jim Rumbaugh as its creators. They are generally referred to as the Three Amigos, although wags like to drop the first syllable of the second word. Although they are most credited with the UML, I think it somewhat unfair to give them the dominant credit. The UML notation was first formed in the Booch/Rumbaugh Unified Method. Since then, much of the work has been led by OMG committees. During these later stages, Jim Rumbaugh is the only one of the three to have made a heavy commitment. My view is that it's these members of the UML committee process that deserve the principal credit for the UML.

Notations and Meta-Models

The UML, in its current state, defines a notation and a meta-model. The **notation** is the graphical stuff you see in models; it is the graphical syntax of the modeling language. For instance, class diagram notation defines how items and concepts, such as class, association, and multiplicity, are represented.

Of course, this leads to the question of what exactly is meant by an association or multiplicity or even a class. Common usage suggests some informal definitions, but many people want more rigor than that.

The idea of rigorous specification and design languages is most prevalent in the field of formal methods. In such techniques, designs and specifications are represented using some derivative of predicate calculus. Such definitions are mathematically rigorous and allow no ambiguity. However, the value of these definitions is by no means universal. Even if you can prove that a program satisfies a mathematical specification, there is no way to prove that the mathematical specification meets the real requirements of the system.

Most graphical modeling languages have very little rigor; their notation appeals to intuition rather than to formal definition. On the whole, this does not seem to have done much harm. These methods may be informal, but many people still find them useful—and it is usefulness that counts.

However, methodologists are looking for ways to improve the rigor of methods without sacrificing their usefulness. One way to do this is to define a **meta-model:** a diagram, usually a class diagram, that defines the concepts of the language.

Figure 1.1, a small piece of the UML meta-model, shows the relationship among features. (The extract is there to give you a flavor of what meta-models are like. I'm not even going to try to explain it.)

How much does the meta-model affect a user of the modeling notation? The answer depends mostly on the mode of usage. A sketcher usually doesn't care too much; a blueprinter should care rather more. It's vitally important to those who use the UML as a programming language, as it defines the abstract syntax of that language.

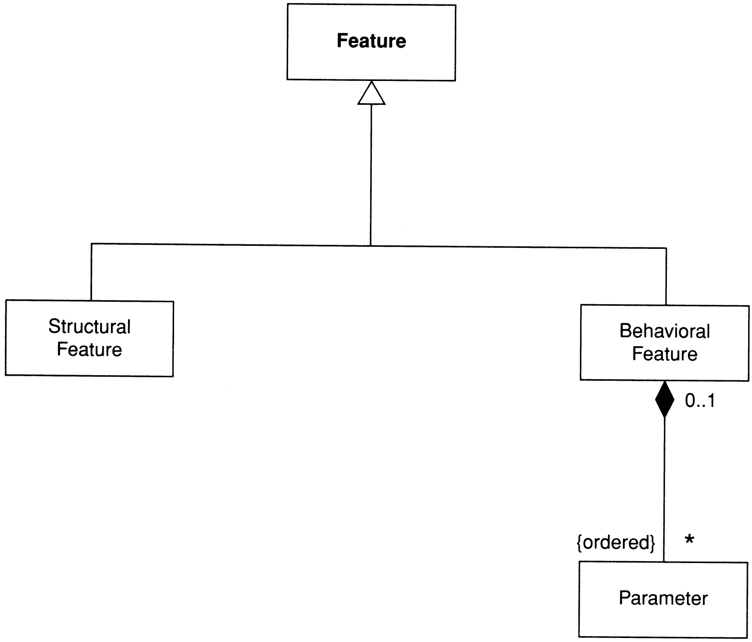

Figure 1.1 *A small piece of the UML meta-model*

Many of the people who are involved in the ongoing development of the UML are interested primarily in the meta-model, particularly as this is important to the usage of the UML and a programming language. Notational issues often run second place, which is important to bear in mind if you ever try to get familiar with the standards documents themselves.

As you get deeper into the more detailed usage of the UML, you realize that you need much more than the graphical notation. This is why UML tools are so complex.

I am not rigorous in this book. I prefer the traditional methods path and appeal mainly to your intuition. That's natural for a small book like this written by an author who's inclined mostly to a sketch usage. If you want more rigor, you should turn to more detailed tomes.

UML Diagrams

UML 2 describes 13 official diagram types listed in Table 1.1 and classified as indicated on Figure 1.2. Although these diagram types are the way many people