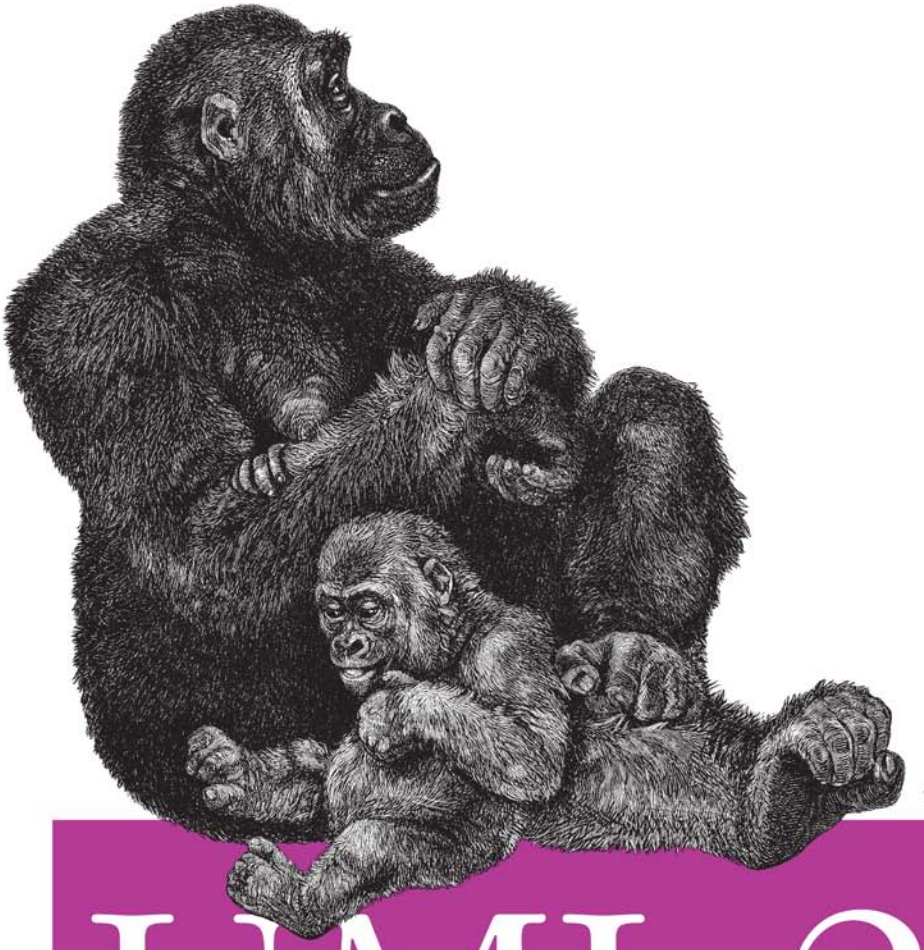
A Pragmatic Introduction to UML



Learning

UML 2.0

O'REILLY®

Russ Miles & Kim Hamilton

O'REILLY®

Learning UML 2.0

If you're like most software developers, you're building systems that are increasingly complex. Whether you're creating a desktop application or an enterprise system, complexity is the big hairy monster you must manage.

The Unified Modeling Language (UML) helps you manage this complexity. Whether you are looking to use UML as a blueprint language, a sketch tool, or as a programming language, this book will give you the need-to-know information on how to apply UML to your project. Although there are plenty of books available that describe UML, *Learning UML 2.0* will show you how to use it. Topics covered include:

- Capturing your system's requirements in your model to help you ensure that your designs meet your users' needs
- Modeling the parts of your system and their relationships
- Modeling how the parts of your system work together to meet your system's requirements
- Modeling, capturing, and deploying your system in the real world

Engaging and accessible, this book shows you how to use UML to craft and communicate your project's design. Russ Miles and Kim Hamilton have written a pragmatic introduction to UML based on hard-earned practice, not theory. Regardless of the software process or methodology you use, *Learning UML 2.0* is the one source you need to get up and running with UML 2.0. Additional information, including exercises, can be found at *http://www.learninguml2.com*.

Russ Miles is a software engineer for General Dynamics UK, where he works with Java and Distributed Systems. However, his current passion is Aspect Orientation and AspectJ in particular.

Kim Hamilton is a senior software engineer at a major aerospace corporation, where she has designed and implemented a variety of systems, including web applications and distributed systems.

"Since its original introduction in 1997, the Unified Modeling Language has revolutionized software development. Every integrated software development environment in the world—open source, standards-based, proprietary—now supports UML, and more importantly, the model-driven approach to software development. This makes learning the newest UML standard, UML 2.0, critical for all software developers—and there isn't a better choice than this clear, step-by-step guide to learning the language."

—Richard Mark Soley, Chairman and CEO, OMG

www.oreilly.com

US $44.99 **CAN $58.99**

ISBN-10: 0-596-00982-8

ISBN-13: 978-0-596-00982-3

9 780596 009823 54499

Safari® BOOKS ONLINE ENABLED

Includes FREE 45-Day Online Edition

Learning UML 2.0

Other resources from O'Reilly

Related titles

UML 2.0 in a Nutshell
UML Pocket Reference
Prefactoring

oreilly.com

oreilly.com is more than a complete catalog of O'Reilly books. You'll also find links to news, events, articles, weblogs, sample chapters, and code examples.

oreillynet.com is the essential portal for developers interested in open and emerging technologies, including new platforms, programming languages, and operating systems.

Conferences

O'Reilly brings diverse innovators together to nurture the ideas that spark revolutionary industries. We specialize in documenting the latest tools and systems, translating the innovator's knowledge into useful skills for those in the trenches. Visit *conferences.oreilly.com* for our upcoming events.

Safari Bookshelf (*safari.oreilly.com*) is the premier online reference library for programmers and IT professionals. Conduct searches across more than 1,000 books. Subscribers can zero in on answers to time-critical questions in a matter of seconds. Read the books on your Bookshelf from cover to cover or simply flip to the page you need. Try it today for free.

Learning UML 2.0

Russ Miles and Kim Hamilton

O'REILLY®
Beijing • Cambridge • Farnham • Köln • Paris • Sebastopol • Taipei • Tokyo

Learning UML 2.0
by Russ Miles and Kim Hamilton

Copyright © 2006 O'Reilly Media, Inc. All rights reserved.
Printed in the United States of America.

Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.

O'Reilly books may be purchased for educational, business, or sales promotional use. Online editions are also available for most titles (*safari.oreilly.com*). For more information, contact our corporate/institutional sales department: (800) 998-9938 or *corporate@oreilly.com*.

Editors: Brett McLaughlin and Mary T. O'Brien
Production Editor: Laurel R.T. Ruma
Copyeditor: Laurel R.T. Ruma
Proofreader: Reba Libby
Indexer: Angela Howard
Cover Designer: Karen Montgomery
Interior Designer: David Futato
Cover Illustrator: Karen Montgomery
Illustrators: Robert Romano, Jessamyn Read, and Lesley Borash

Printing History:

April 2006: First Edition.

Nutshell Handbook, the Nutshell Handbook logo, and the O'Reilly logo are registered trademarks of O'Reilly Media, Inc. *Learning UML 2.0*, the image of a gorilla, and related trade dress are trademarks of O'Reilly Media, Inc.

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and O'Reilly Media, Inc. was aware of a trademark claim, the designations have been printed in caps or initial caps.

While every precaution has been taken in the preparation of this book, the publisher and authors assume no responsibility for errors or omissions, or for damages resulting from the use of the information contained herein.

This book uses RepKover™, a durable and flexible lay-flat binding.

ISBN-10: 0-596-00982-8
ISBN-13: 978-0-596-00982-3
[M] [9/07]

Table of Contents

Preface

The Unified Modeling Language (UML) is the standard way to model systems, particularly software systems. If you are working on a system beyond "Hello, World," then having UML in your toolbox of skills is a must, and that's where *Learning UML 2.0* comes in.

Learning UML 2.0 is about coming to grips with UML quickly, easily, and practically. Along with a thorough set of tutorials on each of the different UML diagram types, this book gives you the tools to use UML effectively when designing, implementing, and deploying systems. The topics covered include:

- A brief overview of why it is helpful to model systems
- How to capture high-level requirements in your model to help ensure the system meets users' needs
- How to model the parts that make up your system
- How to model the behavior and interactions between parts when the system is running
- How to move from the model into the real world by capturing how your system is deployed
- How to create custom UML profiles to accurately model different system domains

Audience

Learning UML 2.0 is for anyone interested in learning about UML, but it is helpful to have some exposure to object-oriented (OO) design and some familiarity with Java. However, even if you have only a small amount of experience with object orientation, *Learning UML 2.0* will improve and extend your knowledge of OO concepts and give you a comprehensive set of tools to work with UML.

Although this book is intended to take you through each subject on the path to learning UML, some UML modeling subjects, such as use cases and activity diagrams, are self-explanatory, which means you can dive right into them.

About This Book

Learning UML 2.0 aims to answer the "what," "how," and "why should I care?" for every aspect of UML. Each chapter picks one subject from UML and explains it based on these questions.

Since not everyone is new to UML, there are two main routes through this book. If you're new to UML as a subject and want to get an overview of where the modeling language came from, then you should start with Chapter 1. However, if you want to get your hands dirty as quickly as possible, then you can either skip the introduction chapter to delve directly into use cases or jump to the chapter that describes the UML diagram in which you are most interested.

Now you know what *Learning UML 2.0* is about, it should be explained what this book is not about. This book is not about any one particular modeling tool or implementation language. However, some tools have their own way of doing things, and some implementation languages do not support everything you can legally model in UML. Wherever appropriate, we have tried to point out where UML tools or implementation languages deviate from or follow the UML standard.

Lastly, because of the large variation in software development processes, this book is not about any particular process or methodology. Instead, it focuses on modeling and provides guidelines about appropriate levels of modeling that can be applied in the context of your software development process. Since this book adheres to the UML 2.0 standard, it works alongside any process or methodology you use.

Assumptions This Book Makes

The following general assumptions are made as to the reader's knowledge and experience:

- An understanding of object orientation
- Knowledge of the Java™ language for some of the examples

Conventions Used in This Book

The following typographical conventions are used in this book:

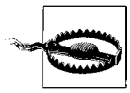
Italic
: Indicates new terms, URLs, email addresses, filenames, file extensions, pathnames, directories, and Unix utilities.

`Constant width`
: Indicates commands, options, switches, variables, attributes, keys, functions, types, classes, namespaces, methods, modules, properties, parameters, values, objects, events, event handlers, XML tags, HTML tags, macros, the contents of files, or the output from commands.

`Constant width bold`
: Shows commands or other text that should be typed literally by the user.

`Constant width italic`
: Shows text that should be replaced with user-supplied values.

This icon signifies a tip, suggestion, or general note.



This icon indicates a warning or caution.

Using Code Examples

This book is here to help you get your job done. In general, you may use the code in this book in your programs and documentation. You do not need to contact us for permission unless you're reproducing a significant portion of the code. For example, writing a program that uses several chunks of code from this book does not require permission. Selling or distributing a CD-ROM of examples from O'Reilly books *does* require permission. Answering a question by citing this book and quoting example code does not require permission. Incorporating a significant amount of example code from this book into your product's documentation *does* require permission.

We appreciate, but do not require, attribution. An attribution usually includes the title, author, publisher, and ISBN. For example: "*Learning UML 2.0*, by Russ Miles and Kim Hamilton. Copyright 2006 O'Reilly Media, Inc., 0-596-00982-8."

If you feel your use of code examples falls outside fair use or the permission given above, feel free to contact us at *permissions@oreilly.com*.

Safari® Enabled

When you see a Safari® Enabled icon on the cover of your favorite technology book, that means the book is available online through the O'Reilly Network Safari Bookshelf.

Safari offers a solution that's better than e-books. It's a virtual library that lets you easily search thousands of top tech books, cut and paste code samples, download chapters, and find quick answers when you need the most accurate, current information. Try it for free at *http://safari.oreilly.com*.

How to Contact Us

Everything has been done to ensure that the examples within this book are accurate, tested, and verified to the best of the authors' ability. However, even though UML is a standard modeling language, the best practices as to its usage may change with time and this may have an impact on this book's contents. If so, please address comments and questions concerning this book to the publisher:

O'Reilly Media, Inc.
1005 Gravenstein Highway North
Sebastopol, CA 95472
(800) 998-9938 (in the United States or Canada)
(707) 829-0515 (international or local)
(707) 829-0104 (fax)

There is a web page for this book where you can find errata, examples, and any additional information. You can access this page at:

http://www.oreilly.com/catalog/learnuml2

To comment or ask technical questions about this book, email:

bookquestions@oreilly.com

For more information about our books, conferences, Resource Centers, and the O'Reilly Network, see our web site:

http://www.oreilly.com

Additional information about this topic, including exercises, can be found at:

http://www.learninguml2.com

Acknowledgments

From the Authors

Thanks to Brett and Mary, our ace editors. We are indebted to Brett for providing valuable guidance throughout, and to Mary for her UML expertise, her amazing work bringing this book to completion, and her ability to line up an outstanding team of reviewers.

We'd also like to thank all the kind individuals who put in the hours to provide such excellent technical feedback on this book. Thanks to Ed Chou, Glen Ford, Stephen Mellor, Eric Naiburg, Adewale Oshineye, Dan Pilone and Neil Pitman, and Richard Mark Soley (the history of UML would not have been nearly as interesting without your help).

From Russ Miles

First and foremost, my thanks go to my family and friends: Mum, Dad, Bobbie, Rich, Ad, Corinne (thanks for all your help through the last hectic stages, you're one in a million!), Martin and Sam, Jason and Kerry, and Aimee (wonder dog!). You are always there for me 100 percent and, as a bonus, have the uncanny but very useful ability to get me away from the Mac once in a while when I really need it.

I'd also like to take this opportunity to thank my uncle, Bruce Sargent. You got me started on the first steps in this career and for that I am, and always will be, very grateful!

I'd like to thank all my proofreaders, including Rob Wilson, Laura Paterson, and Grant Tarrant-Fisher. You've been great proofreaders, tech reviewers and, most of all, friends. With your comments this a much better book than anything I could have put together on my own. Also, a special thanks to Rachel "Kong" Stevens for being the unwitting inspiration for the front cover—we love ya!

A big thanks must go to M. David Peterson (*http://www.xsltblog.com*) and Sylvain Hellegouarch (*http://www.defuze.org*) for all their help and inspiration with the CMS example that is used throughout this book. You're both top bloggers, developers, and friends and I want to say thanks to you and all the LLUP hackers *(http://www.x2x2x.org/projects/wiki*) for making my coding life that much more interesting, cheers!

Last, but not least—with what is quickly becoming a standard catch-all—thanks to everyone who has helped me out while writing this book. I haven't forgotten your help and I know I owe you all a beer or two!

From Kim Hamilton

Thanks again to Ed Chou for his gaming expertise that helped create the FPS example (among his many other excellent contributions!) and for the long hours spent reviewing this book at every phase. A big thanks goes to my reviewers: Frank Chiu, Albert Chu, Yu-Li Lin, Justin Lomheim, Samarth Pal, Leland So, and Delson Ting. You were great at everything—from providing technical feedback to pointing out the humor in the word OMG. Thanks to John Arcos, Ben Faul, Mike Klug, Dwight Yorke, and Paul Yuenger, whose support helped me get this book out the door. Also, thanks to Thomas Chen for his CMS help!

Most of all, thanks to my wonderful family and friends—Mom, Dad, Ron, Mark, Grandma and Ed, Grandpa (in loving memory), Aunt Gene, Anne Marie, Kim, Ed C, Sokun, and Tien—who have all been so supportive this past year. Special thanks to my Mom and Dad: my Mom keeps me going with her love, friendship, and phone calls; and my Dad has always been my number one technical mentor.

CHAPTER 1
Introduction

The Unified Modeling Language (UML) is *the* standard modeling language for software and systems development. This statement alone is a pretty conclusive argument for making UML part of your software repertoire, however it leaves some questions unanswered. Why is UML unified? What can be modeled? How is UML a language? And, probably most importantly, why should you care?

Systems design on any reasonably large scale is difficult. Anything from a simple desktop application to a full multi-tier enterprise scale system can be made up of hundreds—and potentially thousands—of software and hardware components. How do you (and your team) keep track of which components are needed, what their jobs are, and how they meet your customers' requirements? Furthermore, how do you share your design with your colleagues to ensure the pieces work together? There are just too many details that can be misinterpreted or forgotten when developing a complex system without some help. This is where modeling—and of course UML—comes in.

In systems design, you model for one important reason: to manage complexity. Modeling helps you see the forest for the trees, allowing you to focus on, capture, document, and communicate the important aspects of your system's design.

A model is an *abstraction* of the real thing. When you model a system, you abstract away any details that are irrelevant or potentially confusing. Your model is a *simplification* of the real system, so it allows the design and viability of a system to be understood, evaluated, and criticized quicker than if you had to dig through the actual system itself. Even better, with a formal modeling language, the language is abstract yet just as precise as a programming language. This precision allows a language to be machine-readable, so it can be interpreted, executed, and transformed between systems.

To effectively model a system, you need one very important thing: a language with which the model can be described. And here's where UML comes in.

What's in a Modeling Language?

A modeling language can be made up of pseudo-code, actual code, pictures, diagrams, or long passages of description; in fact, it's pretty much anything that helps you describe your system. The elements that make up a modeling language are called its *notation*. Figure 1-1 shows an example of a piece of UML notation.

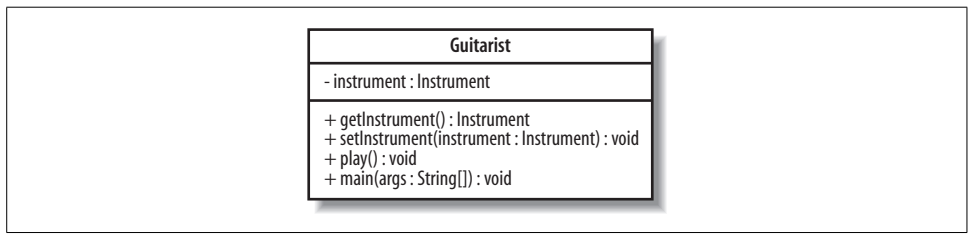


Figure 1-1. A class declaration as it can be shown using UML notation

There are references to the UML meta-model and profiles throughout this book. A more complete description of what the UML meta-model contains and why it is useful is available in Appendix B, but for now, just think of the UML meta-model as the description of what each element of notation means and a profile as a customization of that description for a specific domain (i.e., banking).

However, notation is not the whole story. Without being told that one of the boxes in Figure 1-1 represents a class, you wouldn't necessarily know what it is, even though you might be able to guess. The descriptions of what the notation means are called the *semantics* of the language and are captured in a language's meta-model.

A modeling language can be anything that contains a notation (a way of expressing the model) and a description of what that notation means (a meta-model). But why should you consider using UML when there are so many different ways of modeling, including many you could make up on your own?

Every approach to modeling has different advantages and disadvantages, but UML has six main advantages:

It's a formal language
: Each element of the language has a strongly defined meaning, so you can be confident that when you model a particular facet of your system it will not be misunderstood.

It's concise
: The entire language is made up of simple and straightforward notation.

It's comprehensive
: It describes all important aspects of a system.

It's scaleable
: Where needed, the language is formal enough to handle massive system modeling projects, but it also scales down to small projects, avoiding overkill.

It's built on lessons learned
: UML is the culmination of best practices in the object-oriented community during the past 15 years.

It's the standard
: UML is controlled by an open standards group with active contributions from a worldwide group of vendors and academics, which fends off "vendor lock-in." The standard ensures UML's transformability and interoperability, which means you aren't tied to a particular product.

Detail Overload: Modeling with Code

Software code is an example of a potential modeling language where none of the detail has been abstracted away. Every line of code *is* the detail of how your software is intended to work. Example 1-1 shows a very simple class in Java, yet there are many details in this declaration.

Example 1-1. Even in a simple Java class, there can be a lot of detail to navigate through

```
package org.oreilly.learningUML2.ch01.codemodel;

public class Guitarist extends Person implements MusicPlayer {

   Guitar favoriteGuitar;

   public Guitarist (String name) {
      super(name);
   }

   // A couple of local methods for accessing the class's properties
   public void setInstrument(Instrument instrument ) {
      if (instrument instanceof Guitar) {
         this.favoriteGuitar = (Guitar) instrument;
      }
      else {
         System.out.println("I'm not playing that thing!");
      }
   }

    public Instrument getInstrument( ) {
      return this.favoriteGuitar;
   }

   // Better implement this method as MusicPlayer requires it
   public void play( ) {
      System.out.println(super.getName( ) + "is going to do play the guitar now ...");

      if (this.favoriteGuitar != null) {
```

Example 1-1. Even in a simple Java class, there can be a lot of detail to navigate through (continued)

```
        for (int strum = 1; strum < 500; strum++) {
           this.favoriteGuitar.strum( );
        }
        System.out.println("Phew! Finished all that hard playing");
     }
     else {
        System.out.println("You haven't given me a guitar yet!");
     }
  }

  // I'm a main program so need to implement this as well
  public static void main(String[] args) {
     MusicPlayer player = new Guitarist("Russ");
     player.setInstrument(new Guitar("Burns Brian May Signature"));
     player.play( );
  }
}
```

Example 1-1 shows all of the information about the Guitar class, including inheritance relationships to other classes, member variables involving other classes, and even implementation details for the methods themselves.

What's wrong with using software source code as your model? All of the details are there, every element of the language's notation has meaning to the compiler, and with some effective code-level comments, such as JavaDoc, you have an accurate representation of your software system, don't you?

The truth is that you haven't actually modeled anything other than the software implementation. The source code focuses only on the software itself and ignores the rest of the system. Even though the code is a complete and (generally) unambiguous definition of what the software will do, the source code alone simply cannot tell you how the software is to be used and by whom, nor how it is to be deployed; the bigger picture is missing entirely if all you have is the source code.

As well as ignoring the bigger picture of your system, software code presents a problem in that you need to use other techniques to explain your system to other people. You have to understand code to read code, but source code is the language for software developers and is not for other stakeholders, such as customers and system designers. Those people will want to focus just on requirements or perhaps see how the components of your system work together to fulfill those requirements. Because source code is buried in the details of how the software works, it cannot provide the higher level abstract views of your system that are suitable for these types of stakeholders.

Now imagine that you have implemented your system using a variety of software languages. The problem just gets worse. It is simply impractical to ask all the stakeholders in your system to learn each of these implementation languages before they can understand your system.

Finally, if your design is modeled as code, you also lose out when it comes to reuse because design is often reusable whereas code may not be. For example, reimplementing a Java Swing application in HTML or .NET is much simpler if the design is modeled rather than reverse engineering the code. (Reverse engineering is extracting the design of a system from its implementation.)

All of these problems boil down to the fact that source code provides only one level of abstraction: the software implementation level. Unfortunately, this root problem makes software source code a poor modeling language.

Verbosity, Ambiguity, Confusion: Modeling with Informal Languages

At the opposite end of the spectrum from complete and precise source code models are informal languages. *Informal languages* do not have a formally defined notation; there are no hard and fast rules as to what a particular notation can mean, although sometimes there are guidelines.

A good example of an informal language is natural language. Natural language—the language that you're reading in this book—is notoriously ambiguous in its meaning. To accurately express something so that everyone understands what you are saying is at best a challenge and at worst flat-out impossible. Natural language is flexible and verbose, which happens to be great for conversation but is a real problem when it comes to systems modeling.

The following is a *slightly* exaggerated but technically accurate natural language model of Example 1-1:

> `Guitarist` is a class that contains six members: one static and five non-static. `Guitarist` uses, and so needs an instance of, `Guitar`; however, since this might be shared with other classes in its package, the `Guitar` instance variable, called `favoriteGuitar`, is declared as `default`.
>
> Five of the members within `Guitarist` are methods. Four are not static. One of these methods is a constructor that takes one argument, and instances of `String` are called `name`, which removes the default constructor.
>
> Three regular methods are then provided. The first is called `setInstrument`, and it takes one parameter, an instance of `Instrument` called `instrument`, and has no return type. The second is called `getInstrument` and it has no parameters, but its return type is `Instrument`. The final method is called `play`. The `play` method is actually enforced by the `MusicPlayer` interface that the `Guitarist` class implements. The `play` method takes no parameters, and its return type is `void`.
>
> Finally, `Guitarist` is also a runable program. It contains a method that meets the Java specification for a `main` method for this reason.

If you take a hard look at this definition, you can see problems everywhere, almost all resulting from ambiguity in the language. This ambiguity tends to result in the, "No, that's not what I meant!" syndrome, where you've described something as

clearly as possible, but the person that you are conveying the design to has misunderstood your meaning (see Figure 1-2).

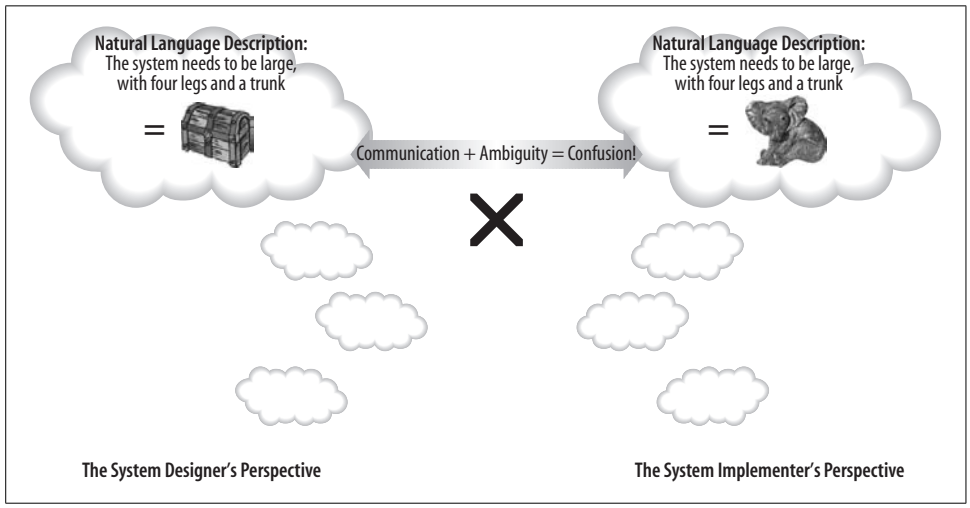


Figure 1-2. Even a simple natural language sentence can be interpreted differently by different stakeholders in the system

The problems with informal languages are by no means restricted to written languages. The same description of `Guitarist` might be presented as a picture like that shown in Figure 1-3.

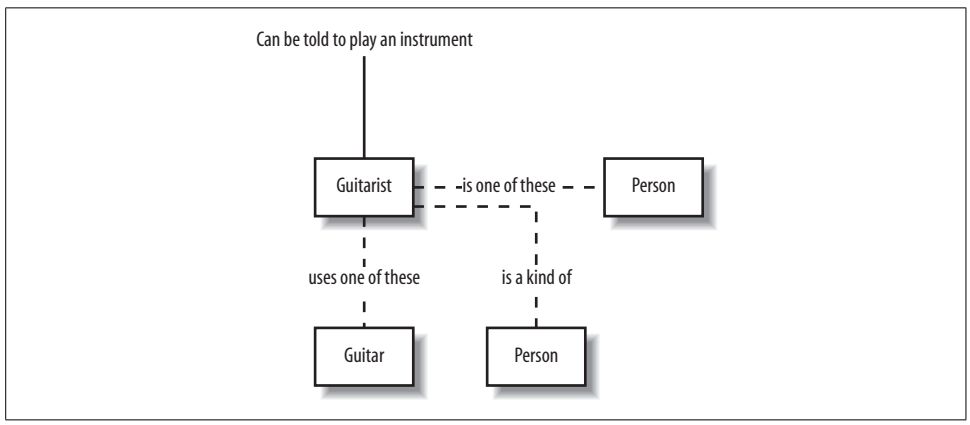


Figure 1-3. Informal notation can be confusing; even though my intentions with this diagram might appear obvious, you really can't be sure unless I also tell you what the notation means

Figure 1-3 is another example of an informal language, and it happens to be a notation that I just made up. It makes perfect sense to me, but you could easily misinterpret my intentions.

As with the natural language model, all of the details are present in Figure 1-3's picture, but without a definition of what the boxes, connections, and labels mean, you can't be sure about your interpretation (or mine!).

So, why does any of this matter if your team has a home-grown modeling technique it's been using for years and you all understand what each other means? If you ever have to show your design to external stakeholders, they might become frustrated trying to understand your home-grown symbols, when you could have used a standard notation they already know. It also means you don't have to learn a new modeling technique every time you switch jobs!

The basic problem with informal languages is that they don't have exact rules for their notation. In the natural language example, the meanings of the model's sentences were obscured by the ambiguity and verbosity of the English language. The picture in Figure 1-3 may not have suffered from quite the same verbosity problems, but without knowing what the boxes and lines represent, the meaning of the model was left largely to guesswork.

Because informal languages are not precise, they can't be transformed into code as a formal language can. Imagine if Figure 1-3 had a set of formal rules; then you could generate code that implemented the classes for `Guitarist`, `Person`, and so on. But this is impossible without understanding the rules. Unfortunately, informal languages will always suffer from the dual problem of verbosity and ambiguity, and this is why they are a poor—and sometimes extremely dangerous—technique for modeling systems, as shown in Figure 1-4.

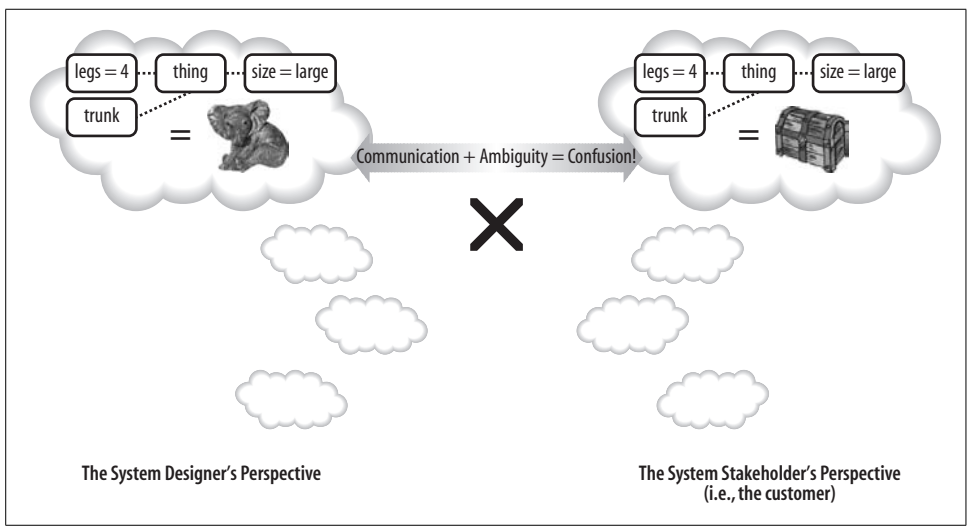


Figure 1-4. With an informal notation, the problem of confusion through ambiguity still exists

Although natural language is dangerously ambiguous, it is still one of the best techniques for capturing requirements, as you will see when you learn about use cases in Chapter 2.

Getting the Balance Right: Formal Languages

You've now seen some of the pitfalls of using a too-detailed language for modeling (source code) and a too-verbose and ambiguous language for modeling (natural language). To effectively model a system—avoiding verbosity, confusion, ambiguity, and unnecessary details—you need a *formal modeling language*.

Ideally, a formal modeling language has a simple notation whose meaning is well-defined. The modeling language's notation should be small enough to be learned easily and must have an unambiguous definition of the notation's meaning. UML is just such a formal modeling language.

Figure 1-5 shows how the code structure in Example 1-1 can be expressed in UML. For now, don't worry too much about the notation or its meaning; at this point, the UML diagram is meant to be used only as a comparison to the informal pictorial and natural language models shown previously.

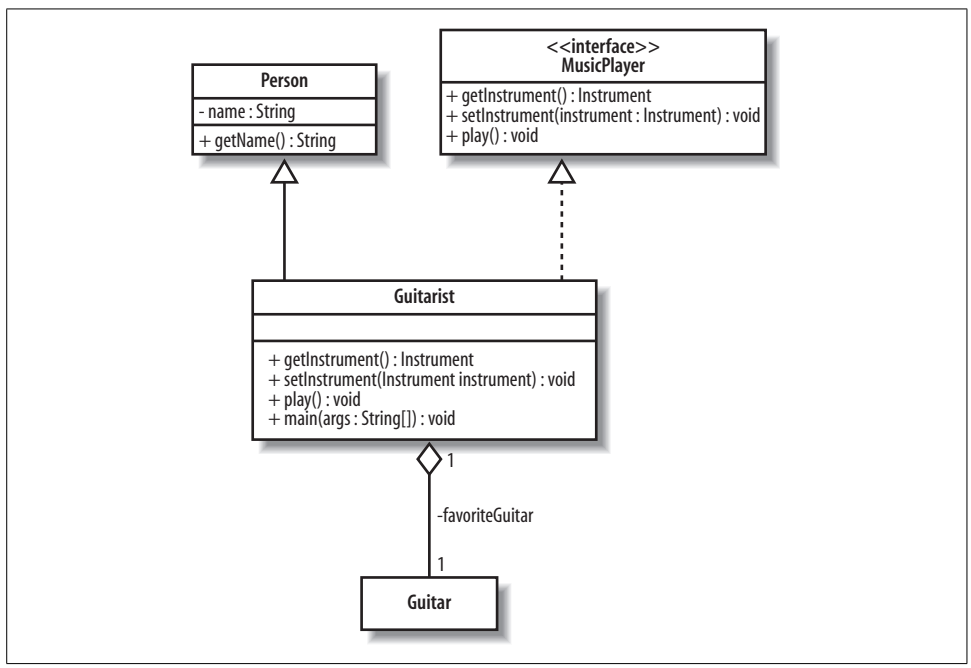


Figure 1-5. Expressing the static structure of the Guitarist class structure in formal UML notation

Even if you don't yet understand all of the notation used in Figure 1-5, you can probably start to grasp that there are some details present in the code—see Example 1-1—that are not modeled here. For example, the specific implementation of the `play()` method has been abstracted away, allowing you to visualize the code's structure without excess clutter.

The best thing about having modeled the system using UML is that the notation in Figure 1-5 has a specific and defined meaning. If you were to take this diagram to any other stakeholder in your system, provided he knows UML, the design would be clearly understood. This is the advantage of using formal languages for modeling as shown in Figure 1-6.

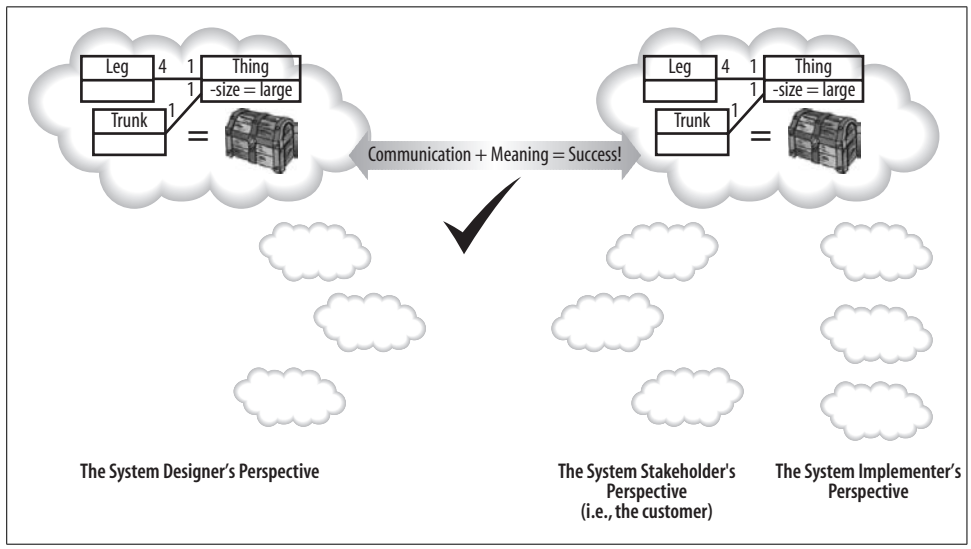


Figure 1-6. With a modeling language that has a formally defined meaning, you can ensure that everyone is reading the picture the same way

Why UML 2.0?

The first version of UML allowed people to communicate designs unambiguously, convey the essence of a design, and even capture and map functional requirements to their software solutions. However, the world changed more fundamentally with the recognition that systems modeling, rather than just software modeling, could also benefit from a unified language such as UML.

The driving factors of component-oriented software development, model-driven architectures, executable UML, and the need to share models between different tools placed demands on UML that it had not originally been designed to meet.

Also, UML 1.x and all of its previous revisions were designed as a unified language for *humans*. When it became important for models to be shared between *machines*—specifically between Computer Aided Systems Engineering (CASE) tools—UML 1.x was again found wanting. UML 1.x's underlying notation rules and its meta-model were (ironically) not formally defined enough to enable machine-to-machine sharing of models.

MDA and Executable UML

Two reasonably new approaches to system development inspired many of the improvements made in UML 2.0. In a nutshell, Model Driven Architectures (MDAs) provide a framework that supports the development of Platform Independent Models (PIMs)—models that capture the system in a generic manner that is divorced from concerns such as implementation language and platform.

PIMs can then be transformed into separate Platform Specific Models (PSMs) that contain concrete specifications for a particular system deployment (containing details such as implementation language and communications protocols, etc.). MDA requires a formally structured and interoperable meta-model to perform its transformations, and this level of meta-model is now provided by UML 2.0.

For many of the same reasons, executable UML provides a means by which a PSM could contain enough complete information so that the model can be effectively run. Some day, you could conceivably drag around a few symbols, and complete, runnable software would pop out! An executable UML engine requires that the UML model be defined well enough for it to be able to generate and execute the modeled system.

Unfortunately, even though UML 2.0 is supposed to provide the mechanisms to make MDA and executable UML a reality, tools support is not yet fully developed.

Although UML 1.5 described a system fairly well, the model describing the model—the meta-model—had become patched and overly complex. Like any system that has an overly complex design, and is fragile and difficult to extend, UML had become overly complex, fragile, and difficult to extend; it was time for a re-architecture.

The designers of UML 2.0 were very careful to ensure that UML 2.0 would not be too unfamiliar to people who were already using UML 1.x. Many of the original diagrams and associated notations have been retained and extended in UML 2.0 as shown in Table 1-1. However, new diagram types have been introduced to extend the language just enough so that it can support the latest best practices.

With Version 2.0, UML has evolved to support the new challenges that software and system modelers face today. What began many years ago as a unification of the different methods for software design has now grown into a unified modeling language that is ready and suitable to continue to be the standard language for the myriad of different tasks involved in software and systems design.

Table 1-1. To describe the larger landscape of systems design, UML 2.0 renamed and clarified its diagrams for the new challenges facing system modelers today

Diagram type	What can be modeled?	Originally introduced by UML 1.x or UML 2.0	To learn about this diagram type, go to…
Use Case	Interactions between your system and users or other external systems. Also helpful in mapping requirements to your systems.	UML 1.x	Chapter 2
Activity	Sequential and parallel activities within your system.	UML 1.x	Chapter 3
Class	Classes, types, interfaces, and the relationships between them.	UML 1.x	Chapters 4 and 5
Object	Object instances of the classes defined in class diagrams in configurations that are important to your system.	Informally UML 1.x	Chapter 6
Sequence	Interactions between objects where the order of the interactions is important.	UML 1.x	Chapter 7
Communication	The ways in which objects interact and the connections that are needed to support that interaction.	Renamed from UML 1.x's collaboration diagrams	Chapter 8
Timing	Interactions between objects where timing is an important concern.	UML 2.0	Chapter 9
Interaction Overview	Used to collect sequence, communication, and timing diagrams together to capture an important interaction that occurs within your system.	UML 2.0	Chapter 10
Composite Structure	The internals of a class or component, and can describe class relationships within a given context.	UML 2.0	Chapter 11
Component	Important components within your system and the interfaces they use to interact with each other.	UML 1.x, but takes on a new meaning in UML 2.0	Chapter 12
Package	The hierarchical organization of groups of classes and components.	UML 2.0	Chapter 13

Table 1-1. To describe the larger landscape of systems design, UML 2.0 renamed and clarified its diagrams for the new challenges facing system modelers today (continued)

Diagram type	What can be modeled?	Originally introduced by UML 1.x or UML 2.0	To learn about this diagram type, go to…
State Machine	The state of an object throughout its lifetime and the events that can change that state.	UML 1.x	Chapter 14
Deployment	How your system is finally deployed in a given real-world situation.	UML 1.x	Chapter 15

Models and Diagrams

Many newcomers to UML focus on the different types of diagrams used to model their system. It's very easy to assume that the set of diagrams that have been created actually *are* the model. This is an easy mistake to make because when you are using UML, you will normally be interacting with a UML tool and a particular set of diagrams. But UML modeling is not just about diagrams; it's about capturing your system as a model—the diagrams are actually just windows into that model.

A particular diagram will show you some parts of your model but not necessarily everything. This makes sense, since you don't want a diagram showing everything in your model all at once—you want to be able to split contents of your model across several diagrams. However, not everything in your model needs to exist on a diagram for it to be a part of your model.

So, what does this mean? Well, the first thing to understand is that your model sits behind your modeling tool and diagrams as a collection of elements. Each of those elements could be a use case, a class, an activity, or any other construct that UML supports. The collection of all the elements that describe your system, including their connections to each other, make up your model.

However, if all you could do was create a model made up of elements, then you wouldn't have much to look at. This is where diagrams come in. Rather than actually being your model, diagrams are used merely as a canvas on which you can create new elements that are then added to your model and organize related elements into a set of views on your underlying model.

So, when you next use your UML tool to work with a set of diagrams in UML notation, it is worth remembering that what you are manipulating is a view of the contents of your model. You can change elements of your model within the diagram, but the diagram itself is *not* the model—it's just a useful way of presenting some small part of the information your model contains.

"Degrees" of UML

UML can be used as much or as little as you like. Martin Fowler describes three common ways that people tend to use UML:

UML as a sketch
: Use UML to make brief sketches to convey key points. These are throwaway sketches—they could be written on a whiteboard or even a beer coaster in a crunch.

UML as a blueprint
: Provide a detailed specification of a system with UML diagrams. These diagrams would not be disposable but would be generated with a UML tool. This approach is generally associated with software systems and usually involves using forward and reverse engineering to keep the model synchronized with the code.

UML as a programming language
: This goes directly from a UML model to executable code (not just portions of the code as with forward engineering), meaning that every aspect of the system is modeled. Theoretically, you can keep your model indefinitely and use transformations and code generation to deploy to different environments.

The approach used depends on the type of application you're building, how rigorously the design will be reviewed, whether you are developing a software system, and, if it is software, the software development process you're using.

In certain industries, such as medical and defense, software projects tend to lean toward UML as a blueprint because a high level of quality is demanded. Software design is heavily reviewed since it could be mission-critical: you don't want your heart monitoring machine to suddenly display the "blue screen of death."

Some projects can get away with less modeling. In fact, some commercial industries find that too much modeling is cumbersome and slows down productivity. For such projects, it makes sense to use UML as a sketch and have your model contain some architectural diagrams and a few class and sequence diagrams to illustrate key points.

UML and the Software Development Process

When you are using UML to model a software system, the "degree of UML" you apply is partially influenced by the software development process you use.

A software development process is a recipe used for constructing software—determining the capabilities it has, how it is constructed, who works on what, and the timeframes for all activities. Processes aim to bring discipline and predictability to