A Brain-Friendly Guide to OOA&D

Head First Object-Oriented Analysis & Design



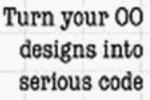
Impress friends with your UML prowess



Bend your mind around dozens of OO exercises



Avoid embarrassing relationship mistakes







Load important OO design principles straight into your brain



See how polymorphism, encapsulation and inheritance helped Jen refactor her love life

Praise for Head First OOA&D

"Head First Object-Oriented Analysis and Design is a refreshing look at the subject of OOA&D. What sets this book apart is its focus on learning. There are too many books on the market that spend a lot of time telling you why, but do not actually enable the practitioner to start work on a project. Those books are very interesting, but not very practical. I strongly believe that the future of software development practice will focus on the practitioner. The authors have made the content of OOA&D accessible and usable for the practitioner."

Ivar Jacobson, Ivar Jacobson Consulting

"I just finished reading HF OOA&D, and I loved it! The book manages to get across the essentials of object-oriented analysis and design with UML and use cases, and even several lectures on good software design, all in a fast-paced, easy to understand way. The thing I liked most about this book was its focus on why we do OOA&D—to write great software! By defining what great software is and showing how each step in the OOA&D process leads you towards that goal, it can teach even the most jaded Java programmer why OOA&D matters. This is a great 'first book' on design for anyone who is new to Java, or even for those who have been Java programmers for a while but have been scared off by the massive tomes on OO Analysis and Design."

Kyle Brown, Distinguished Engineer, IBM

"Finally a book on OOA&D that recognizes that the UML is just a notation and that what matters when developing software is taking the time to think the issues through."

- Pete McBreen, Author, Software Craftsmanship

"The book does a good job of capturing that entertaining, visually oriented, 'Head First' writing style. But hidden behind the funny pictures and crazy fonts is a serious, intelligent, extremely well-crafted presentation of OO Analysis and Design. This book has a strong opinion of how to design programs, and communicates it effectively. I love the way it uses running examples to lead the reader through the various stages of the design process. As I read the book, I felt like I was looking over the shoulder of an expert designer who was explaining to me what issues were important at each step, and why."

Edward Sciore, Associate Professor, Computer Science Department Boston College

"This is a well-designed book that delivers what it promises to its readers: how to analyze, design, and write serious object-oriented software. Its contents flow effortlessly from using use cases for capturing requirements to analysis, design, implementation, testing, and iteration. Every step in the development of object-oriented software is presented in light of sound software engineering principles. The examples are clear and illustrative. This is a solid and refreshing book on object-oriented software development."

 Dung Zung Nguyen, Lecturer Rice University

Praise for other Head First books by the authors

"When arriving home after a 10-hour day at the office programming, who has the energy to plow through yet another new facet of emerging technology? If a developer is going to invest free time in self-driven career development, should it not be at least remotely enjoyable? Judging from the content of O'Reilly's new release Head Rush Ajax, the answer is yes...Head Rush Ajax is a most enjoyable launchpad into the world of Ajax web applications, well worth the investment in time and money."

- Barry Hawkins, Slashdot.org

"By starting with simple concepts and examples, the book gently takes the reader from humble beginnings to (by the end of the book) where the reader should be comfortable creating Ajax-based websites... Probably the best web designer centric book on Ajax."

- Stefan Mischook, Killersites.com

"Using the irreverent style common of the Head First/Head Rush series of books, this book starts at the beginning and introduces you to all you need to know to be able to write the JavaScript that will both send requests to the server and update the page with the results when they are returned...One of the best things about this book (apart form the excellent explanations of how the code works) is that it also looks at security issues...If you learn Ajax from this book you are unlikely to forget much of what you learn."

- Stephen Chapman, JavaScript.About.com

"Head Rush Ajax is the book if you want to cut through all the hype and learn how to make your web apps sparkled...your users will love you for it!"

- Kristin Stromberg, Aguirre International

"If you know some HTML, a dollop of CSS, a little JavaScript, and a bit of PHP, but you're mystified about what all the Ajax hype is about, this book is for you... You'll have a blast learning Ajax with Head Rush Ajax. By the time you've reached the end of the book, all those web technologies that didn't quite fit together in your head will all snap into place and you'll have The Ajax Power! You'll know the secrets behind some of the most popular web applications on the Internet. You'll impress your friends and coworkers with you knowledge of how those interactive maps and web forms really work."

— Elisabeth Freeman, Director, Technology, The Walt Disney Internet Group Co-Author, Head First Design Patterns and Head First HTML with CSS ℰ XHTML

"If you thought Ajax was rocket science, this book is for you. Head Rush Ajax puts dynamic, compelling experiences within reach for every web developer."

— Jesse James Garrett, Adaptive Path

"This stuff is brain candy; I can't get enough of it."

 Pauline McNamara, Center for New Technologies and Education Fribourg University, Switzerland

Praise for other Head First Books

"I *heart* Head First HTML with CSS & XHTML – it teaches you everything you need to learn in a 'fun coated' format!"

- Sally Applin, UI Designer and Fine Artist, http://sally.com.

"My wife stole the book. She's never done any web design, so she needed a book like *Head First HTML* with CSS & XHTML to take her from beginning to end. She now has a list of web sites she wants to build – for our son's class, our family, ... If I'm lucky, I'll get the book back when she's done."

- David Kaminsky, Master Inventor, IBM

"Freeman's Head First HTML with CSS & XHTML is a most entertaining book for learning how to build a great web page. It not only covers everything you need to know about HTML, CSS, and XHTML, it also excels in explaining everything in layman's terms with a lot of great examples. I found the book truly enjoyable to read, and I learned something new!"

> — Newton Lee, Editor-in-Chief, ACM Computers in Entertainment http://www.acmcie.org

From the awesome *Head First Java* folks, this book uses every conceivable trick to help you understand and remember. Not just loads of pictures: pictures of humans, which tend to interest other humans. Surprises everywhere. Stories, because humans love narrative. (Stories about things like pizza and chocolate. Need we say more?) Plus, it's darned funny.

- Bill Camarda, READ ONLY

"This book's admirable clarity, humor and substantial doses of clever make it the sort of book that helps even non-programmers think well about problem-solving."

> — Cory Doctorow, co-editor of Boing Boing Author, "Down and Out in the Magic Kingdom" and "Someone Comes to Town, Someone Leaves Town"

"I feel like a thousand pounds of books have just been lifted off of my head."

 Ward Cunningham, inventor of the Wiki and founder of the Hillside Group

"I literally love this book. In fact, I kissed this book in front of my wife."

- Satish Kumar

Head First Object-Oriented Analysis and Design

by Brett D. McLaughlin, Gary Pollice, and David West

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In other words, if you use anything in *Head First OOA&D* to, say, write code that controls an American space shuttle, you're on your own.

No dogs, rabbits, or woodchucks were harmed in the making of this book, or Todd and Gina's dog door.

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[M]

To all the brilliant people who came up with various ways to gather requirements, analyze software, and design code...

...thanks for coming up with something good enough to produce great software, but hard enough that we needed this book to explain it all. **Brett McLaughlin** is a guitar player who is still struggling with the realization that you can't pay the bills if you're into acoustic fingerstyle blues and jazz. He's just recently discovered, to his delight, that writing books that help people become better programmers does pay the bills. He's very happy about this, as are his wife Leigh, and his kids, Dean and Robbie.

Before Brett wandered into Head First land, he developed enterprise Java applications for Nextel Communications and Allegiance Telecom. When that became fairly mundane, Brett took on application servers, working on the internals of the Lutris Enhydra servlet engine and EJB container. Along the way, Brett got hooked on open source software, and helped found several cool programming tools, like Jakarta Turbine and JDOM. Write to him at brett@oreilly.com.



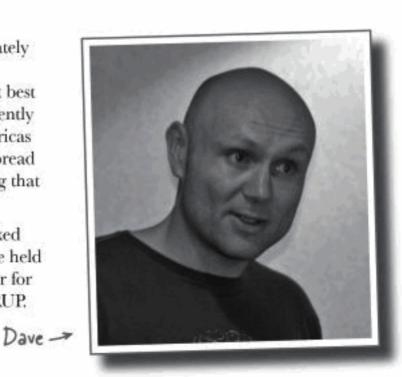


Gary Pollice is a self-labeled curmudgeon (that's a crusty, ill-tempered, usually old man) who spent over 35 years in industry trying to figure out what he wanted to be when he grew up. Even though he hasn't grown up yet, he did make the move in 2003 to the hallowed halls of academia where he has been corrupting the minds of the next generation of software developers with radical ideas like, "develop software for your customer, learn how to work as part of a team, design and code quality and elegance and correctness counts, and it's okay to be a nerd as long as you are a great one."

Gary is a Professor of Practice (meaning he had a real job before becoming a professor) at Worcester Polytechnic Institute. He lives in central Massachusetts with his wife, Vikki, and their two dogs, Aloysius and Ignatius. You can visit his WPI home page at http://web.cs.wpi.edu/~gpollice/. Feel free to drop him a note and complain or cheer about the book.

Dave West would like to describe himself as sheik geek. Unfortunately no one else would describe him in that way. They would say he is a professional Englishman who likes to talk about software development best practices with the passion and energy of an evangelical preacher. Recently Dave has moved to Ivar Jacobson Consulting, where he runs the Americas and can combine his desire to talk about software development and spread the word on rugby and football, and argue that cricket is more exciting that baseball.

Before running the Americas for Ivar Jacobson Consulting, Dave worked for a number of years at Rational Software (now a part of IBM). Dave held many positions at Rational and then IBM, including Product Manager for RUP where he introduced the idea of process plug-ins and agility to RUP. Dave can be contacted at dwest@ivarjacobson.com.



Gary.

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Table of Contents (the real thing)

Intro

Your brain on OOA&D. Here *you* are trying to *learn* something, while here your *brain* is doing you a favor by making sure the learning doesn't *stick*. Your brain's thinking, "Better leave room for more important things, like which wild animals to avoid and whether naked snowboarding is a bad idea." So how *do* you trick your brain into thinking that your life depends on knowing object-oriented analysis and design?

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Well-designed apps rock

1

Great Software Begins Here

So how do you really write great software? It's never easy trying to figure out where to start. Does the application actually do what it's supposed to? And what about things like duplicate code—that can't be good, can it? It's usually pretty hard to know what you should work on first, and still make sure you don't screw everything else up in the process. No worries here, though. By the time you're done with this chapter, you'll know how to write great software, and be well on your way to improving the way you develop applications forever. Finally, you'll understand why OOAD is a four-letter word that your mother actually wants you to know about.

How am I supposed to know where to start?
I feel like every time I get a new project to work on, everyone's got a different opinion about what to do first. Sometimes I get it right, and sometimes I end up reworking the whole app because I started in the wrong place. I just want to write great software! So what should I do first in Rick's app?



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gathering requirements

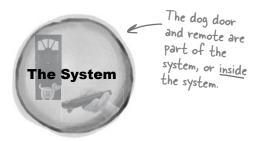
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Give Them What They Want

Everybody loves a satisfied customer. You already know that the first step in writing great software is making sure it does what the customer wants it to. But how do you figure out **what a customer really wants?** And how do you make sure that the customer even *knows* what they really want? That's where **good requirements** come in, and in this chapter, you're going to learn how to **satisfy your customer** by making sure what you deliver is actually what they asked for. By the time you're done, all of your projects will be "satisfaction guaranteed," and you'll be well on your way to writing great software, every time.

Todd a	nd Gina's Pog Poor, version 2.0 Requirements List
1. The	Todd and Gina's Pog Poor, version 2.0 What the Poor Poes
2. A b	1. Fido barks to be let out.
do:	2. Todd or Gina hears Fido barking.
3. On	Todd or Gina presses the button on the remote control.
elc adı	4. The dog door opens.
	5. Fido goes outside.
_	6. Fido does his business.
	7. Fido goes back inside.
4	8. The door shuts automatically.

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requirements change

3

I Love You, You're Perfect... Now Change

Think you've got just what the customer wanted?

Not so fast... So you've talked to your customer, gathered requirements, written out your use cases, and delivered a killer application. It's time for a nice relaxing cocktail, right? Right... until your customer decides that they really wanted something different than what they told you. They love what you've done, really, but it's not quite good enough anymore. In the real world, requirements are always changing, and it's up to you to roll with these changes and keep your customer satisfied.

```
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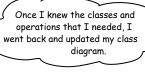
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4

Taking Your Software into the Real World

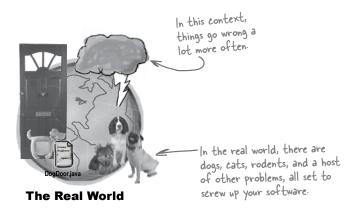
It's time to graduate to real-world applications.

Your application has to do more than work on your own personal development machine, finely tuned and perfectly setup; your apps have to work when **real people use them**. This chapter is all about making sure that your software works in a **real-world context**. You'll learn how **textual analysis** can take that use case you've been working on and turn it into classes and methods that you know are what your customers want. And when you're done, you too can say: "I did it! My software is **ready for the real world!**"





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good design = flexible software

5 (part 1)

Nothing Ever Stays the Same

Change is inevitable. No matter how much you like your software right now, it's probably going to change tomorrow. And the harder you make it for your software to change, the more difficult it's going to be to respond to your customer's changing needs. In this chapter, we're going to revisit an old friend, try and improve an existing software project, and see how small changes can turn into big problems. In fact, we're going to uncover a problem so big that it will take a TWO-PART chapter to solve it!

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5 (interlude)

OO CATASTROPHE!

 Risk Avoidance
 Famous Designers
 Code Constructs
 Maintenance and Reuse
 Software Neuroses

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good design = flexible software

5 (part 2)

Give Your Software a 30-minute Workout

Ever wished you were just a bit more flexible?

When you run into problems making changes to your application, it probably means that your software needs to be **more flexible and resilient**. To help stretch your application out, you're going to do some analysis, a whole lot of design, and learn how OO principles can really **loosen up your application**. And for the grand finale, you'll see how **higher cohesion can really help your coupling**. Sound interesting? Turn the page, and let's get back to fixing that inflexible application.

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This BIG PROBLEM is really just a collection of functionalities, where each piece of functionality is really a smaller problem on its own.

solving really big problems

Small Problem

> Small Problem

> > **Problem**

Small Problem

"My Name is Art Vandelay... I am an Architect"

It's time to build something REALLY BIG. Are you ready?

You've got a ton of tools in your OOA&D toolbox, but how do you use those tools when you have to build something really big? Well, you may not realize it, but you've got everything you need to handle big problems. We'll learn about some new tools, like domain analysis and use case diagrams, but even these new tools are based on things you already know about—like listening to the customer and understanding what you're going to build before you start writing code. Get ready... it's time to start playing the architect.

Small Problem

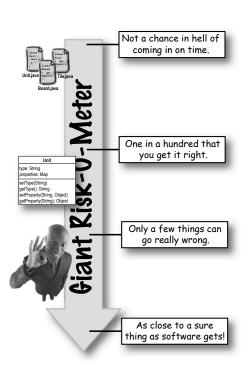
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architecture

7

Bringing Order to Chaos

You have to start somewhere, but you better pick the *right* somewhere! You know how to break your application up into lots of small problems, but all that means is that you have LOTS of small problems. In this chapter, we're going to help you figure out where to start, and make sure that you don't waste any time working on the wrong things. It's time to take all those little pieces laying around your workspace, and figure out how to turn them into a well-ordered, well-designed application. Along the way, you'll learn about the all-important 3 Qs of architecture, and how Risk is a lot more than just a cool war game from the '80s.



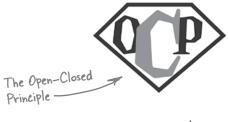
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design principles

8

Originality is Overrated

Imitation is the sincerest form of not being stupid. There's nothing as satisfying as coming up with a completely new and original solution to a problem that's been troubling you for days—until you find out someone else solved the same problem, long before you did, and did an even better job than you did! In this chapter, we're going to look at some design principles that people have come up with over the years, and how they can make you a better programmer. Lay aside your thoughts of "doing it your way"; this chapter is about doing it the smarter, faster way.





The Don't Repeat Yourself Principle



The Single Responsibility Principle



Principle

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iterating and testing

9

The Software is Still for the Customer

It's time to show the customer how much you really care.

Nagging bosses? Worried clients? Stakeholders that keep asking, "Will it be done on time?" No amount of well-designed code will please your customers; you've got to **show them something working**. And now that you've got a solid OO programming toolkit, it's time to learn how you can **prove to the customer** that your software works. In this chapter, we learn about two ways to **dive deeper** into your software's functionality, and give the customer that warm feeling in their chest that makes them say, **Yes**, **you're definitely the right developer for this job!**

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Unit All the properties type: String that were common properties: Map across units are id: int represented as name: String < variables outside of the properties Map weapons: Weapon * 🗢 setType(String) Sam figured that id getType(): String would get set in the Unit setProperty(String, Object) constructor, so no need getProperty(String): Object for a setld() method. getId(): int < setName(String) < getName(): String Each of the new addWeapon(Weapon) < properties gets its getWeapons(): Weapon

the ooa&d lifecycle

10

Putting It All Together

Are we there yet? We've been working on lots of individual ways to improve your software, but now it's time to put it all together. This is it, what you've been waiting for: we're going to take everything you've been learning, and show you how it's all really part of a single process that you can use over and over again to write great software.

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appendix i: leftovers

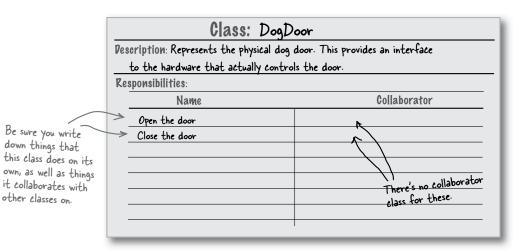
i

The Top Ten Topics (we didn't cover)

Believe it or not, there's still more. Yes, with over 550 pages under your belt, there are still things we couldn't cram in. Even though these last ten topics don't deserve more than a mention, we didn't want to let you out of Objectville without a little more information on each one of them. But hey, now you've got just a little bit more to talk about during commercials of CATASTROPHE... and who doesn't love some stimulating OOA&D talk every now and then?

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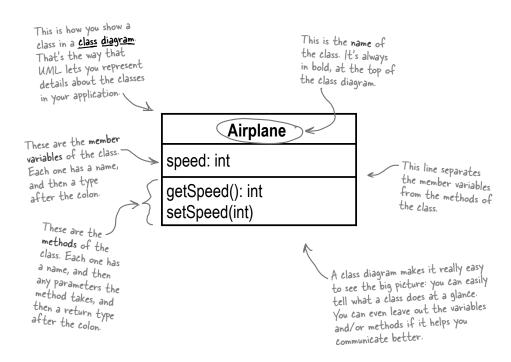
appendix ii: welcome to objectville



Speaking the Language of 00

Get ready to take a trip to a foreign country. It's time to visit Objectville, a land where objects do just what they're supposed to, applications are all well-encapsulated (you'll find out exactly what that means shortly), and designs are easy to reuse and extend. But before we can get going, there are a few things you need to know first, and a little bit of language skills you're going to have to learn. Don't worry, though, it won't take long, and before you know it, you'll be speaking the language of OO like you've been living in the well-designed areas of Objectville for years.

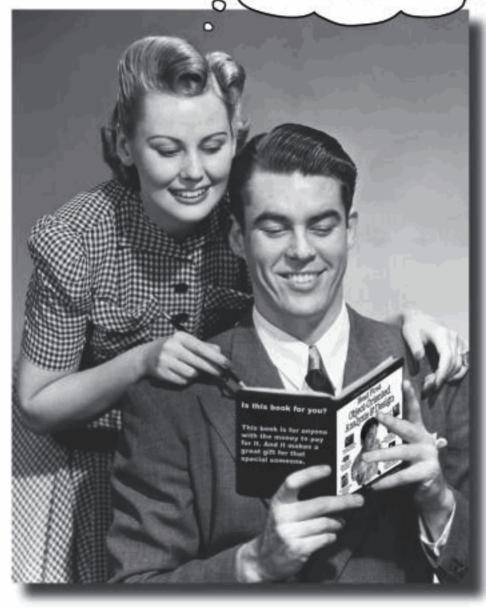
UML and class diagrams	577
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how to use this book

Intro

I can't believe they put *that* in an objectoriented analysis and design book!



In this section, we answer the burning question: "So why DID they put that in an OOA D book?"

Who is this book for?

If you can answer "yes" to all of these:

Do you know Java? (You don't need to be a guru.)

You'll probably be okay if
you know C# instead.

- Do you want to learn, understand, remember, and apply object-oriented analysis and design to real world projects, and write better software in the process?
- 3 Do you prefer stimulating dinner party conversation to dry, dull, academic lectures?

this book is for you.

Who should probably back away from this book?

If you can answer "yes" to any one of these:

- Are you completely new to Java? (You don't need to be advanced, and even if you don't know Java, but you know C#, you'll probably understand almost all of the code examples. You also might be okay with just a C++ background.)
- Are you a kick-butt OO designer/developer looking for a reference book?
- Are you afraid to try something different? Would you rather have a root canal than mix stripes with plaid? Do you believe that a technical book can't be serious if programming concepts are anthropomorphized?

this book is not for you.

Enote from marketing: this book is for anyone with a credit card. I

We know what you're thinking.

"How can this be a serious programming book?"

"What's with all the graphics?"

"Can I actually learn it this way?"

And we know what your brain is thinking.

Your brain craves novelty. It's always searching, scanning, waiting for something unusual. It was built that way, and it helps you stay alive.

So what does your brain do with all the routine, ordinary, normal things you encounter? Everything it can to stop them from interfering with the brain's real job—recording things that matter. It doesn't bother saving the boring things; they never make it past the "this is obviously not important" filter.

How does your brain know what's important? Suppose you're out for a day hike and a tiger jumps in front of you, what happens inside your head and body?

Neurons fire. Emotions crank up. Chemicals surge.

And that's how your brain knows...

This must be important! Don't forget it!

But imagine you're at home, or in a library. It's a safe, warm, tiger-free zone. You're studying. Getting ready for an exam. Or trying to learn some tough technical topic your boss thinks will take a week, ten days at the most.

Just one problem. Your brain's trying to do you a big favor. It's trying to make sure that this obviously non-important content doesn't clutter up scarce resources. Resources that are better spent storing the really big things. Like tigers. Like the danger of fire. Like how you should never again snowboard in shorts.

And there's no simple way to tell your brain, "Hey brain, thank you very much, but no matter how dull this book is, and how little I'm registering on the emotional Richter scale right now, I really do want you to keep this stuff around."



THIS isn't worth

saving

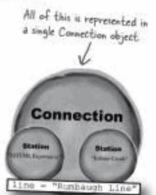
Great. Only 637 more dull. dry, boring pages.

We think of a "Head First" reader as a learner.

So what does it take to learn something? First, you have to get it, then make sure you don't forget it. It's not about pushing facts into your head. Based on the latest research in cognitive science, neurobiology, and educational psychology, learning takes a lot more than text on a page. We know what turns your brain on.

Some of the Head First learning principles:

Make it visual. Images are far more memorable than words alone, and make learning much more effective (up to 89% improvement in recall and transfer studies). It also makes things more understandable. Put the words within or near the graphics they relate to, rather than on the bottom or on another page, and learners will be up to twice as likely to solve problems related to the content.



Use a conversational and personalized style. In recent studies,

students performed up to 40% better on post-learning tests if the content spoke directly to the reader, using a first-person, conversational style rather than taking a formal tone. Tell stories instead of lecturing. Use casual language. Don't take yourself too seriously. Which would you pay more attention to: a stimulating dinner party companion, or a lecture?

Get the learner to think more deeply. In other words, unless you actively flex your neurons, nothing much happens in your head. A reader has to be motivated, engaged, curious, and inspired to solve problems, draw conclusions, and generate new knowledge. And for that, you need challenges, exercises, and thought-provoking questions, and activities that involve

both sides of the brain, and multiple senses.

abstract void roam(); No method body! End it with a semicolon

It really sucks to be an

abstract method. You don't have a body.

> Get-and keep-the reader's attention. We've all had the "I really want to learn this but I can't stay awake past page one" experience. Your brain pays attention to things that are out of the ordinary, interesting, strange, eye-catching, unexpected.

Learning a new, tough, technical topic doesn't have to be boring. Your brain will learn much more quickly if it's not.

Touch their emotions. We now know that your ability to remember something is largely dependent on its emotional content. You remember what you care about. You remember when you feel something. No, we're not talking heart-wrenching stories about a boy and his dog. We're talking emotions like surprise, curiosity, fun, "what the...?", and the feeling of "I Rule!" that comes when you solve a puzzle, learn something everybody else thinks is hard, or realize you know something that "I'm more technical than thou" Bob from engineering doesn't.

Great software every time? I can hardly imagine what that would be like!



Metacognition: thinking about thinking

If you really want to learn, and you want to learn more quickly and more deeply, pay attention to how you pay attention. Think about how you think. Learn how you learn.

Most of us did not take courses on metacognition or learning theory when we were growing up. We were expected to learn, but rarely taught to learn.

But we assume that if you're holding this book, you really want to learn objectoriented analysis and design. And you probably don't want to spend a lot of time. And since you're going to develop software, you need to remember what you read. And for that, you've got to understand it. To get the most from this book, or any book or learning experience, take responsibility for your brain. Your brain on this content.

The trick is to get your brain to see the new material you're learning as Really Important. Crucial to your well-being. As important as a tiger. Otherwise, you're in for a constant battle, with your brain doing its best to keep the new content from sticking.

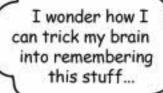
So just how DO you get your brain to think objectoriented analysis and design is a hungry tiger?

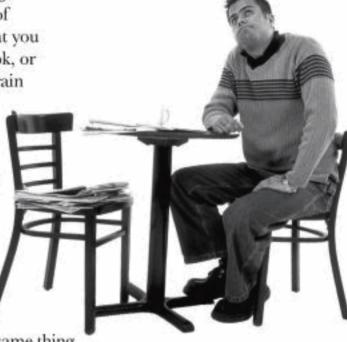
There's the slow, tedious way, or the faster, more effective way. The slow way is about sheer repetition. You obviously know that you are able to learn and remember even the dullest of topics if you keep pounding the same thing into your brain. With enough repetition, your brain says, "This doesn't feel important to him, but he keeps looking at the same thing over and over, so I suppose it must be."

The faster way is to do **anything that increases brain activity**, especially different types of brain activity. The things on the previous page are a big part of the solution, and they're all things that have been proven to help your brain work in your favor. For example, studies show that putting words within the pictures they describe (as opposed to somewhere else in the page, like a caption or in the body text) causes your brain to try to makes sense of how the words and picture relate, and this causes more neurons to fire. More neurons firing = more chances for your brain to get that this is something worth paying attention to, and possibly recording.

A conversational style helps because people tend to pay more attention when they perceive that they're in a conversation, since they're expected to follow along and hold up their end. The amazing thing is, your brain doesn't necessarily care that the "conversation" is between you and a book! On the other hand, if the writing style is formal and dry, your brain perceives it the same way you experience being lectured to while sitting in a roomful of passive attendees. No need to stay awake.

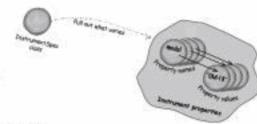
But pictures and conversational style are just the beginning.





Here's what WE did:

We used **pictures**, because your brain is tuned for visuals, not text. As far as your brain's concerned, a picture really is worth 1,024 words. And when text and pictures work together, we embedded the text in the pictures because your brain works more effectively when the text is within the thing the text refers to, as opposed to in a caption or buried in the text somewhere.



We used **redundancy**, saying the same thing in *different* ways and with different media types, and *multiple senses*, to increase the chance that the content gets coded into more than one area of your brain.

We used concepts and pictures in **unexpected** ways because your brain is tuned for novelty, and we used pictures and ideas with at least *some* **emotional** *content*, because your brain is tuned to pay attention to the biochemistry of emotions. That which causes you to *feel* something is more likely to be remembered, even if that feeling is nothing more than a little **humor**, **surprise**, or **interest**.



We used a personalized, **conversational style**, because your brain is tuned to pay more attention when it believes you're in a conversation than if it thinks you're passively listening to a presentation. Your brain does this even when you're *reading*.

We included more than 80 **activities**, because your brain is tuned to learn and remember more when you **do** things than when you *read* about things. And we made the exercises challenging-yet-do-able, because that's what most people prefer.

We used **multiple learning styles**, because you might prefer step-by-step procedures, while someone else wants to understand the big picture first, and someone else just wants to see a code example. But regardless of your own learning preference, everyone benefits from seeing the same content represented in multiple ways.



We include content for **both sides of your brain**, because the more of your brain you engage, the more likely you are to learn and remember, and the longer you can stay focused. Since working one side of the brain often means giving the other side a chance to rest, you can be more productive at learning for a longer period of time.

And we included **stories** and exercises that present **more than one point of view**, because your brain is tuned to learn more deeply when it's forced to make evaluations and judgements.

We included **challenges**, with exercises, and by asking **questions** that don't always have a straight answer, because your brain is tuned to learn and remember when it has to work at something. Think about it—you can't get your body in shape just by watching people at the gym. But we did our best to make sure that when you're working hard, it's on the right things. That **you're not spending one extra dendrite** processing a hard-to-understand example, or parsing difficult, jargon-laden, or overly terse text.

We used **people**. In stories, examples, pictures, etc., because, well, because you're a person. And your brain pays more attention to people than it does to things.

We used an 80/20 approach. We assume that if you're going for a PhD in software design, this won't be your only book. So we don't talk about everything. Just the stuff you'll actually need.







Here's what YOU can do to bend your brain into submission

So, we did our part. The rest is up to you. These tips are a starting point; listen to your brain and figure out what works for you and what doesn't. Try new things.

Cut this out and stick it on your refrigerator.

Slow down. The more you understand, the less you have to memorize.

Don't just read. Stop and think. When the book asks you a question, don't just skip to the answer. Imagine that someone really is asking the question. The more deeply you force your brain to think, the better chance you have of learning and remembering.

2 Do the exercises. Write your own notes.

We put them in, but if we did them for you, that would be like having someone else do your workouts for you. And don't just look at the exercises. **Use a pencil.** There's plenty of evidence that physical activity while learning can increase the learning.

Read the "There are No Dumb Questions"

That means all of them. They're not optional side-bars—they're part of the core content!

Don't skip them.

Make this the last thing you read before bed. Or at least the last challenging thing.

Part of the learning (especially the transfer to long-term memory) happens after you put the book down. Your brain needs time on its own, to do more processing. If you put in something new during that processing time, some of what you just learned will be lost.

6 Drink water. Lots of it.

Your brain works best in a nice bath of fluid. Dehydration (which can happen before you ever feel thirsty) decreases cognitive function.

(6) Talk about it. Out loud.

Speaking activates a different part of the brain. If you're trying to understand something, or increase your chance of remembering it later, say it out loud. Better still, try to explain it out loud to someone else. You'll learn more quickly, and you might uncover ideas you hadn't known were there when you were reading about it.

(7) Listen to your brain.

Pay attention to whether your brain is getting overloaded. If you find yourself starting to skim the surface or forget what you just read, it's time for a break. Once you go past a certain point, you won't learn faster by trying to shove more in, and you might even hurt the process.

8 Feel something!

Your brain needs to know that this matters. Get involved with the stories. Make up your own captions for the photos. Groaning over a bad joke is still better than feeling nothing at all.

Design something!

Apply what you read to something new you're designing, or rework an older project. Just do something to get some experience beyond the exercises and activities in this book. All you need is a problem to solve... a problem that might benefit from one or more techniques that we talk about.

Read Me

This is a learning experience, not a reference book. We deliberately stripped out everything that might get in the way of learning whatever it is we're working on at that point in the book. And the first time through, you need to begin at the beginning, because the book makes assumptions about what you've already seen and learned.

We assume you are familiar with Java.

It would take an entire book to teach you Java (in fact, that's exactly what it took: *Head First Java*). We chose to focus this book on analysis and design, so the chapters are written with the assumption that you know the basics of Java. When intermediate or advanced concepts come up, they're taught as if they might be totally new to you, though.

If you're completely new to Java, or coming to this book from a C# or C++ background, we strongly recommend you turn to the back of the book and read Appendix II before going on. That appendix has some intro material that will help you start this book off on the right foot.

We only use Java 5 when we have to.

Java 5.0 introduces a lot of new features to the Java language, ranging from generics to paramaterized types to enumerated types to the **foreach** looping construct. Since many professional programmers are just moving to Java 5, we didn't want you getting hung up on new syntax while you're trying to learn about OOA&D. In most cases, we stuck with pre-Java 5 syntax. The only exception is in Chapter 1, when we needed an enumerated type—and we explained enums in that section in some detail.

If you're new to Java 5, you should have no trouble with any of the code examples. If you're already comfortable with Java 5, then you will get a few compiler warnings about unchecked and unsafe operations, due to our lack of typed collections, but you should be able to update the code for Java 5 on your own quite easily.

The activities are NOT optional.

The exercises and activities are not add-ons; they're part of the core content of the book. Some of them are to help with memory, some are for understanding, and some will help you apply what you've learned. **Don't skip the exercises**. The crossword puzzles are the only things you don't have to do, but they're good for giving your brain a chance to think about the words and terms you've been learning in a different context.

The redundancy is intentional and important.

One distinct difference in a Head First book is that we want you to really get it. And we want you to finish the book remembering what you've learned. Most reference books don't have retention and recall as a goal, but this book is about learning, so you'll see some of the same concepts come up more than once.

The examples are as lean as possible.

Our readers tell us that it's frustrating to wade through 200 lines of an example looking for the two lines they need to understand. Most examples in this book are shown within the smallest possible context, so that the part you're trying to learn is clear and simple. Don't expect all of the examples to be robust, or even complete—they are written specifically for learning, and aren't always fully-functional.

In some cases, we haven't included all of the import statements needed, but we assume that if you're a Java programmer, you know that **ArrayList** is in **java.util**, for example. If the imports are not part of the normal core J2SE API, we mention it. We've also placed all the source code on the web so you can download it. You'll find it at http://www.headfirstlabs.com/books/hfoo/.

Also, for the sake of focusing on the learning side of the code, we did not put our classes into packages (in other words, they're all in the Java default package). We don't recommend this in the real world, and when you download the code examples from this book, you'll find that all classes are in packages.

The 'Brain Power' exercises don't have answers.

For some of them, there is no right answer, and for others, part of the learning experience of the Brain Power activities is for you to decide if and when your answers are right. In some of the Brain Power exercises you will find hints to point you in the right direction.

The Technical Team

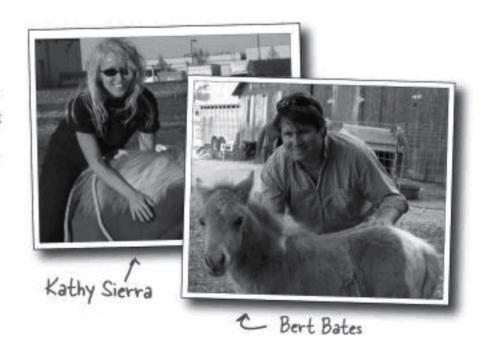


Huge thanks to our amazing trio of technical reviewers. These guys caught mistakes that we missed, let us know when we were moving too fast (or too slow), and even let us know when our jokes sucked. Several times, they turned chapters around in a matter of hours... we're not sure if that means they're really helpful, or need to get away from software development a little more. **Hannibal** in particular made our week when he let us know that the big OOA&D arrow in Chapter 10 was "Hot!" Thanks guys, this book wouldn't be nearly as solid without your hard work.

Kathy Sierra and Bert Bates:

We continue to be amazed at the insight and expertise that **Bert Bates** has about cliffs, and that **Kathy Sierra** has about dog doors. If that doesn't make much sense, don't be surprised—everything you know about almost everything gets turned on its head when you meet this pair, and yet we all came out much for the better because of their help.

Bert and Kathy did a ton of review at the eleventh hour, and we're thankful they did. Their help and guidance continues to be the heart of Head First.



Acknowledgements

My co-authors:

Because I'm doing the typing, I get to step out of "we" mode for a moment and say thanks to my co-authors, **Dave West** and **Gary Pollice**. Neither of these guys knew what they were signing up for when they came on board, but I've never been so impressed by a couple of guys willing to explain, defend, and even change their opinions and knowledge about software design, requirements and analysis, and lift shafts. They were simply incredible, writing up until the very last day, and even got me to relax and laugh until I cried on several occasions.

Our editor:



This book wouldn't be in your hands if not for **Mary O'Brien**. I think it's fair to say she fought more battles and paved the way for us to work without interruption more times than any of us really are aware of. Most importantly, she made this the single most enjoyable project we've worked on in our careers. Frankly, she kicked our asses a number of times, and it made all the difference. She really doesn't realize how much of an effect she has on the people she works with, because we don't tell her enough how much we respect her and value her opinions. So there, now you know, Mary. If we could put your name on the cover, we would (oh, wait... we did!).

Mary O'Brien

The O'Reilly team:

These books are a team effort, never more so than on this one. **Mike Hendrickson** and **Laurie Petrycki** oversaw this project at various times, and took heated phone calls more than once. **Sanders Kleinfeld** cut his Head First teeth on this project, and managed to come out alive; better yet, he did a great job, improving the book, and we all are excited that this is just the first of many Head First books he'll be working on. **Mike Loukides** found Bert and Kathy way back when, and **Tim O'Reilly** had the foresight to turn their crazy idea into a series. As always, **Kyle Hart** is instrumental in getting these books "out there", and **Edie Freedman**'s beautiful cover design continues to amaze us all.

A particularly special thanks goes out to **Louise Barr**, the Head First Design Editor. Lou pulled several 12- and 14-hour days to help us with graphics in this book, and put together the amazing Objectville Subway Map in Chapter 10. Lou, your work has improved the learning quality of this book, and we can't thank you enough for your contributions.

>

Special thanks

Near the completion of this book, **Laura Baldwin**, the CFO of O'Reilly, encountered some personal tragedy. It's hard to know what to say in these situations, especially because Laura has really become the backbone of O'Reilly in many ways. Laura, we are thinking and praying for you and your family, and we wish you all the very, very best in the days to come. We know you'd want nothing more than to see everyone at O'Reilly working harder than ever while you're away.

This book is certainly a testament to the people at O'Reilly continuing to deliver, and in many of our conversations, your name came up as someone we wanted to support, and not let down in any way. Your effect on this company is extraordinary, and O'Reilly and the Head First series will all be much better for the day you can return to us in full swing.

1 well-designed apps rock

Great Software Can hardly get over it, Begins Here

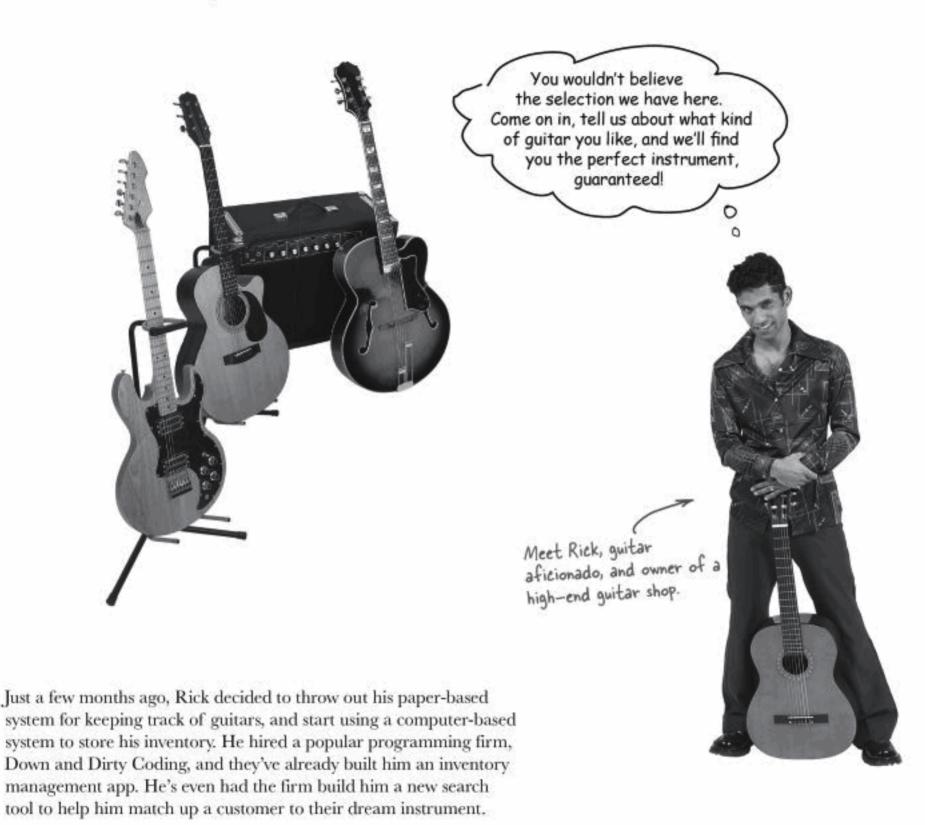
I can hardly get over it,
Sue, but since I started using
OOA&D, I'm just a new man... a
new man, I'll tell you!



So how do you really write great software? It's never easy trying to figure out where to start. Does the application actually do what it's supposed to? And what about things like duplicate code—that can't be good, can it? It's usually pretty hard to know what you should work on first, and still make sure you don't screw everything else up in the process. No worries here, though. By the time you're done with this chapter, you'll know how to write great software, and be well on your way to improving the way you develop applications forever. Finally, you'll understand why OOA&D is a four-letter word that your mother actually wants you to know about.

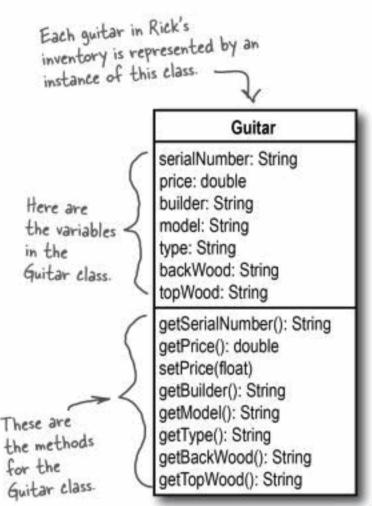
Rock and roll is forever!

There's nothing better than the sound of a killer guitar in the hands of a great player, and Rick's Guitars specializes in finding the perfect instrument for his discerning customers.



Rick's shiny new application...

Here's the application that the programming firm built for Rick... they've put together a system to completely replace all of Rick's handwritten notes, and help him match his customers with the perfect guitar. Here's the UML class diagram they gave Rick to show him what they did:



Here's Rick's entire inventory, as well as a way for him to The inventory stores a list search for guitars. of all the guitars that Rick currently has available. Inventory quitars: List addGuitar(String, double, String, String, String, String, String) getGuitar(String): Guitar This method search(Guitar): Guitar takes in all of a guitar's details, creates This method This is the search method; a Guitar object, takes a guitar's it takes in a client's and adds it to serial number, ideal guitar, and returns Rick's inventory. and returns that a guitar from Rick's guitar's object inventory that matches up with the client's specs.

Rick decided these are the defining characters of a guitar: the serial number, how much it costs, the builder and model, what type it is (acoustic or electric), and what woods are used in the guitar.

We've got some treats for you in Appendix II. Check it out before going on if you're new to UML or OO programming.

New to Objectville?

If you're new to object oriented programming, haven't heard of UML before, or aren't sure about the diagram above, it's OK! We've prepared a special "Welcome to Objectville" care package for you to get you started. Flip to the back of the book, and read Appendix II—we promise you'll be glad you did. Then come back here, and this will all make a lot more sense.

Here what the code for Guitar.java looks like

You've seen the class diagram for Rick's application on the last page; now let's look at what the actual code for **Guitar.java** and **Inventory.java** look like.

```
properties we saw from
                                                               the class diagram for
                                                               the Guitar class.
public class Guitar {
  private String serialNumber, builder, model, type, backWood, topWood;
  private double price;
  public Guitar (String serial Number, double price,
                   String builder, String model, String type,
                   String backWood, String topWood) {
    this.serialNumber = serialNumber;
    this.price = price;
    this.builder = builder;
                                                           UML class diagrams don't
    this.model = model;
                                                            show constructors; the Guitar
    this.type = type;
                                                            constructor does just what you'd
    this.backWood = backWood;
                                                            expect, though: sets all the initial
    this.topWood = topWood;
                                                            properties for a new Guitar.
  public String getSerialNumber() {
    return serial Number;
  public double getPrice() {
                                                                         Guitar
    return price;
                                                                 serialNumber: String
  public void setPrice(float newPrice) (
                                                                 price: double
    this.price = newPrice;
                                                                 builder: String
                                                                 model: String
  public String getBuilder() {
                                          You can see how
    return builder;
                                                                 type: String
                                          the class diagram
                                                                 backWood: String
                                           matches up with
  public String getModel() {
                                                                 topWood: String
                                          the methods in the
    return model;
                                          Guitar class's code.
                                                                 getSerialNumber(): String
  public String getType() {
                                                                 getPrice(): double
    return type;
                                                                 setPrice(float)
                                                                 getBuilder(): String
  public String getBackWood() {
                                                                 getModel(): String
    return backWood;
                                                                 getType(): String
  public String getTopWood() {
                                                                 getBackWood(): Str
    return topWood;
                                                                 getTopWood(): Strin
  1
```

These are all the

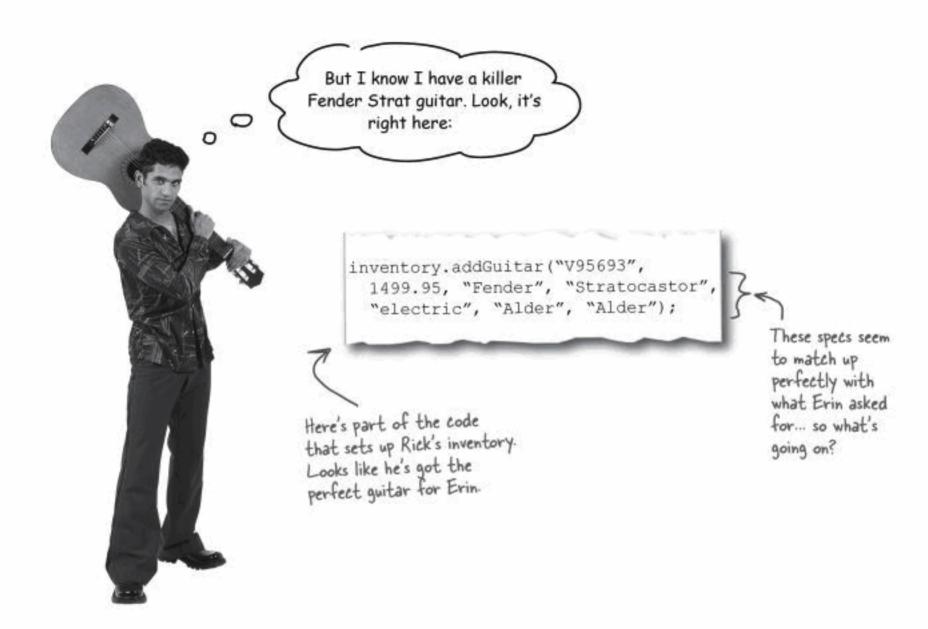
And Inventory.java...

```
Remember, we've stripped
                                       out the import statements
public class Inventory {
  private List guitars;
                                       to save some space.
  public Inventory() {
    quitars = new LinkedList();
  public void addGuitar(String serialNumber, double price,
                         String builder, String model,
                         String type, String backWood, String topWood) {
    Guitar guitar = new Guitar(serialNumber, price, builder,
                                                                          addGuitar() takes in all
                                 model, type, backWood, topWood);
                                                                         the properties required
    guitars.add(guitar);
                                                                         to create a new Guitar
                                                                         instance, creates one, and
  public Guitar getGuitar (String serialNumber) {
    for (Iterator i = guitars.iterator(); i.hasNext(); ) {
                                                                         adds it to the inventory.
      Guitar guitar = (Guitar)i.next();
      if (quitar.qetSerialNumber().equals(serialNumber)) {
        return guitar;
    return null;
                                                                  This method is a bit of a mess...
  public Guitar search (Guitar search Guitar) {
                                                                  it compares each property of the
    for (Iterator i = quitars.iterator(); i.hasNext(); ) {
                                                                  Guitar object it's passed in to each
      Guitar guitar = (Guitar)i.next();
                                                                  Guitar object in Rick's inventory.
      // Ignore serial number since that's unique
      // Ignore price since that's unique
      String builder = searchGuitar.getBuilder();
      if ((builder != null) && (!builder.equals("")) &&
          (!builder.equals(guitar.getBuilder())))
        continue;
      String model = searchGuitar.getModel();
      if ((model != null) && (!model.equals("")) &&
           (!model.equals(guitar.getModel())))
      String type = searchGuitar.getType();
      if ((type != null) && (!searchGuitar.equals("")) &&
           (!type.equals(guitar.getType())))
        continue;
      String backWood = searchGuitar.getBackWood();
                                                                             Inventory
      if ((backWood != null) && (!backWood.equals("")) &&
                                                               guitars: List
           (!backWood.equals(guitar.getBackWood())))
        continue;
                                                               addGuitar(String, double, String, String, String,
      String topWood = searchGuitar.getTopWood();
                                                                       String, String)
      if ((topWood != null) && (!topWood.equals("")) &&
                                                               getGuitar(String): Guitar
           (!topWood.equals(guitar.getTopWood())))
                                                               search(Guitar): Guitar
        continue;
    return null;
                                                                                         Inventory.java
```

But then Rick started losing customers...

It seems like no matter who the customer is and what they like, Rick's new search program almost always comes up empty when it looks for good guitar matches. But Rick knows he has guitars that these customers would like... so what's going on? FindGuitarTester.java simulates a typical day for Rick now... a customer comes in, tells him what they like, and he runs a search on his inventory.

```
public class FindGuitarTester (
  public static void main(String[] args) {
    // Set up Rick's guitar inventory
    Inventory inventory = new Inventory();
    initializeInventory(inventory);
    Guitar whatErinLikes = new Guitar("", 0, "fender", "Stratocastor",
                                         "electric", "Alder", "Alder");
    Guitar guitar = inventory.search(whatErinLikes);
    if (guitar != null) {
                                                                   Erin is looking
      System.out.println("Erin, you might like this " +
                                                                   for an Fender
        guitar.getBuilder() + " " + guitar.getModel() + " "
                                                                  "Strat" quitar,
        guitar.getType() + " guitar:\n
                                                                   made of Alder.
        quitar.getBackWood() + " back and sides, \n
        guitar.getTopWood() + " top.\nYou can have it for only $" +
        guitar.getPrice() + "!");
      System.out.println("Sorry, Erin, we have nothing for you.");
  private static void initializeInventory(Inventory inventory) {
    // Add guitars to the inventory...
                                                              FindGuitarTester.java
                                                              I'm sorry, Rick, I guess I'll
     File Edit Window Help C7#5
                                                               just go to that other store
     %java FindGuitarTester
                                                                    across town.
     Sorry, Erin, we have nothing for you.
             Here's what happens when Erin
             comes into Rick's store, and Rick
             tries to find her a guitar.
```



Sharpen your pencil

How would you redesign Rick's app?

Look over the last three pages, showing the code for Rick's app, and the results of running a search. What problems do you see? What would you change? Write down the FIRST thing you'd do to improve Rick's app in the blanks before.

0

What's the FIRST thing you'd change?

It's obvious that Rick's app has problems, but it's not so obvious what we should work on first. And it looks like there's no shortage of opinion:

> Look at all those Strings! That's terrible... can't we use constants or objects instead?

Whoa... these notes from the owner says he wants his clients to have multiple choices. Shouldn't the search() method return a list of matches?

0



Guitar

serialNumber: String price: double builder: String model: String type: String backWood: String topWood: String

getPrice(): double setPrice(float) getBuilder(): String getModel(): String getType(): String getBackWood(): String getTopWood(): String

getSerialNumber(): String

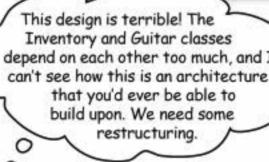
Inventory

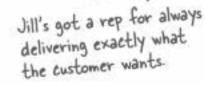
quitars: List

addGuitar(String, double, String, String, St

String, String) getGuitar(String): Guitar search(Guitar): Guitar

This design is terrible! The Inventory and Guitar classes depend on each other too much, and I can't see how this is an architecture that you'd ever be able to build upon. We need some restructuring.





Joe's fairly new to programming, but he's a big believer in writing objectoriented code.

Frank's been around for a while and really knows his 00 principles and design patterns.



What would you do first?

How am I supposed to know where to start? I feel like every time I get a new project to work on, everyone's got a different opinion about what to do first. Sometimes I get it right, and sometimes I end up reworking the whole app because I started in the wrong place. I just want to write great software!

So what should I do first in Rick's app?



How do you write great software, <u>every</u> time? Wait a second... I hate
to butt in, but what does "great
software" mean? That's sort of a
vague term to be throwing around,
isn't it?

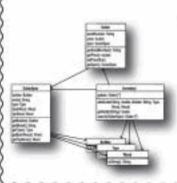


Good question... and there are lots of different answers:

The customer-friendly programmer says:

"Great software always does what the customer wants it to. So even if customers think of new ways to use the software, it doesn't break or give them unexpected results."



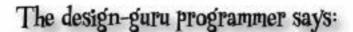


The object-oriented programmer says:

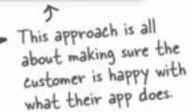
"Great software is code that is object-oriented. So there's not a bunch of duplicate code, and each object pretty much controls its own behavior. It's also easy to extend because your design is really solid and flexible."

Good OO programmers are always looking for ways to make their code more flexible.

Not sure about what all—that means? It's OK... you'll learn about all these things in the upcoming chapters.



"Great software is when you use tried-and-true design patterns and principles. You've kept your objects loosely coupled, and your code open for extension but closed for modification. That also helps make the code more reusable, so you don't have to rework everything to use parts of your application over and over again."



This design—focused approach optimizes code for extension and reuse, and takes advantages of design patterns and proven 00 techniques.





What do you think "great software" means?

You've seen what several different types of programmers think great software is... so who is right? Or do you have your own definition of what makes an application great? It's your turn to write down what you think makes for great software:

ite your name here	·····	and write what you think of software means here.
	says:	
"		
		
» .		
10		

Great software is... more than just one thing

It's going to take more than just a simple definition to figure out exactly what "great software" means. In fact, all of the different programmers on page 10 talked about a part of what makes software great.

First, great software must satisfy the customer. The software must do what the customer wants it to do.



Win your customers over

Customers will think your software is great when it does what it's supposed to do.

Building software that works right is great, but what about when it's time to add to your code, or reuse it in another application? It's not enough to just have software that works like the customer wants it to; your software better be able to stand the test of time.

Second, great software is well-designed, well-coded, and easy to maintain, reuse, and extend.



Make your code as smart as you are.

You (and your co-workers) will think your software is great when it's easy to maintain, reuse, and extend. Wow, if my code could do all that, then it really would be great software! I even think I see how you could turn this into a few simple steps that work on every project.



<u>Great</u> software in <u>3 easy steps</u>

1. Make sure your software does what the customer wants it to do.

It may not seem easy now, but we'll show you how OOAFD and some basic principles can change your software forever.

This step focuses on the customer.

Make sure the app does what it's supposed to do FIRST. This is where getting good requirements and doing some analysis comes in.

2. Apply basic 00 principles to add flexibility.

Once your software works, you can look for any duplicate code that might have slipped in, and make sure you're using good OO programming techniques.

Strive for a
 maintainable,
 reusable design.

Got a good object-oriented app that does what it should? It's time to apply patterns and principles to make sure your software is ready to use for years to come.

Remember Rick? Remember his lost customers?

Let's put our ideas about how to write great software to the test and see if they hold up in the real world. Rick's got a search tool that isn't working, and it's your job to fix the application, and turn it into something great. Let's look back at the app and see what's going on:

```
Here's our
test program
that reveals
              public class FindGuitarTester (
a problem
                                                                          Rick's app should
with the
                public static void main (String[] args) {
                                                                          match Erin's
search tool.
                  // Set up Rick's guitar inventory
                                                                          preferences here ...
                  Inventory inventory = new Inventory();
                                                                                                 ...to this
                  initializeInventory(inventory);
                                                                                                 auitar
                                                                                                 in Rick's
                  Guitar whatErinLikes = new Guitar ("", 0, "fender", "Stratocastor",
                                                                                                 inventory.
                                                        "electric", "Alder", "Alder");
                  Guitar guitar = inventory.search(whatErinLikes);
                  if (quitar != null)
                                                                    inventory.addGuitar("V95693",
                                                                      1499.95, "Fender", "Stratocastor",
   FindGuitarTester.java
                                                                      "electric", "Alder", "Alder");
```

So let's apply our 3 steps:

Remember, we need to start out by making sure the app actually does what Rick wants... and it's definitely not doing that right now.

J. Make sure your software does what the customer wants it to do.

2. Apply basic

00 principles to

add flexibility.

3. Strive for a

maintainable,

reusable design.

Don't worry too much about
trying to apply patterns or
other 00 techniques to your app
at this point... just get it to
where it's working like it should.

If we're starting with functionality,
let's figure out what's going on with that
broken search() method. It looks like in Rick's
inventory, he's got "fender", all lowercase,
and the customer's specs have "Fender" with
a capital "F". We just need to do a caseinsensitive string comparison in the
search() method.

Let's get a little help from some of our programmer buddies

Frank: Sure, that would fix the problem Rick's having now, but I think there's probably a better way to make this work than just calling toLowerCase() on a bunch of strings all over the place.

Joe: Yeah, I was thinking the same thing. I mean, all that string comparison seems like a bad idea. Couldn't we use constants or maybe some enumerated types for the builders and woods?

Jill: You guys are thinking way too far ahead. Step 1 was supposed to be fixing the app so it does what the customer wants it to do. I thought we weren't supposed to worry about design yet.

Frank: Well, yeah, I get that we're supposed to focus on the customer. But we can at least be smart about *how* we fix things, right? I mean, why create problems we'll have to come back and fix later on if we can avoid them from the start?

Jill: Hmmm... I guess that does make sense. We don't want our solution to this problem creating new design problems for us down the road. But we're still not going to mess with the other parts of the application, right?

Frank: Right. We can just remove all those strings, and the string comparisons, to avoid this whole case-matching thing.

Joe: Exactly. If we go with enumerated types, we can ensure that only valid values for the builder, woods, and type of guitar are accepted. That'll make sure that Rick's clients actually get to look at guitars that match their preferences.

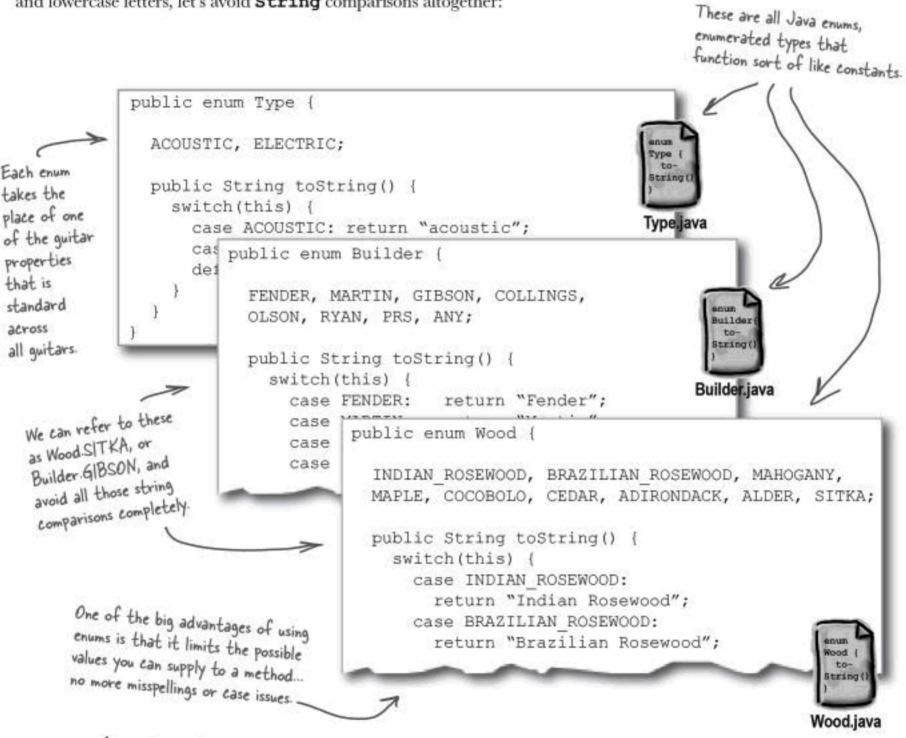
Jill: And we've actually done a little bit of design at the same time... very cool! Let's put this into action.



Don't <u>create</u> problems to <u>solve</u> problems.

Pitching String comparisons

The first improvement we can make to Rick's guitar search tool is getting rid of all those annoying **String** comparisons. And even though you could use a function like **toLowerCase()** to avoid problems with uppercase and lowercase letters, let's avoid **String** comparisons altogether:



Dumb Questions

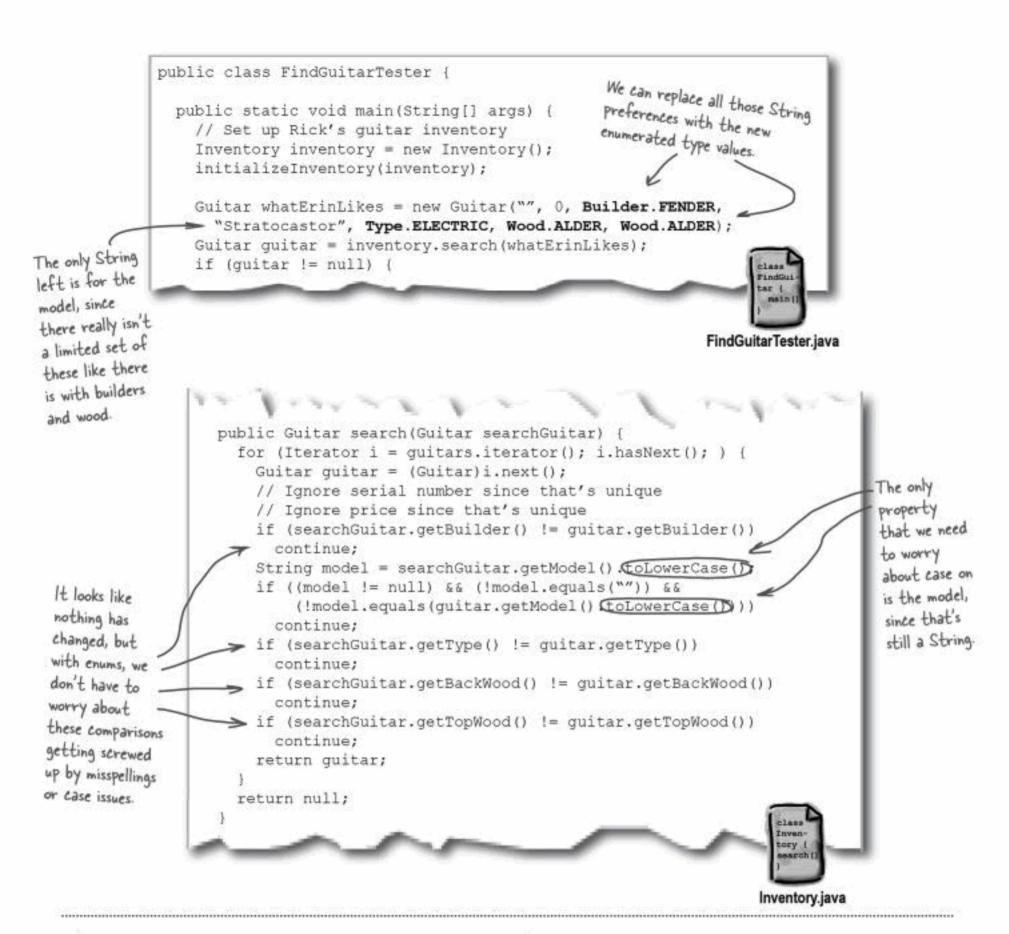
Q: I've never seen an enum before. What is that, exactly?

A: Enums are enumerated types. They're available in C, C++, Java version 5.0 and up, and will even be a part of Perl 6.

Enumerated types let you define a type name, like **Wood**, and then a set of values that are allowed for that type (like **COCOBOLO**, **SITKA**, and **MAHOGANY**). Then, you refer to a specific value like this: **Wood**. **COCOBOLO**.



And why are enumerated types so helpful here?



A: The cool thing about enums is that methods or classes that use them are protected from any values not defined in the enum. So you can't misspell or mistype an enum without getting a compiler error. It's a great way to get not only type safety, but value safety; you can avoid getting bad data for anything that has a standard range or set of legal values.

Q: I'm using an older version of Java. Am I stuck?

A: No, not at all. Visit the Head First Labs web site at http://www.headfirstlabs.com, where we've posted a version of Rick's Guitars that doesn't use enums, and will work with older JDKs.

Let's take a look at the big picture:

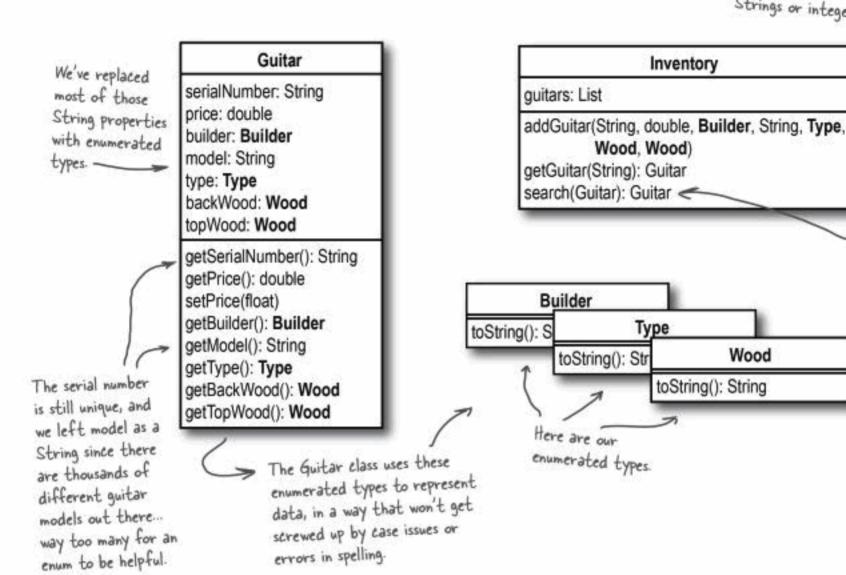
Now the addGuitar() method takes in several enums, instead of Strings or integer constants.

Inventory

Type

Wood

toString(): String



Even though it looks like nothing's changed in search(), now we're using enums to make sure we don't miss any matches because of spelling or capitalization.

So what have we really done here?

We've gotten a lot closer to completing step 1 in building great software. Rick's problem with searches coming up empty when he's got a matching guitar in his inventory is a thing of the past.

Even better, we've made Rick's application less fragile along the way. It's not going to break so easily now, because we've added both type safety and value safety with these enums. That means less problems for Rick, and less maintenance for us.

> Code that is not fragile is generally referred to as robust code.

1. Make sure your software does what the customer wants it to do.

Sharpen your pencil

Apply Step 1 to your own project.

working on (you can also use a project you fini	sned recently).
Now, write down the first thing you did when you this project. Did it have anything to do with madid what the customer wanted it to?	: (CONTROL OF CONTROL
If you started out focusing on something other think about how you might have approached the you knew about the 3 steps to building great so have been different? Do you think your applicate better or worse than it is right now?	nings differently if oftware. What would

Dumb Questions

Q: So it's OK to do a little design when I'm working on Step 1, right?

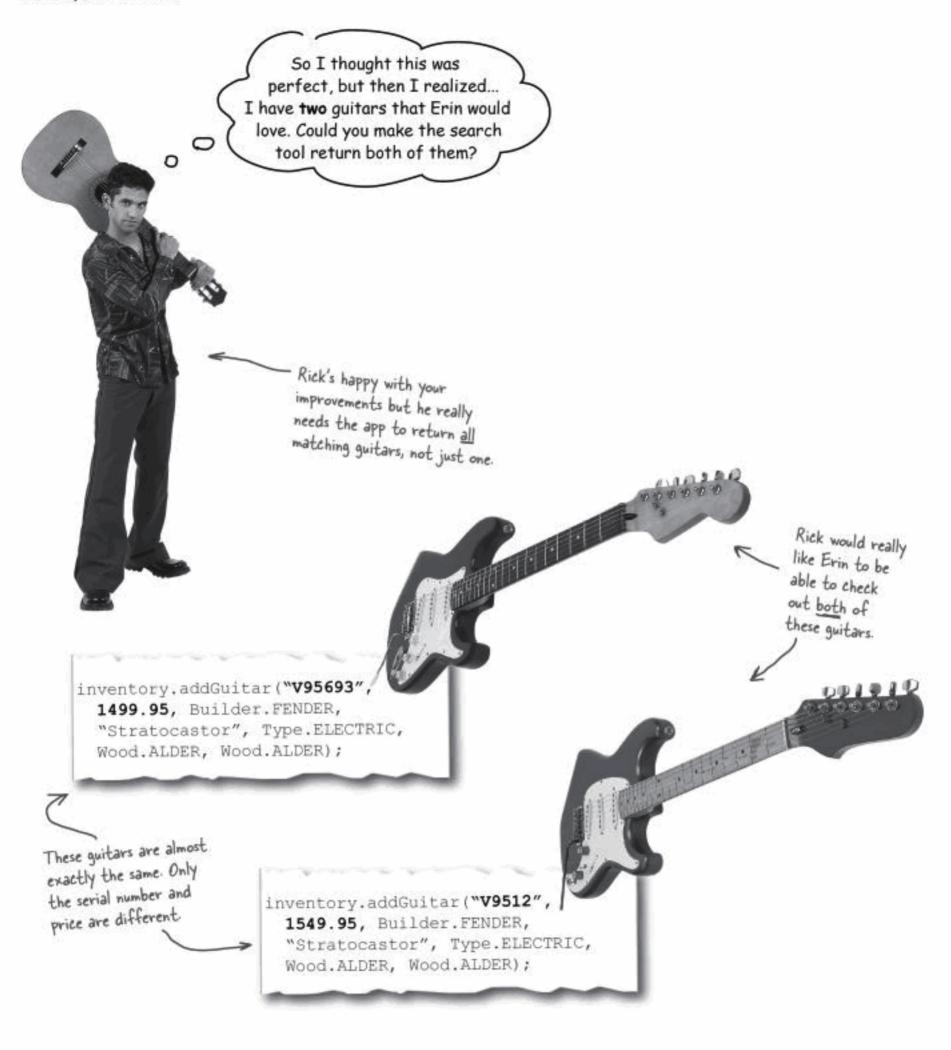
A: Yeah, as long as your focus is still on the customer's needs. You want the basic features of your application in place before you start making big design changes. But while you're working on functionality, you can certainly use good OO principles and techniques to make sure your application is well designed from the start.

Q: That diagram over on page 18 is a class diagram right? Or is it class diagrams, since it's more than one class?

A: It is a class diagram, and a single diagram can have multiple classes in it. In fact, class diagrams can show a lot more detail than you've seen so far, and we'll be adding to them in the next several chapters.

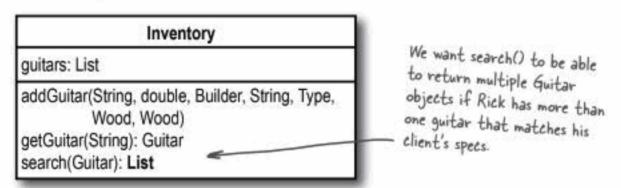
Q: So we're ready to move on to Step 2, and start applying OO principles, right?

A: Not quite... there's one more thing Rick would like us to help him with before we're ready to start analyzing our code for places we might be able to improve it. Remember, our first job is to please the customer, and then we really focus on improving our OO design.



Rick's customers want choices!

Rick's come up with a new requirement for his app: he wants his search tool to return *all* the guitars that match his client's specs, not just the first one in his inventory.





Code Magnets

Let's continue with Step 1, and make sure we've got the app working right. Below is the code for the search() method in Rick's inventory tool, but it's up to you to fill in the missing pieces. Use the code magnets at the bottom of the page to return all the matching guitars from Rick's inventory.

public search(Guitar searchGuitar) {

```
= new ();
for (Iterator i = guitars.iterator(); i.hasNext(); ) {
 Guitar guitar = (Guitar)i.next();
  // Ignore serial number since that's unique
 // Ignore price since that's unique
 if (searchGuitar.getBuilder() != guitar.getBuilder())
    continue;
  String model = searchGuitar.getModel();
 if ((model != null) && (!model.equals("")) &&
      (!model.equals(quitar.qetModel())))
    continue;
 if (searchGuitar.getType() != guitar.getType())
 if (searchGuitar.getBackWood() != guitar.getBackWood())
    continue;
  if (searchGuitar.getTopWood() != guitar.getTopWood())
    continue;
return
LinkedLis
                        matchingGuitars
                                                    ArrayList
                                                              ArrayList
              tchingGuitara
                              matchingGuitars
                         add
     inkedList
                                                                         21
                                                          you are here >
```



Code Magnets

Let's keep on with Step 1, and make sure we've got the app working right. Below is the code for the search() method in Rick's inventory tool, but it's up to you to fill in the missing pieces. Use the code magnets at the bottom of the page to return all the matching guitars from Rick's inventory.

```
You actually could
                                                                         have used either a
         public
                         search (Guitar search Guitar)
                                                                         LinkedList or an
                                    = new LinkedList
                   matchingGuitars
                                                    ; i.hasNext(); ) ( ArrayList here...
                                                                          both choices are OK.
             Guitar guitar = (Guitar)i.next();
             // Ignore serial number since that's unique
             // Ignore price since that's unique
             if (searchGuitar.getBuilder() != guitar.getBuilder())
                continue;
             String model = searchGuitar.getModel();
             if ((model != null) && (!model.equals("")) &&
                  (!model.equals(quitar.qetModel())))
                continue;
             if (searchGuitar.getType() != guitar.getType())
Matching guitars
                continue;
get added to the if (searchGuitar.getBackWood() != guitar.getBackWood())
list of options
                continue;
for Rick's client.
             if (searchGuitar.getTopWood() != guitar.getTopWood())
                continue;
                                                                               ArrayList
             matchingGuitars
                                        quitar
                                                                                  ArrayList
           return matchingGuitars
```

Dumb Questions

Q: So I'm not done with the first step until the application works like my customer wants it to?

A: Exactly. You want to make sure that the application works like it should before you dive into applying design patterns or trying to do any real restructuring of how the application is put together.

Q: And why is it so important to finish Step 1 before going on to Step 2?

A: You're going to make lots of changes to your software when you're getting it to work right. Trying to do too much design before you've at least got the basic functionality down can end up being a waste, because a lot of the design will change as you're adding new pieces of functionality to your classes and methods.

You seem sort of hung up on this "Step 1" and "Step 2" business. What if I don't code my apps that way?

A: There's nothing that says you have to follow these steps exactly, but they do provide an easy path to follow to make sure your software does what it's supposed to, and is well-designed and easy to reuse. If you've got something similar that accomplishes the same goals, that's great!

Test drive

We've talked a lot about getting the right requirements from the customer, but now we need to make sure we've actually got those requirements handled by our code. Let's test things out, and see if our app is working like Rick wants it to:

```
Here's -
              public class FindGuitarTester {
the test
                                                                      We're using enumerated
program,
                public static void main (String[] args) {
                                                                     types in this test drive. No
                  // Set up Rick's guitar inventory
updated
                                                                     typing mistakes this time!
                  Inventory inventory = new Inventory();
to use the
                  initializeInventory(inventory);
new version
of Rick's
                  Guitar whatErinLikes = new Guitar ("", 0, Builder.FENDER,
                                                                                                   In this new
search tool
                                                         "Stratocastor", Type.ELECTRIC,
                                                                                                   version, we need
                                                         Wood. ALDER, Wood. ALDER);
                                                                                                   to iterate over
                  List matchingGuitars = inventory.search(whatErinLikes);
                                                                                                  all the choices
                  if (!matchingGuitars.isEmpty()) {
This time
                    System.out.println("Erin, you might like these guitars:");
                                                                                                  returned from
                    for (Iterator i = matchingGuitars.iterator(); i.hasNext(); ) {
we get a
                                                                                                  the search tool
                      Guitar guitar = (Guitar)i.next();
whole list
                       System.out.println(" We have a " +
of quitars
                         guitar.getBuilder() + " " + guitar.getModel() + " " +
that match
                         guitar.getType() + " guitar:\n " +
the client's
                         quitar.getBackWood() + " back and sides, \n
                         quitar.getTopWood() + " top.\n You can have it for only $" +
specs.
                         guitar.getPrice() + "!\n ----");
                  } else {
                    System.out.println("Sorry, Erin, we have nothing for you.");
                                                                                            FindGu:
                                                                                      FindGuitarTester.java
              File Edit Window Help SweetSmell
               %java FindGuitarTester
               Erin, you might like these guitars:
                                                                                       Yes! That's exactly what I
                 We have a Fender Stratocastor electric guitar:
                    Alder back and sides,
                                                                                               want it to do.
                    Alder top.
                 You can have it for only $1499.95!
                 We have a Fender Stratocastor electric guitar:
                    Alder back and sides,
                    Alder top.
                 You can have it for only $1549.95!
        Everything worked! Erin gets
        several guitar recommendations,
        and Rick's customers are going
        to start buying guitars again.
```

Back to our steps

Now that Rick's all set with our software, we can begin to use some OO principles and make sure the app is flexible and well-designed.

1. Make sure your software does what the customer wants it to do.

Now that the app does what Rick wants, we're finished up with this step.

> So this is where we can make sure there's no duplicate code, and all our objects are well

> > designed, right?

2. Apply basic 00 principles to add flexibility.

↓ 3. Strive for a maintainable,

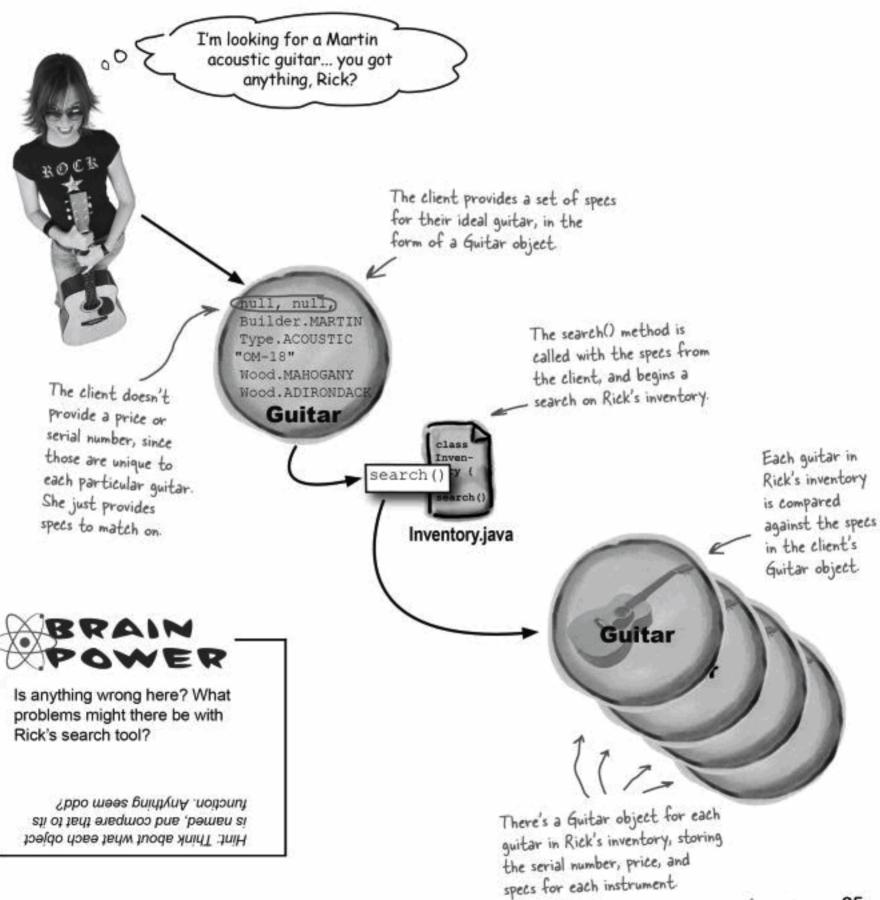
reusable design.

Here's where you take software that works, and make sure the way it's put together actually makes sense.



Looking for problems

Let's dig a little deeper into our search tool, and see if we can find any problems that some simple OO principles might help improve. Let's start by taking a closer look at how the **search()** method in **Inventory** works:



Analyze the search() method

Let's spend a little time analyzing exactly what goes on in the search() method of Inventory.java. Before we look at the code, though, let's think about what this method should do.

1 The client provides their guitar preferences.

Each of Rick's clients has some properties that they're interested in finding in their ideal guitar: the woods used, or the type of guitar, or a particular builder or model. They provide these preferences to Rick, who feeds them into his inventory search tool. The client can specify only general properties of an instrument So they never supply a serial number or a price.

The search tool looks through Rick's inventory.

Once the search tool knows what Rick's client wants, it starts to loop through each guitar in Rick's inventory.

Each guitar is compared to the client's preferences.

For each guitar in Rick's inventory, the search tool sees if that guitar matches the client's preferences. If there's a match, the matching guitar is added to the list of choices for the client.

All the general properties, like the top wood and guitar builder, are compared to the client's preferences.

A Rick's client is given a list of matching guitars.

Finally, the list of matching guitars is returned to Rick and his client. The client can make a choice, and Rick can make a sale.

Use a textual description of the problem you're trying to solve to make sure that your design lines up with the intended functionality of your application.

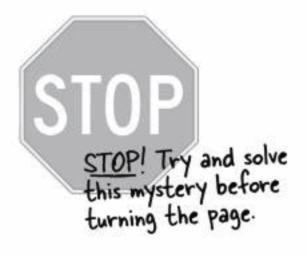


In the better-designed areas of Objectville, objects are very particular about their jobs. Each object is interested in doing its job, and only its job, to the best of its ability. There's nothing a well-designed object hates more than being used to do something that really isn't its true purpose.

Unfortunately, it's come to our attention that this is exactly what is happening in Rick's inventory search tool: somewhere, an object is being used to do something that it really shouldn't be doing. It's your job to solve this mystery and figure out how we can get Rick's application back in line.

To help you figure out what's gone amiss, here are some helpful tips to start you on your search for the mismatched object type:

- Objects should do what their names indicate.
 If an object is named Jet, it should probably takeOff() and land(), but it shouldn't takeTicket()—that's the job of another object, and doesn't belong in Jet.
- 2. Each object should represent a single concept. You don't want objects serving double or triple duty. Avoid a Duck object that represents a real quacking duck, a yellow plastic duck, and someone dropping their head down to avoid getting hit by a baseball.
- 3. Unused properties are a dead giveaway.
 If you've got an object that is being used with no-value or null properties often, you've probably got an object doing more than one job. If you rarely have values for a certain property, why is that property part of the object?
 Would there be a better object to use with just a subset of those properties?



2006 No. 100.000 N	
What do you think you sh	ould do to fix the problem? What changes would you make?
9	



Encapsulation allows you to group your application into logical parts.

New to encapsulation? Flip back to Appendix II, read that short introduction to Objectville, and then come back here and keep reading. You know, Rick's clients really aren't providing a Guitar object...
I mean, they don't actually give him a guitar to compare against his inventory.

Frank: Hey, that's right, Joe. I hadn't thought about that before.

Jill: So what? Using a Guitar object makes it really easy to do comparisons in the search() method.

Joe: Not any more than some other object would. Look:

```
if (searchGuitar.getBuilder() !=

guitar.getBuilder()) {

continue;

}

A small

fragment
from the
search()
method in
Inventory.
```

Joe: It really doesn't matter what type of object we're using there, as long as we can figure out what specific things Rick's clients are looking for.

Frank: Yeah, I think we should have a new object that stores just the specs that clients want to send to the search() method. Then they're not sending an entire Guitar object, which never seemed to make much sense to me.

Jill: But isn't that going to create some duplicate code? If there's an object for all the client's specs, and then the Guitar has all its properties, we've got two getBuilder() methods, two getBackWood() methods... that's not good.

Frank: So why don't we just encapsulate those properties away from Guitar into a new object?

Joe: Whoa... I was with you until you said "encapsulate." I thought that was when you made all your variables private, so nobody could use them incorrectly. What's that got to do with a guitar's properties?

Frank: Encapsulation is also about breaking your app into logical parts, and then keeping those parts separate. So just like you keep the data in your classes separate from the rest of your app's behavior, we can keep the generic properties of a guitar separate from the actual Guitar object itself.

Jill: And then Guitar just has a variable pointing to a new object type that stores all its properties?

Frank: Exactly! So we've really encapsulated the guitar properties out of Guitar, and put them in their own separate object. Look, we could do something like this...

Sharpen your pencil Create the GuitarSpec object.

Below, you'll see the class diagram for Guitar, and the new GuitarSpec object that Frank, Jill, and Joe have been discussing. It's your job to add all the properties and methods that you think you'll need to GuitarSpec. Then, cross out anything you don't need anymore in the Guitar class. Finally, we've left you some space in the Guitar class diagram in case you think you need to add any new properties or methods. Good luck!

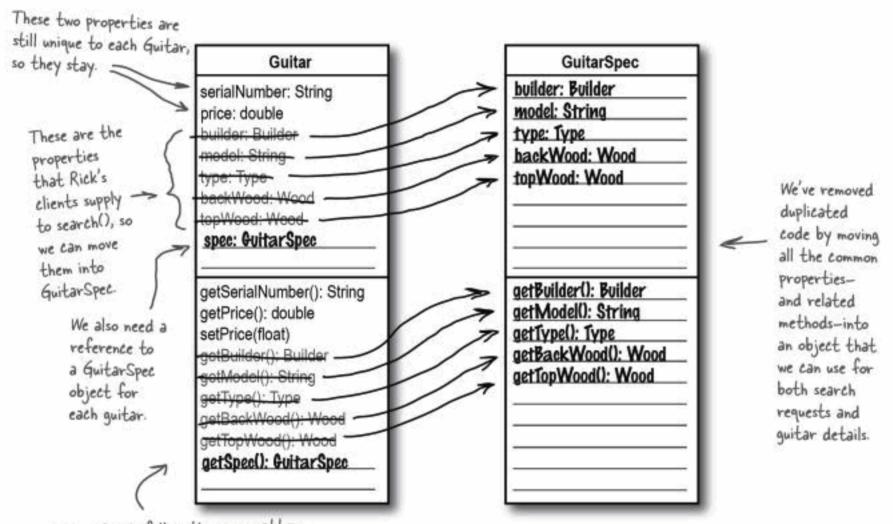
Guitar GuitarSpec serialNumber: String price: double builder: Builder model: String Move anything type: Type out of the backWood: Wood Guitar object that you think topWood: Wood belongs in the new Guitar Spec class. getSerialNumber(): String getPrice(): double setPrice(float) You can add getBuilder(): Builder extra properties and methods to getModel(): String Guitar if you getType(): Type think you need to. getBackWood(): Wood getTopWood(): Wood

^{*} If you get stuck, think about the things that are common between the Guitar object and what a client would supply to the search() method.



Create the GuitarSpec object.

Below you'll see the class diagram for Guitar, and the new GuitarSpec object that Frank, Jill, and Joe have been discussing. It's your job to add all the properties and methods that you think you'll need to GuitarSpec. See if you made the same changes that we did.



The methods follow the same pattern as the properties: we remove any duplication between the client's specs and the Guitar object

Now update your own code

With this class diagram, you should be able to add the **GuitarSpec** class to your application, and update the **Guitar** class as well. Go ahead and make any changes you need to **Inventory.java** so that the search tool compiles, as well.

Dumb Questions

Q: I understand why we need an object for the client to send specs to search()... but why are we using that object to hold properties for Guitar, too?

A: Suppose you just used GuitarSpec to hold client specs for sending to the search () method, and you kept the Guitar class just the same as it was. If Rick started carrying 12-string guitars, and wanted a numStrings property, you'd have to add that property—and code for a getNumStrings() method—to both the GuitarSpec and Guitar classes. Can you see how this would lead to duplicate code?

Instead, we can put all that (potentially) duplicate code into the **GuitarSpec** class, and then have **Guitar** objects reference an instance of it to avoid any duplication.

Anytime you see duplicate code, look for a place to encapsulate!

Q: I still am confused about how this is a form of encapsulation. Can you explain that again?

A: The idea behind encapsulation is to protect information in one part of your application from the other parts of your application. In its simplest form, you can protect the data in your class from the rest of your app by making that data private. But sometimes the information might be an entire set of properties—like the details about a guitar—or even behavior—like how a particular type of duck flies.

When you break that behavior out from a class, you can change the behavior without the class having to change as well. So if you changed how properties were stored, you wouldn't have to change your Guitar class at all, because the properties are encapsulated away from Guitar.

That's the power of encapsulation: by breaking up the different parts of your app, you can change one part without having to change all the other parts. In general, you should encapsulate the parts of your app that might vary away from the parts that will stay the same.

Let's see how we're coming along on our three steps to great software.

1. Make sure your software does what the customer wants it to do.

Here's what we're doing now: working on design.

2. Apply basic 00 principles to add flexibility.

> This is where you look for big problems, especially related to things like duplicate code or bad class design.

3. Strive for a maintainable, reusable design.

Remember, we've got even more design work to do in this step, so before you're done, your software is really easy to extend and reuse.

Update the Inventory class

Now that we've encapsulated away the specifications of a guitar, we'll need to make a few other changes to our code.

```
Inventory
           guitars: List
           addGuitar(String, double, Builder, String, Type,
                    Wood, Wood)
           getGuitar(String): Guitar
            search(GuitarSpec): List
Now search() takes a
Guitar Spec, instead of an
                         public class Inventory {
entire Guitar object
                            // variables, constructor, and other methods
                            public List search(GuitarSpec searchSpec) {
                              List matchingGuitars = new LinkedList();
                              for (Iterator i = guitars.iterator(); i.hasNext(); ) {
                                 Guitar guitar = (Guitar)i.next();
                                GuitarSpec guitarSpec = guitar.getSpec();
     All of the information
                                 if (searchSpec.getBuilder() != guitarSpec.getBuilder())
     we use in comparing
                                   continue;
     quitars is in GuitarSpec
                                 String model = searchSpec.getModel().toLowerCase();
     now, not the Guitar class.
                                 if ((model != null) && (!model.equals("")) &&
                                      (!model.equals(guitarSpec.getModel().toLowerCase())))
                                 if (searchSpec.getType() != guitarSpec.getType())
       This code is almost the
                                   continue;
       same as it was before,
                                 if (searchSpec.getBackWood() != guitarSpec.getBackWood())
       except now we're using
                                   continue;
       information in the
                                 if (searchSpec.getTopWood() != guitarSpec.getTopWood())
       Guitar Spec object
                                   continue;
                                 matchingGuitars.add(guitar);
                              return matchingGuitars;
                                                         Even though we changed our
                                                                                         Inventory.java
                                                         classes a bit, this method still
                                                          returns a list of guitars that
                                                          match the client's spees.
```

Getting ready for another test drive

You'll need to update the **FindGuitarTester** class to test out all these new changes:

```
public class FindGuitarTester (
          public static void main(String[] args) {
            // Set up Rick's guitar inventory
This time, the
            Inventory inventory = new Inventory();
client sends a
            initializeInventory(inventory);
Guitar Spec to
         → GuitarSpec whatErinLikes =
search(). -
              new GuitarSpec (Builder.FENDER, "Stratocastor", Type.ELECTRIC,
                              Wood.ALDER, Wood.ALDER);
            List matchingGuitars = inventory.search(whatErinLikes);
            if (!matchingGuitars.isEmpty()) {
              System.out.println("Erin, you might like these guitars:");
              for (Iterator i = matchingGuitars.iterator(); i.hasNext(); ) (
                Guitar guitar = (Guitar)i.next();
                GuitarSpec spec = guitar.getSpec(); <
                System.out.println(" We have a " +
                                                                        We're using the new
                   spec.getBuilder() + " " + spec.getModel() +
                                                                        Guitar Spec class
                   spec.getType() + " guitar:\n
                   spec.getBackWood() + " back and sides, \n
                  spec.getTopWood() + " top.\n You can have it for only $" +
                  guitar.getPrice() + "!\n ----");
              System.out.println("Sorry, Erin, we have nothing for you.");
          private static void initialize Inventory (Inventory inventory) {
            // Add guitars to the inventory...
```



You can download the current version of Rick's search tool at http://www.headfirstlabs.com. Just look for Head First OOA&D, and find "Rick's Guitars (with encapsulation)". FindGuitarTester.java



You've learned a lot about writing great software, and there's still more to go! Take a deep breath and think about some of the terms and principles we've covered. Connect the words on the left to the purposes of those techniques and principles on the right.

FLexibility

Encapsulation

Functionality

Design Pattern

Without me, you'll never actually make the customer happy. No matter how well-designed your application is, I'm the thing that puts a smile on the customer's face.

I'm all about reuse and making sure you're not trying to solve a problem that someone else has already figured out.

You use me to keep the parts of your code that stay the same separate from the parts that change; then it's really easy to make changes to your code without breaking everything.

Use me so that your software can change and grow without constant rework. I keep your application from being fragile.

→ Answers on page 52.

Dumb Questions

Q: Encapsulation isn't the only OO principle I can use at this stage, is it?

A: Nope. Other good OO principles that you might want to think about at this stage are inheritance and polymorphism. Both of these relate to duplicate code and encapsulation though, so starting out by looking for places where you could use encapsulation to better your design is always a good idea.

We'll talk about a lot more OO programming principles throughout this book (and even see a few sing in Chapter 8), so don't worry if you are still getting a handle on things at this point. You'll learn a lot more about encapsulation, class design, and more before we're done. Q: But I don't really see how this encapsulation makes my code more flexible. Can you explain that again?

A: Once you've gotten your software to work like it's supposed to, flexibility becomes a big deal. What if the customer wants to add new properties or features to the app? If you've got tons of duplicate code or confusing inheritance structures in your app, making changes is going to be a pain.

By introducing principles like encapsulation and good class design into your code, it's easier to make these changes, and your application becomes a lot more flexible.

Getting back to Rick's app...

Let's make sure all our changes haven't messed up the way Rick's tool works. Compile your classes, and run the FindGuitarTester program again:

The results aren't different this time, but the application is better designed, and much more flexible.

```
*java FindGuitarTester
Erin, you might like these guitars:
We have a Fender Stratocastor electric guitar:
Alder back and sides,
Alder top.
You can have it for only $1499.95!

----
We have a Fender Stratocastor electric guitar:
Alder back and sides,
Alder top.
You can have it for only $1549.95!

Alder top.
You can have it for only $1549.95!
```



Can you think of three specific ways that welldesigned software is easier to change than software that has duplicate code?

Design once, design twice

Once you've taken a first pass over your software and applied some basic OO principles, you're ready to take another look, and this time make sure your software is not only flexible, but easily reused and extended.

A. Make sure your software does what the customer wants it to do.

2. Apply basic 00 principles to add flexibility.

3. Strive for a maintainable, reusable design.

It's time to really think about reuse, and how easy it is to make changes to your software. Here's where you can take some well-designed classes and really turn them into a reusable, extensible piece of software.

Once you've applied some basic OO principles, you're ready to apply some patterns and really focus on reuse.



(really) Let's make sure Inventory.java is¹well-designed

We've already used encapsulation to improve the design of Rick's search tool, but there are still some places in our code where we could get rid of potential problems. This will make our code easier to extend when Rick comes up with that next new feature he wants in his inventory search tool, and easier to reuse if we want to take just a few parts of the app and use them in other contexts.

Now that you've made Rick a working search tool, you know he's gonna call you back when he wants changes made to the tool.

Here's the search() method from Inventory.java. Take a close look at this code.

```
public List search(GuitarSpec searchSpec) {
  List matchingGuitars = new LinkedList();
  for (Iterator i = quitars.iterator(); i.hasNext(); ) {
    Guitar guitar = (Guitar)i.next();
    GuitarSpec guitarSpec = guitar.getSpec();
    if (searchSpec.getBuilder() != guitarSpec.getBuilder())
      continue;
    String model = searchSpec.getModel().toLowerCase();
    if ((model != null) && (!model.equals("")) &&
         (!model.equals(guitarSpec.getModel().toLowerCase())))
      continue;
    if (searchSpec.getType() != guitarSpec.getType())
    if (searchSpec.getBackWood() != guitarSpec.getBackWood())
      continue;
    if (searchSpec.getTopWood() != guitarSpec.getTopWood())
      continue;
    matchingGuitars.add(guitar);
  return matchingGuitars;
```

Sharpen your pencil

What would you change about this code?

There's a big problem with the code shown above, and it's up to you to figure it out. In the blanks below, write down what you think the problem is, and how you would fix it. See what we said on page 37

Inventory.java

You know, I've always loved playing 12-string guitars. How hard would it be to update my app so I can sell 12-string guitars, and let my clients search for them, too?



How easy is it to make this change to Rick's application?

Take a look at the class diagram for Rick's application, and think about what you would need to do to add support for 12-string guitars. What properties and methods would you need to add, and to what classes? And what code would you need to change to allow Rick's clients to search for 12-strings?

How many classes did you have to modify to make this change? Do you think Rick's application is well designed right now?

Guitar

serialNumber: String

price: double spec: GuitarSpec

getSerialNumber(): String

getPrice(): double setPrice(float)

getSpec(): GuitarSpec

Sharpen your pencil

GuitarSpec

builder: Builder model: String type: Type

backWood: Wood topWood: Wood

getBuilder(): Builder getModel(): String getType(): Type

getBackWood(): Wood getTopWood(): Wood

Annotate Rick's class diagram.

Rick wants to be able to sell 12-string guitars. Get out your pencil, and add notes to the class diagram showing the following things:

- Where you'd add a new property, called numStrings, to store the number of strings a guitar has.
- Where you'd add a new method, called getNumStrings(), to return the number of strings a guitar has.
- What other code you think you'd need to change so that Rick's clients can specify that they want to try out 12-string guitars.

Finally, in the blanks below, write down any problems with this design that you found when adding support for 12-string guitars.

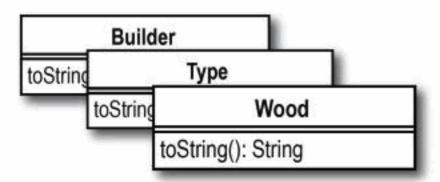
Inventory

guitars: List

addGuitar(String, double, Builder, String, Type,

Wood, Wood)

getGuitar(String): Guitar search(GuitarSpec): List Here's a hint: you should get an answer here related to what you wrote down in the blanks back on page 37.





What's the advantage of using a numStrings property instead of just adding a boolean property to indicate if a guitar is a 12-string?



Annotate Rick's class diagram.

Rick wants to be ble to sell 12-string guitars. Get out your pencil, and add notes to the class diagram showing the following things:

- 1. Where you'd add a new property, called numStrings, to store the number of strings a quitar has.
- 2. Where you'd add a new method, called getNumStrings(), to return the number of strings a quitar has.
- 3. What other code you think you'd need to change so that Rick's clients can specify that they want to try out 12-string guitars.

Finally, in the blanks below, write down any problems with this design that you found when adding support for 12-string guitars.

We're adding a property to Guitar Spec, but we have to change code in the Inventory class's search() method, as well as in the constructor to the Guitar class.

Here's what we came up with... did you write down something similar?

numStrings property to the Guitar Spee class. GuitarSpec builder: Builder model: String type: Type backWood: Wood topWood: Wood getBuilder(): Builder getModel(): String We need a getType(): Type getNumStrings()

getBackWood(): Wood

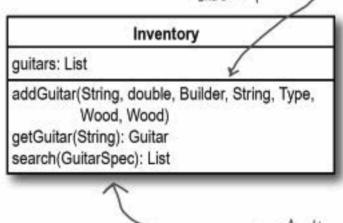
getTopWood(): Wood

We need to add a

Guitar serialNumber: String price: double spec: GuitarSpec getSerialNumber(): String getPrice(): double setPrice(float) getSpec(): GuitarSpec

We need to change the constructor of this class, since it takes in all the properties in Guitar Spec, and creates a GuitarSpec object itself.

This class's add Guitar () method deals with all of a guitar's properties, too. New properties means changes to this methodthat's a problem. 7



Builder Type toString Wood toString toString(): String

Another problem: we have to change the search() method here to account for the new property in

Guitar Spec.

method in this

class to return

a guitar has.

how many strings

So that's the problem,
right? We shouldn't have to
change code in Guitar and Inventory to
add a new property to the GuitarSpec
class. Can't we just use more
encapsulation to fix this?

That's right—we need to encapsulate the guitar specifications and isolate them from the rest of Rick's guitar search tool.

Even though you're adding a property only to the **GuitarSpec** class, there are two other classes that have to be modified: **Guitar** and **Inventory**. The constructor of **Guitar** has to take an additional property now, and the **search()** method of **Inventory** has to do an extra property comparison.

This constructor creates a GuitarSpec object, so every time the spec changes, this code has to change, too.

Guitar, java

This code is not easy to reuse. The classes are all interdependent, and you can't use one class without using all the others, too.

```
public Guitar String serialNumber,

double price.

Builder builder,
String model, Type type,
Wesd backWood, Wood topWood)

this.serialNumber = serialNumber;
this.price = price;
this.spec = new GuitarSpec (builder, model,
type, BackWood, topWood);

}
```

```
public List gearch QuitarSpec searchSpec) (
  List matchingGuitars = new LinkedList();
  for (Iterator i = quitars.iterator(); i.hasNext(); ) {
    Guitar guitar = (Guitar)i.next();
    GuitarSpec guitarSpec = guitar.getSpec();
   if (searchSpec.getBuilder() != guitarSpec.getBuilder())
    String model = searchSpec.getModel().toLowerCase();
    if ((model !- null) && (!model.equals("")) &&
        (!model.equals(guitarSpec.getModel().toLowerCase())))
      continue;
    if (searchSpec.getType() != guitarSpec.getType())
      continue:
    if (searchSpec.getBackWood() != guitarSpec.getBackWood())
      continue;
    if (searchSpec.getTopWood() != guitarSpec.getTopWood())
      continue;
    matchingGuitars.add(guitar);
  return matchingGuitars;
```



It's not enough to know what's wrong with Rick's app, or even to figure out that we need some more encapsulation. Now ke need to actually figure out how to fix his app so it's easier to reuse and extend.

The problem:

Adding a new property to **GuitarSpec.java** results in changes to the code in **Guitar.java** and **Inventory.java**. The application should be restructured so that adding properties to **GuitarSpec** doesn't affect the code in the rest of the application.

Your task:

- Add a numStrings property and getNumStrings() method to GuitarSpec.java.
- Modify Guitar.java so that the properties of GuitarSpec are encapsulated away from the constructor of the class.
- 6 Change the search () method in Inventory.java to delegate comparing the two GuitarSpec objects to the GuitarSpec class, instead of handling the comparison directly.
- Update FindGuitarTester.java to work with your new classes, and make sure everything still works.
- 6 Compare your answers with ours on page 44, and then get ready for another test drive to see if we've finally got this application finished.

All you should have to do here is update — your code that ereates a sample inventory to use the new Guitar constructor.

Not sure what delegation is? Check this out

Dumb Questions

Q: You said I should "delegate" comparisons to GuitarSpec. What's delegation?

A: Delegation is when an object needs to perform a certain task, and instead of doing that task directly, it asks another object to handle the task (or sometimes just a part of the task).

So in the design puzzle, you want the search () method in Inventory to ask GuitarSpec to tell it if two specs are equal, instead of comparing the two GuitarSpec objects directly within the search () method itself. search () delegates the comparison to GuitarSpec.

Q: What's the point of that?

A: Delegation makes your code more reusable. It also lets each object worry about its own functionality, rather than spreading the code that handles a single object's behavior all throughout your application

One of the most common examples of delegation in Java is the equals () method. Instead of a method trying to figure out if two objects are equal, it calls equals () on one of the objects and passes in the second object. Then it just gets back a true or false response from the equals () method.

Q: And what does delegation have to do with code being more reusable?

A: Delegation lets each object worry about equality (or some other task) on its own. This means your objects are more independent of each other, or more loosely coupled. Loosely coupled objects can be taken from one app and easily reused in another, because they're not tightly tied to other objects' code.

Q: And what does loosely coupled mean again?

A: Loosely coupled is when the objects in your application each have a specific job to do, and they do only that job. So the functionality of your app is spread out over lots of well-defined objects, which each do a single task really well.

Q: And why is that good?

A: Loosely coupled applications are usually more flexible, and easy to change. Since each object is pretty independent of the other objects, you can make a change to one object's behavior without having to change all the rest of your objects. So adding new features or functionality becomes a lot easier.

Scholar's Corner

delegation. The act of one object forwarding an

elegation. The act of one object forwarding an operation to another object, to be performed on behalf of the first object.





Design Puzzle Solution

It's not enough to know what's wrong with Rick's app, or even to figure out that we need some more encapsulation. Now ke need to actually figure out how to fix his app so we can test it out.

The problem:

Adding a new property to **GuitarSpec.java** results in changes to the code in **Guitar.java** and **Inventory.java**. The application should be refactored so that adding properties to **GuitarSpec** doesn't affect the code in the rest of the application.

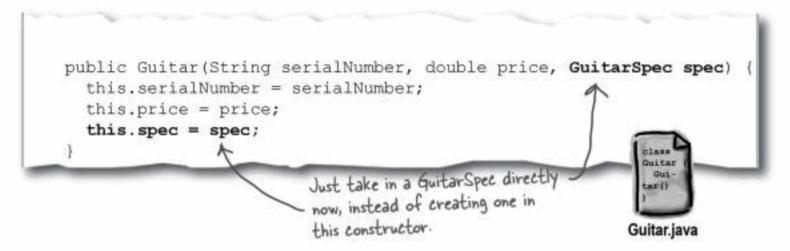
Your task:

Add a numStrings property and getNumStrings() method to GuitarSpec.java.

```
public class GuitarSpec {
                 // other properties
                 private int numStrings;
This is pretty
easy stuff ...
                 public GuitarSpec (Builder builder, String model,
                   Type type, int numStrings, Wood backWood, Wood topWood) {
                   this.builder = builder;
                   this.model = model;
                   this.type = type;
                   this.numStrings = numStrings;
                   this.backWood = backWood;
                   this.topWood = topWood;
                 // Other methods
                 public int getNumStrings() {
                   return numStrings;
```

GuitarSpec.java

Modify Guitar. java so that the properties of GuitarSpec are encapsulated away from the constructor of the class.



3 Change the search () method in Inventory. java to delegate comparing the two GuitarSpec objects to the GuitarSpec class, instead of handling the comparison directly.

```
The search()
          public List search(GuitarSpec searchSpec) {
                                                                                method got a
            List matchingGuitars = new LinkedList();
             for (Iterator i = guitars.iterator(); i.hasNext(); ) {
                                                                                lot simpler.
               Guitar guitar = (Guitar)i.next();
               if (guitar.getSpec().matches(searchSpec))
                 matchingGuitars.add(guitar);
             return matchingGuitars;
                                                                      Inventory java
                         public boolean matches (GuitarSpec otherSpec) {

✓ if (builder != otherSpec.builder)

     Most of the code
                             return false;
      from search() has
                           if ((model != null) && (!model.equals("")) &&
      been pulled out,
                               (!model.equals(otherSpec.model)))
      and put into a
                             return false;
      matches() method
                           if (type != otherSpec.type)
      in GuitarSpec.java.
                             return false;
                           if (numStrings != otherSpec.numStrings)
                             return false;
                           if (backWood != otherSpec.backWood)
                             return false;
                           if (topWood != otherSpec.topWood)
                             return false;
Adding properties to
                           return true;
GuitarSpec now requires
```

One last test drive (and an app ready for reuse)

Wow, we've done a lot of work since Rick showed us that first version of his guitar app. Let's see if the latest version still works for Rick and his clients, and manages to satisfy our own goal of having a welldesigned, easily maintainable application that we can reuse.

This is what
you should see
when you run
FindGuitarTester
with your new code.

%java FindGuitarTester
Erin, you might like these guitars:
 We have a Fender Stratocastor 6-string electric guitar:
 Alder back and sides,
 Alder top.
 You can have it for only \$1499.95!
---We have a Fender Stratocastor 6-string electric guitar:
 Alder back and sides,
 Alder top.
 You can have it for only \$1549.95!

Erin gets a couple of guitars to choose from, and Rick is back to selling guitars to his elite clientele.



Congratulations!
You've turned Rick's broken
inventory search tool into a welldesigned piece of great software.

What we did

Let's take a quick look back at how we got Rick's search tool working so well: Remember our 3 steps? We followed them to turn Rick's broken search tool into functional, well-designed software.

We started out by fixing some of the functionality problems with Rick's search tool.

1. Make sure your software does what the customer wants it to do.

We went on to add some more functionality, so that the search returns a list of quitars.

While we were adding features, we made sure our design choices were really solid.

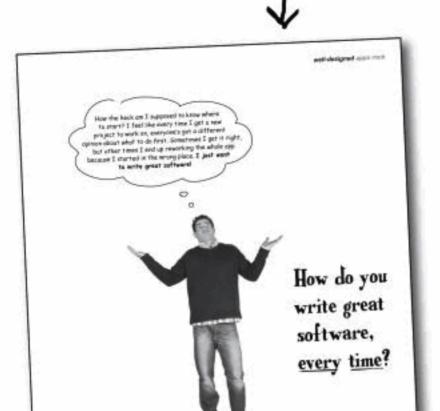
2. Apply basic 00 principles to add flexibility.

We also encapsulated out the guitar properties, and made sure we could add new properties to the app easily.

3. Strive for a maintainable, reusable design.

We even added delegation so that our objects are less dependent upon each other, and can be reused easily.

Remember this poor guy?



He just wanted to write great software. So what's the answer? How do you write great software consistently?

You just need a set of steps to follow that makes sure your software works and is well designed. It can be as simple as the three steps we used in working on Rick's app; you just need something that works, and that you can use on all of your software projects.

We call this OOAFD for short

Object-Oriented Analysis & Design helps you write great software, every time

All this time that we've been talking about the three steps you can follow to write great software, we've really been talking about OOA&D.

OOA&D is really just an approach to writing software that focuses on making sure your code does what it's supposed to, and that it's well designed. That means your code is flexible, it's easy to make changes to it, and it's maintainable and reusable.

00A&D is about writing great software, not doing a bunch of paperwork!

Customers are satisfied when their apps WORK.

We'll talk all about requirements in Chapter 2

We can get requirements from the customer to make sure that we build them what they ask for. Use cases and diagrams are helpful ways to do that, but it's all about figuring out what the customer wants the app to do.

Customers are satisfied when their apps KEEP WORKING.

Want more

on delegation,

composition, and

aggregation? We'll talk about all of

these in detail in

Chapters 5, and

then again in

Chapter 8.

Nobody is happy when an application that worked yesterday is crashing You've today. If we design our apps well, then they're going to be robust, and learned a bit not break every time a customers uses them in unusual ways. Class and about fragile sequence diagrams can help show us design problems, but the point is to apps already. write well-designed and robust code.

Customers are satisfied when their apps can be UPGRADED.

There's nothing worse than a customer asking for a simple new feature, and being told it's going to take two weeks and \$25,000 to make it happen. Using OO techniques like encapsulation, composition, and delegation will make your applications maintainable and extensible.

Programmers are satisfied when their apps can be REUSED.

Ever built something for one customer, and realized you could use something almost exactly the same for another customer? If you do just a little bit of analysis on your apps, you can make sure they're easily reused, by avoiding all sorts of nasty dependencies and associations that you don't really need. Concepts like the Open-Closed Principle (OCP) and the Single Responsibility Principle (SRP) are big time in helping here.

You'll get to see these principles really strut their stuff in Chapter 8.

Programmers are satisfied when their apps are FLEXIBLE.

Sometimes just a little refactoring can take a good app and turn it into a nice framework that can be used for all sorts of different things. This is where you can begin to move from being a head-down coder and start thinking like a real architect (oh yeah, those guys make a lot more money, too). Big-picture thinking is where it's at.

> Chapters b and 7 are all about looking at the big picture, and really developing a good architecture for your applications.

This is ALL OOA D! It's not about doing silly diagrams ... it's about writing killer applications that leave your customer happy, and you feeling like you've kicked major ass.

This is fantastic! I'm selling guitars like crazy with this new search tool. By the way, I had a few ideas for some new features...

See? You're already getting requests for more work. Rick will have to wait until Chapter 5, though... we've got some hairier issues to tackle in the next chapter.





BULLET POINTS

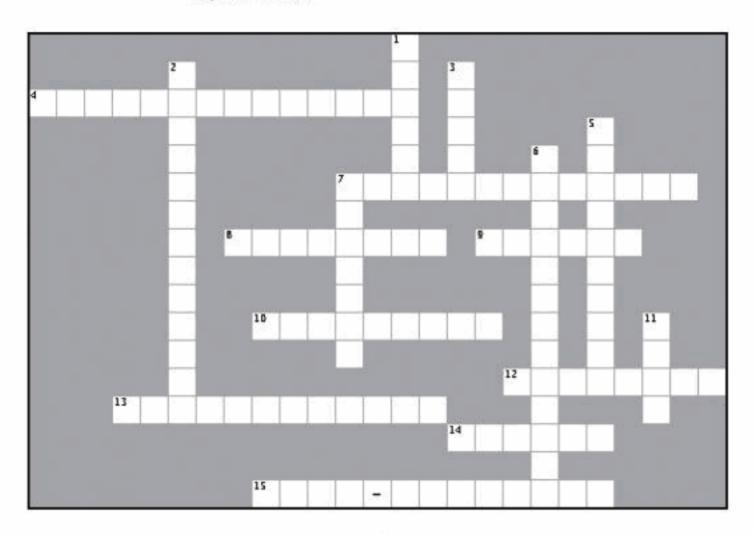
- It takes very little for something to go wrong with an application that is fragile.
- You can use OO principles like encapsulation and delegation to build applications that are flexible.
- Encapsulation is breaking your application up into logical parts.
- Delegation is giving another object the responsibility of handling a particular task.
- Always begin a project by figuring out what the customer wants.
- Once you've got the basic functionality of an app in place, work on refining the design so it's flexible.

- With a functional and flexible design, you can employ design patterns to improve your design further, and make your app easier to reuse.
- Find the parts of your application that change often, and try and separate them from the parts of your application that don't change.
- Building an application that works well but is poorly designed satisfies the customer but will leave you with pain, suffering, and lots of late nights fixing problems.
- Object oriented analysis and design (OOA&D) provides a way to produce well-designed applications that satisfy both the customer and the programmer.



OOA&D Cross

Let's put what you've learned to use, and stetch out your left brain a bit. All of the words to answer the puzzle below are somewhere in this chapter. Good luck!



Across

- These help you avoid solving problems someone else has already solved.
- Customers focus on this part of your applications.
- Objects in loosely coupled applications are more _____ than tightly coupled ones.
- 9. Flexible applications are usually easy to
- 10. This is one type of code you don't want to write.
- 12. Your applications should be easy to
- You usually need some sort of process to write great software _______.
- Encapsulate what ______.
- These types of applications satisfy programmers.

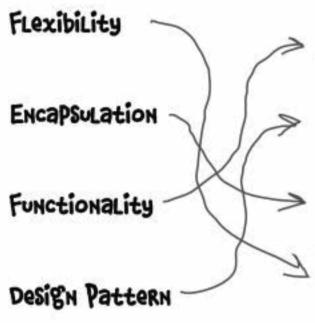
Down

- Once your application works correctly, focus on this.
- Grouping your application into logical parts.
- 3. The goal of OOA&D is to help you write this type of software.
- Use this to let objects focus on more specific tasks.
- 6. A good way to avoid duplicate code
- An application that things can go wrong in easily.
- This is a four letter word your mom will be proud you know.





You've learned a lot about writing great software, and there's still more to go! Take a deep breath and think about some of the terms and principles we've covered. Connect the words on the left to the purpose of those techniques and principles on the right.

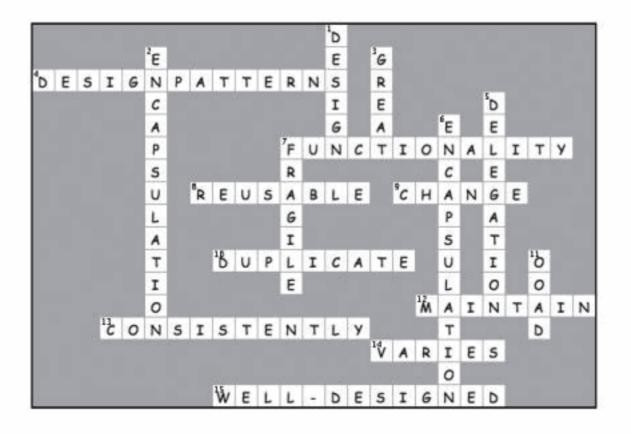


Without me, you'll never actually make the customer happy. No matter how well-designed your application is, I'm the thing that puts a smile on the customer's face.

I'm all about reuse and making sure you're not trying to solve a problem that someone else has already figured out.

You use me to keep the parts of your code that stay the same seperate from the parts that change; then it's really easy to make changes to your code without breaking everything.

Use me so that your software can change and grow without constant rework. I keep your application from being fragile.





What would you change about this code?

There's a big problem with the code shown above, and it's up to you to figure it out. In the blanks below, write down what you think the problem is, and how you would fix it.

Every time a new property is added to GuitarSpec.java, or the methods in GuitarSpec change, the search() method in Inventory.java will have to change, too. We should let GuitarSpec handle comparisons, and encapsulate these properties away from Inventory.

This isn't very good design. Every time a new property — is added to GuitarSpec, this code is going to have to change.

```
public List search (GuitarSpec searchSpec) {
  List matchingGuitars = new LinkedList();
  for (Iterator i = quitars.iterator(); i.hasNext(); ) {
    Guitar guitar = (Guitar)i.next();
    GuitarSpec guitarSpec = guitar.getSpec();
    if (searchSpec.getBuilder() != guitarSpec.getBuilder())
      continue;
    String model = searchSpec.getModel().toLowerCase();
    if ((model != null) && (!model.equals("")) &&
        (!model.equals(quitarSpec.getModel().toLowerCase())))
      continue;
    if (searchSpec.getType() != guitarSpec.getType())
      continue;
    if (searchSpec.getBackWood() != guitarSpec.getBackWood())
      continue;
    if (searchSpec.getTopWood() != guitarSpec.getTopWood())
      continue;
    matchingGuitars.add(guitar);
  return matchingGuitars;
```

Inventory.java

Think about it: is Inventory really focusing on Rick's inventory? Or is it focusing on what makes two GuitarSpec objects the same? You want your classes to focus on their jobs, not the jobs of other classes. Comparing GuitarSpec objects is something GuitarSpec should worry about, not your Inventory class.

2 gathering requirements

Give Them What They Want

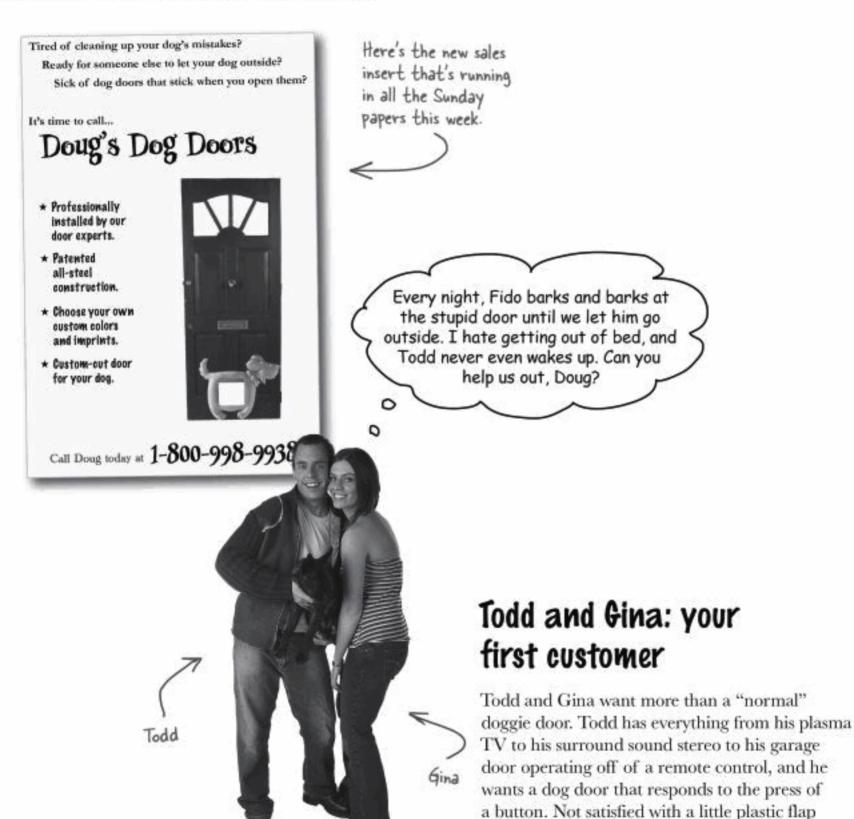
I hope you like it... I've been paying attention to every word you've said lately, and I think this is just perfect for you!



Everybody loves a satisfied customer. You already know that the first step in writing great software is making sure it does what the cutomer wants it to. But how do you figure out what a customer really wants? And how do you make sure that the customer even knows what they really want? That's where good requirements come in, and in this chapter, you're going to learn how to satisfy your customer by making sure what you deliver is actually what they asked for. By the time you're done, all of your projects will be "satisfaction guaranteed," and you'll be well on your way to writing great software, every time.

You've got a new programming gig

You've just been hired as the lead programmer at a new start-up, Doug's Dog Doors. Doug's got a pretty high-tech door under development, and he's decided you're the programmer that can write all the software to make his killer hardware work.



letting their dog in and out, they've given Doug's Dog Doors a call... and now Doug wants you to

build them the dog door of their dreams.

Let's start with the dog door

The first thing we need is a class to represent the dog door. Let's call this class **DogDoor**, and add just a few simple methods;

```
Assume the DogDoor class will
                                                        interface with Doug's custom
                public class DogDoor {
                                                       door hardware.
                   private boolean open;
                   public DogDoor() {
                      this.open = false;
This is pretty
                   public void open() {
simple: open()
                      System.out.println("The dog door opens.");
opens the door ...
                      open = true;
                   public void close() {
 ...and close()
                      System.out.println("The dog door closes.");
 closes the door
                      open = false;
This returns
                   public boolean isOpen() {
the state .
                      return open;
of the door:
whether it's
open or closed.
                            All this code ...
                                 ... goes into
                                 Dog Door java ...
                                                       DogDoor.java
                                         ...which will control
                                         the hardware in
                                         Todd and Gina's
                                         dog door.
                                        Fido's depending on you.
                                                                                          Fido's
                                        not to mention Todd, Gina,
                                                                                          Exit
                                        and your boss, Doug-
```



Code Magnets

Let's write another class, Remote, to allow a remote control to operate the dog door. Todd and Gina can use the remote to open the dog door without having to get out of bed.

Be careful... you may not need all the magnets.

Yes, we know this is a really easy one. We're just getting you warmed up, don't worry.

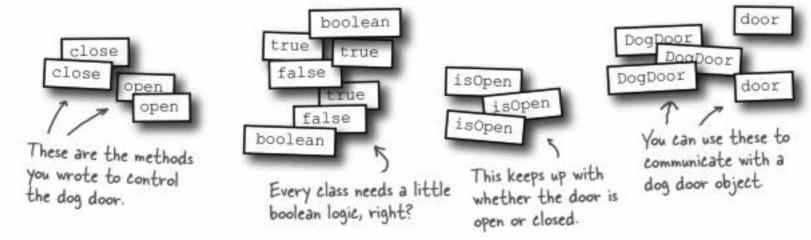
```
public class Remote {

private ______ door;

public Remote(_______) {
    this.door = door;
}

public void pressButton() {
    System.out.println("Pressing the remote control button...");
    if (____.___()) {
        door._____();
    } else {
        door._____();
    }
}

Once you're done, compare your answer with ours on page 108.
```



Test drive

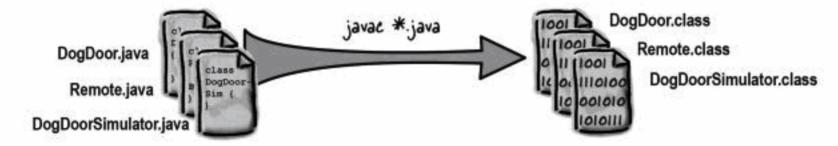
Let's see if everything works. Go ahead and take your new dog door for a test drive.

Create a class to test the door (DogDoorSimulator.java).

```
public class DogDoorSimulator (
  public static void main(String[] args) {
    DogDoor door = new DogDoor();
    Remote remote = new Remote(door);
    System.out.println("Fido barks to go outside...");
    remote.pressButton();
    System.out.println("\nFido has gone outside...");
    remote.pressButton();
    System.out.println("\nFido's all done...");
    remote.pressButton();
    System.out.println("\nFido's back inside...");
    remote.pressButton();
    System.out.println("\nFido's back inside...");
    remote.pressButton();
}

DogDoorSimulator.java
```

Compile all your Java source code into classes.



Run the code!

```
%java DogDoorSimulator
Fido barks to go outside...
Pressing the remote control button...
The dog door opens.

Fido has gone outside...
Pressing the remote control button...
The dog door closes.

Fido's all done...
Pressing the remote control button...
The dog door opens.

Fido's back inside...
Pressing the remote control button...
The dog door closes.
```

It works! Let's go show Todd and Gina...

But when Gina tried it...



Uh oh... when Gina used the door, Fido came back in, but so did a few friends.

Sharpen your pencil

How do you think the rodents are getting into Gina's kitchen? In the blanks below, write down what you think is wrong with the current version of the dog door.

Don't go to the next page until you've written down an answer for this exercise.

There's nothing wrong with our code! Gina must have forgotten to press the button on the remote again after Fido came back in. It's not my fault she's using the door incorrectly!



But the door doesn't work the way Todd and Gina want it to!

Todd and Gina didn't expect to have to close the dog door, so they pressed the button on the remote only once: to let Fido out.

Even worse, in this case, the way they used the door created new problems. Rats and rabbits started coming into their house through the open door, and you're taking the blame.

Let's tackle Todd and Gina's dog door again, but this time, we'll do things a little bit differently. Here's our plan:

- Gather requirements for Looks like we're going to spend a the dog door.
- Figure out what the door should really do.
- Get any additional information we need from Todd and Gina.
- **Build the door RIGHT!**

We're paying a lot more attention to Step 1 in writing great software this time, aren't we?

lot more time talking with Todd and Gina this time around.

> 1. Make sure your software does what the customer wants it to do.

So what exactly is a requirement, anyway?

A requirement is usually a single thing, and you can test that thing to make sure you've actually fulfilled the requirement.

It's a specific thing

_{your} ystem

"system" is the complete app —
or project you're working on.
In this case, your system is
Todd and Gina's complete dog
door setup (which includes the
remote control, by the way).

has to

do

The dog door system has to "do" lots of things: open, close, let Fido out, keep rodents from getting inside... anything that Todd and Gina come up with is part of what the system "does."

work correctly.

Remember, the <u>customer</u> decides when a system works correctly. So if you leave out a requirement, or even if they forget to mention something to you, the system isn't working correctly!

Scholar's Corner

requirement. A requirement is a <u>singular need</u> detailing what a particular product or service should <u>be</u> or <u>do</u>.

It is most commonly used in a formal sense in systems engineering or software engineering.



Listen to the customer

When it comes to requirements, the best thing you can do is **let the customer talk**. And pay attention to what the system needs to do; you
can figure out how the system will do those things later.

Here's what Todd and Gina say; it's your job to translate this into requirements for their door.

Fido's about a foot tall, and we don't want him having to hurt his back leaning over to get out the door.

Gina: And we want the door to automatically close after a few seconds. I don't want to have to wake back up in the middle of the night to close the door.

You: Do you want a single button on the remote, or both an "Open" and "Close" button?

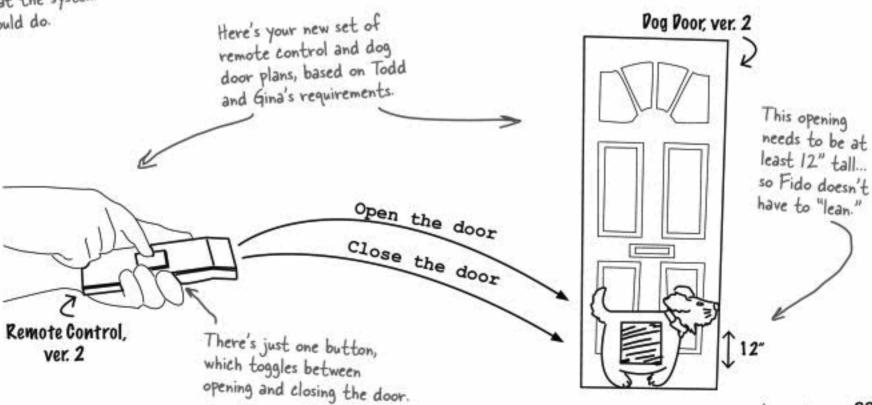
Todd: Well, if the door always closes automatically, we really don't need separate "Open" and "Close" buttons, do we? Let's just stick with a single button on the remote control.

You: Sure. So the button opens the door if it's closed, and it can also close the door if it's open, just in case the door gets stuck.

Todd: Perfect. Gina, anything else you can think of?

Gina: No, I think that's it. That's the dog door of our dreams.

Don't worry
about your
code at this
stage-just make
sure you know
what the system
should do.



Creating a requirements list

Now that we know what Todd and Gina want, let's write down our new set of requirements. We don't need anything too fancy...

Todd and Gina's Pog Poor, version 2.0 Requirements List

1. The dog door opening must be at least 12" tall.

A button on the remote control opens the dog door if the door is closed, and closes the dog door if the door is open.

Once the dog door has opened, it should close automatically if the door isn't already closed.

We'll just close the door after a few seconds of being open.

This is just a list of the things that your customer wants the system you're building them to do.

P

Compare these with Todd

comments on page 63...

see how we turned their words into a basic set of

requirements?

and Gina's

A special bonus prize

In addition to having a list of things you need to do to complete Todd and Gina's dog door, now you can show your boss exactly what you're working on, and what work you think is left to finish the project. Be sure to leave extra space... additional requirements almost always come up as you work on a project. Is this list really going to
help? Todd and Gina completely
forgot to tell us they wanted the door
to automatically close before... won't
they just forget something
again?

You need to understand how the dog door will be used.

You've figured out one of the hardest parts about getting a customer's requirements—sometimes even the customer doesn't know what they really want! So you've got to ask the customer questions to figure out what they want before you can determine exactly what the system should do. Then, you can begin to think beyond what your customers asked for and anticipate their needs, even before they realize they have a problem.



In Todd and
Gina's case, the
system is the dog
door and the
remote control.

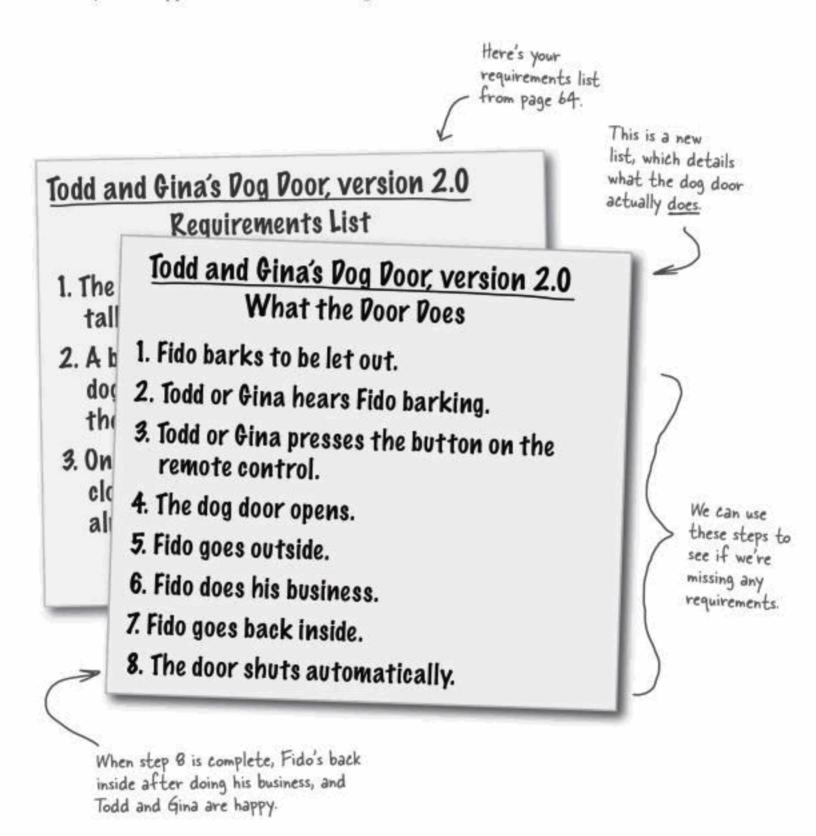
Sharpen your pencil

What sorts of things do you think Todd and Gina might not have thought about when it comes to their new dog door? Make a list of any concerns you might have in making sure Todd and Gina are happy with the new door you're building them.

What does the dog door really need to do?

You know what Todd and Gina want the dog door to do, but it's your job to make sure that the door actually works. In the process, you may even come across some things that Todd and Gina want, but didn't think about on their own.

Let's write down exactly what happens when Fido needs to go outside:



Dumb Questions

Q: So a requirement is just one of the things that a customer wants the application you build for them to do?

A: Actually, a requirement is a lot more than just what the customer wants—although that's a good place to start. Begin by finding out what your customer wants and expects, and what they think the system you're building for them should do. But there's still a lot more to think about...

Remember, most people expect things to work even if problems occur. So you've got to anticipate what might go wrong, and add requirements to take care of those problems as well. A good set of requirements goes beyond just what your customers tell you, and makes sure that the system works, even in unusual or unexpected circumstances.

Q: And the system for Todd and Gina is just the dog door, right?

A: The system is everything needed to meet a customer's goals. In the case of the dog door, the system includes the door, but it also includes the remote control. Without the remote, the dog door wouldn't be complete.

And even though they aren't part of the system, Todd and Gina and Fido are all things you have to at least think about when designing the system. So there's a lot more to worry about than just the actual dog door. O: I don't see why I have to figure out how Todd and Gina are going to use the dog door, and what can go wrong. Isn't that their problem, not mine?

A: Do you remember the first step we talked about in writing great software? You've got to make sure your app works like the customer wants it to—even if that's not how you would use the application. That means you've got to really understand what the system has to do, and how your customers are going to use it.

In fact, the only way to ensure you get Todd and Gina a working, successful dog door is to know the system even better than they do, and to understand exactly what it needs to do. You can then anticipate problems, and hopefully solve them before Todd and Gina ever know something could have gone wrong.

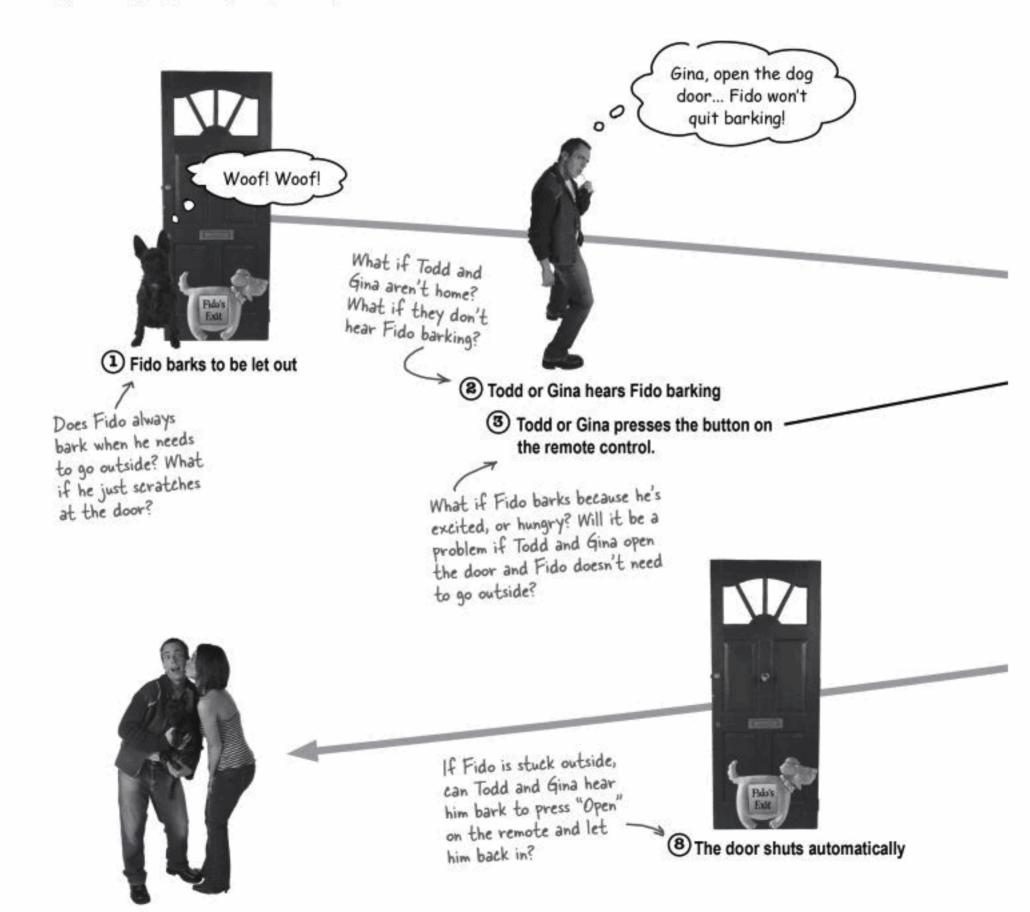
Q: So I should just come up with all sorts of bad things that might happen when Todd and Gina use their door?

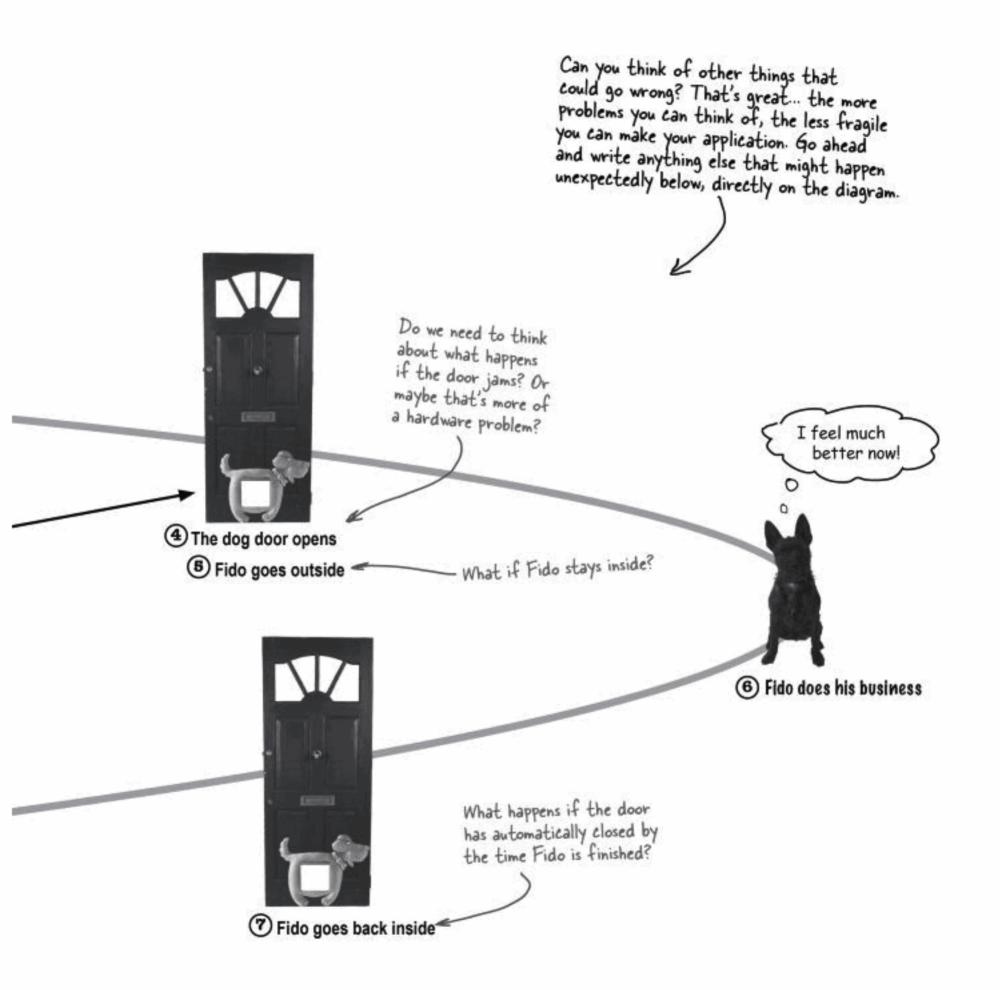
A: Exactly! In fact, let's do that now...

The best way to get good requirements is to understand what a system is supposed to do.

Plan for things going wrong

Below is a diagram of how Todd and Gina's dog door should work; all the numbers match up with the steps in our list on page 66. But things aren't always going to go according to plan, so we've written down some things that might go wrong along the way.





Alternate paths handle system problems

Now that you've figured out some of the things that can go wrong, you need to update your list of things that needs to happen to make the dog door work. Let's write down what should happen if the door closes before Fido gets back inside.

This is that same requirements list from page 64. We may need to update these later, but for now, they're still OK.

Todd and Gina's Pog Poor, version 2.0 Requirements List

1. The What the Poor Poes

2. A 1. Fido barks to be let out.

2. Todd or Gina hears Fido barking.

3. Todd or Gina presses the button on the remote control.

4. The dog door opens.

5. Fido goes outside.

6. Fido does his business.

61) The door shuts automatically.

6.2 Fido barks to be let back inside.

6.3 Todd or Gina hears Fido barking (again).

6.4 Todd or Gina presses the button on the remote control.

6.5 The dog door opens (again).

7. Fido goes back inside.

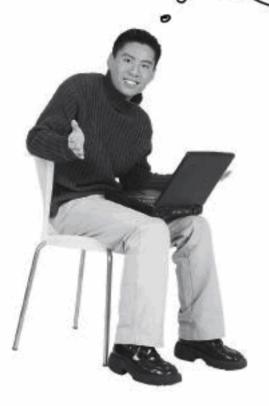
8. The door shuts automatically.

We can use these "sub-numbers" to show some substeps that might happen as part — of Step 6.

outside, there are a few additional steps required to get him back inside. These extra steps are called an alternate path.

All of these new steps handle the problem of the door closing before Fido can get back inside the house.

With some extra steps added, Fido can still get back inside, even though a problem Todd and Gina hadn't thought about occurred. Hey, I took a course in college on this stuff... aren't we just writing a use case?



Yes! You've been writing use cases all along

When you wrote down the steps in getting Fido outside to use the bathroom, you were actually writing a **use case**.

A use case is what people call the steps that a system takes to make something happen. In Todd and Gina's case, the "something"

that needs to happen is getting Fido outside to do his business, and then back inside. Look! It's a use case.

Todd and Gina's Pog Poor version 2.0 What the Poor Poes

- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- 3. Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1 The door shuts automatically.
- 6.2 Fido barks to be let back inside.
- 6.3 Todd or Gina hears Fido barking (again).
- 6.4 Todd or Gina presses the button on the remote control.
- 6.5 The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

You've actually already written the use case for Todd and Gina's dog door.

(Re) introducing use cases

You've been writing a use case for almost 10 pages now, but let's take a closer look at exactly what that list of steps—the use case for Todd and Gina's dog door—is really all about:

A use case describes _ what

Use cases are all about the "what" What does the dog door need to do? Remember, don't worry about the "how" right now... we'll get to that a little bit later.

A single use case focuses on a single goal. The single

goal for Todd and Gina is getting Fido outside

getting out of bed.

your system does

We're still definitely focusing on what the system needs to "do." What should happen in order to get Fido outside (and then back into the house)?

to accomplish a

particular

without either of them customer goal.

If Todd and Gina decide they want to track how many times Fido uses the dog door, that would be a different goal, so you'd need another, different use case.

The user (or users) are outside of the system, not a part of it. Fido uses the system, and he's outside of it; Gina has a goal for the system, and she's also outside of the system.

The customer goal is the point of the use case: what do all these steps need to make happen? We're focusing on the customer, remember? The system has to help that customer accomplish their goal.





The dog door and remote are part of the system, or inside the system.

The entire use case describes exactly what the dog door **does** when Fido needs to go outside.

> The use case ends when the customer goal is complete—that's Fido back inside, after doing his business, with Todd and Gina still comfortable in bed.

Todd and Gina's Dog Door, version 2.0 What the Door Does

- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- 3. Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1 The door shuts automatically.
 - 6.2 Fido barks to be let back inside.
 - 6.3 Todd or Gina hears Fido barking (again).
 - 6.4 Todd or Gina presses the button on the remote control.
 - 6.5 The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

This is an alternate path, but it's still about achieving the same goal as the main path, so it's part of the same use case.

Scholar's Corner

use case. A use case is a technique for capturing the potential requirements of a new system or software change. Each use case provides one or more scenarios that convey how the system should interact with the end user or another system to achieve a specific goal.



One use case, three parts

There are three basic parts to a good use case, and you need all three if your use case is going to get the job done.

Clear Value

The use case must help Todd and Gina deal with Fido.

Every use case must have a **clear**value to the system. If the use case
doesn't help the customer achieve their
goal, then the use case isn't of much use.



The use case starts up when Fido barks... it stops when he's back inside, done with his business.

Start and Stop

2

Every use case must have a definite

starting and stopping point. Something
must begin the process, and then there must be a
condition that indicates that the process is complete.

In the dog door, Fido is the external initiator. He's what starts the entire process.

External Initiator

Every use case is started off by an **external** initiator, outside of the system. Sometimes that initiator is a person, but it could be anything outside of the system.

3



Use Case Magnets

Below is Todd and Gina's use case, and a magnet for each of the three parts of a good use case (one part, Start and Stop, actually has two magnets). Your job is to identify where each magnet goes and attach it to the right part of the use case.



Start and Stop

STOP

Todd and Gina's Pog Poor, version 2.0 What the Poor Poes

- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- 3. Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1 The door shuts automatically.
 - 6.2 Fido barks to be let back inside.
 - 6.3 Todd or Gina hears Fido barking (again).
 - 6.4 Todd or Gina presses the button on the remote control.
 - 6.5 The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

External Initiator

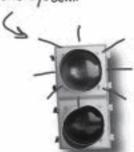
thint: One of these should be really easy... if you look at the icons.

STOP

Put the Super Buy magnet on the part of the use case that is the clear value to Todd and Gina. Put this magnet on the condition in the use case that indicates the process should stop.

Who starts the use case?

What kicks off the use case? This is usually some action outside of the system.



you are here >



Use Case Magnet Solutions

Below is Todd and Gina's use case, along with several use case magnets. Your job was to identify where each magnet goes, and attach it to the right part of the use case.



This is the start of the use case. Nothing begins until Fido barks.

Todd and Gina's Pog Poor, version 2.0 What the Poor Poes

- 1 Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1 The door shuts automatically.
 - 6.2 Fido barks to be let back inside.
 - 6.3 Todd or Gina hears Fido barking (again).
 - 6.4 Todd or Gina presses the button on the remote control.
 - 6.5 The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

Here's the stop condition... Fido is back in, and the door is closed. Fido is the external initiator in this use case.

The entire use case is of value, because Todd and Gina can stay in bed and still get Fido outside.

Dumb Questions

Q: So a use case is just a list of the steps that a system has to do to work correctly?

A: In most cases, yes. But, remember, one of the key points about a use case is that it is focused on accomplishing one particular goal. If your system does more than one thing—like let Fido outside and track how many times he's been out in an entire day—then you'll need more than one use case.

Q: Then my system will have a use case for every goal it accomplishes, right?

A: Exactly! If your system just does one single thing, you'll probably only need one use case. If it does ten or fifteen things, then you're going to have a *lot* of use cases.

Q: And a use case is what the system does to accomplish a goal?

A: Now you've got it. If you write down what the system needs to do to perform a task, you've probably got a use case.

Q: But the use case isn't very specific. Why didn't we talk about the Remote class or the DogDoor class?

A: Use cases are meant to help you understand what a system should do—and often to explain the system to others (like the customer or your boss). If your use case focuses on specific codelevel details, it's not going to be useful to anyone but a programmer. As a general rule, your use cases should use simple, everyday language. If you're using lots of programming terms, or technical jargon, your use case is probably getting too detailed to be that useful.

Q: Is a use case the same as a use case diagram?

A: No, use cases are usually a list of steps (although you can write them differently, something we talk about in the Appendix). Use case diagrams are a way to show use cases visually, but we've already been working on our own diagram of how the system works (check out page 69 for a refresher). Don't worry, though, we'll still look at use case diagrams in Chapter 6.

Q: Then how do I turn my use case into actual code?

A: That's another step in the process of writing your application. In fact, we're going to look at how to take our use case for Todd and Gina and update our code in just a few more pages.

But the purpose of the use case isn't to detail how you'll write your code. You'll probably still have to do some thinking about how you want to actually put the steps of your use case into action.

Q: If the use case doesn't help me write my code, then what's the point? Why spend all this time on use cases?

A: Use cases do help you write your code—they just aren't specific about programming details. For instance, if you didn't write a use case for Todd and Gina, you never would have figured out that Fido might get stuck outside, or realize that the dog door needed to close automatically. Those all came from writing a use case.

Remember, you'll never write great software if you can't deliver an app that does what the customer wants it to do. Use cases are a tool to help you figure that out—and then you're ready to write code to actually implement the system your use case describes.

Checking your requirements against your use cases

So far, you've got an initial set of requirements and a good solid use case. But now you need to go *back* to your requirements and make sure that they'll cover everything your system has to do. And that's where the use case comes in:

Todd and Gina's Pog Poor, version 2.0 Requirements List

- 1. The dog door opening must be at least 12" tall.
- A button on the remote control opens the dog door if the door is closed, and closes the dog door if the door is open.
- Once the dog door has opened, it should close automatically if the door isn't already closed.

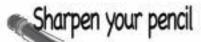
Is anything missing?

Now you need to look over the use case and see if everything the system needs to do is covered by the requirements. Here's our list of requirements that we got from Todd and Gina...

> ...and here's what we know the dog door needs to do.

Todd and Gina's Pog Poor, version 2.0 What the Poor Poes

- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- 3. Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1 The door shuts automatically.
 - 6.2 Fido barks to be let back inside.
 - 6.3 Todd or Gina hears Fido barking (again).
 - 6.4 Todd or Gina presses the button on the remote control.
 - 6.5 The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.



Do your requirements handle everything?

Below on the left is the list of things that the dog door does, pulled straight from our use case on page 78. Your job is to identify the requirement that handles each step of the use case and write that requirement's number down in the blank next to that step of the use case. If a step in the use case doesn't require you to do anything, just write N/A down, for "not applicable".

Todd and Gina's Dog Door, version 2.0 What the Door Does

1. Fido barks to be let out.

2. Todd or Gina hears Fido barking.	-
Todd or Gina presses the button on the remote control.	
4. The dog door opens.	<u> </u>
5. Fido goes outside.	1
6. Fido does his business.	
6.1 The door shuts automatically.	
6.2 Fido barks to be let back inside.	
6.3 Todd or Gina hears Fido barking (again).	

6.4 Todd or Gina presses the button on

the remote control.

8. The door shuts automatically.

Fido goes back inside.

6.5 The dog door opens (again).

Here are the three requirements we have ... you can use any of these for each step in the use case .-

Todd and Gina's Pog Poor, version 2.0 Requirements List

- 1. The dog door opening must be at least 12" tall.
- 2. A button on the remote control opens the dog door if the door is closed, and closes the dog door if the door is open.
- 3. Once the dog door has opened, it should close automatically if the door isn't already closed.

Write 1, 2, 3, or N/A in each of these blanks.

Did you find any steps in the use case that you don't think you have a requirement to handle? If you think you need any additional requirements, write what you think you need to add to the requirements list in the blanks below:



Do your requirements handle everything?

Below on the left is the list of things that the dog door does, pulled straight from our use case on page 78. Your job was to identify the requirement that handles each step of the use case, and write that requirement's number down in the blank next to that step of the use case. You should have written down N/A for a step that didn't require our system to do anything.

Todd and Gina's Dog Door, version 2.0 What the Door Does

		A lot of the things that
		1 C D D D D D D D D D D D D D D D D D D
1. Fido barks to be let out.	N/A	require you to do anything.
2. Todd or Gina hears Fido barking.	N/A	199 - 1771, ₁₇₈
Todd or Gina presses the button on the remote control.	_2_<	You might have put N/A here, since them pushing the button isn't something that's you have
4. The dog door opens.	2	to handle then again, I is UK,
5. Fido goes outside.	1	too, since they wouldn't push a button without a remote.
6. Fido does his business.	N/A	1 72
6.1 The door shuts automatically.	3	Did you get this one? Fido can't get outside if the opening
6.2 Fido barks to be let back inside.	N/A	isn't the right size.
6.3 Todd or Gina hears Fido barking (again).	N/A	
6.4 Todd or Gina presses the button on the remote control.		The alternate path should have been easy once you figured out the requirements
6.5 The dog door opens (again).	_2_)	for the main path.
7. Fido goes back inside.	1	
8. The door shuts automatically.	3	

Did you find any steps in the use case that you don't think you have a requirement to handle? If you think you need any additional requirements, write what you think you need to add to the requirements list down in the blanks below:

No, our requirements cover everything the system needs to do. We're ready to actually write code to handle these requirements now, right?

So now can we write some code?

With use case and requirements in hand, you're ready to write code that you **know** will make Todd and Gina satisfied customers. Let's check out our requirements and see exactly what we're going to have to write code for:

This is something for Doug and the hardware guys to deal with... we don't need any code for this requirement.

Todd and Gina's Pog Poor, version 2.0 Requirements List

- 1. The dog door opening must be at least 12" tall.
- A button on the remote control opens the dog door
 if the door is closed, and closes the dog door if the
 door is open.
- 3. Once the dog door has opened, it should close automatically if the door isn't already closed.

We've already got code to take care this requirement

This is what Todd and Gina added when we talked to them... we need to write code to take care of closing the door automatically.

We're getting pretty psyched about our new door. We love that you thought about Fido getting stuck outside, and took care of that, too.



Automatically closing the door

The only requirement left to code is taking care of automatically closing the door after it's been opened. Let's go back to our **Remote** class and handle that now:



```
import java.util.Timer;
            import java.util.TimerTask;
                                                       - You'll need these two
                                                        import statements to
            public class Remote {
                                                        use Java's timing classes.
              private DogDoor door;
              public Remote(DogDoor door) {
                 this.door = door;
This checks the
state of the
door before
              public void pressButton() {
opening or
                 System.out.println("Pressing the remote control button...");
closing it
              if (door.isOpen()) {
                   door.close (); The remote already has code to
                                            handle closing the door if it's open.
                 } else {
                   door.open();
                                                              All the task does is close
    Create a
                   final Timer timer = new Timer();
                                                              the door, and then turn
    new Timer
                   timer.schedule(new TimerTask() {
                                                              off the timer.
    so we can
                      public void run() {
    schedule the
                        door.close();
    dog door
                                                          This tells the timer how long to
                        timer.cancel();
     closing.
                                                          wait before executing the task... in
                                                         this case, we're waiting 5 seconds,
                    }, 5000);
                                                         which is 5000 milliseconds.
```

Dumb Questions

Q: What's all this Timer stuff? Can't I just use a Java thread to close the door?

A: Sure, there's nothing wrong with using a **Thread** to close the dog door. In fact, that's all the **Timer** class does: kick off a background **Thread**. But the **Timer** class makes running a task in the future easy, so it seemed like a good choice for the **Remote** class.

Q: Why did you make the timer variable final?

A: Because we need to call its cancel () method in the TimerTask anonymous class. If you need to access variables in your anonymous class from the enclosing class (that's Remote in this case), those variables must be final. And, really, just because it makes things work.

Q: Why are you calling cancel()? Won't the timer quit automatically after running the TimerTask?

A: It will, but it turns out that most JVMs take forever before they garbage collect the **Timer**. That ends up hanging the program, and your code will run for hours before it actually quits gracefully. That's no good, but calling **cancel()** manually takes care of the problem.

We need a new simulator!

Our old simulator isn't that useful anymore... it assumes Todd and Gina are closing the door manually, and not letting the timer do its work. Let's update our simulator to make it work with the updated **Remote** class:t



```
public class DogDoorSimulator {
                   public static void main(String[] args) {
                      DogDoor door = new DogDoor();
  This is the same
                      Remote remote = new Remote(door);
  as in our earlier
  version, but
                      System.out.println("Fido barks to go outside...");
  pressing the
                     remote.pressButton();
  button will open
  the door and
                      System.out.println("\nFido has gone outside...");
  start a timer to
                      remote.pressButton(); <
                                                                                — In the new improved dog
  close the door.
                                                                                   door, Gina doesn't need
                      System.out.println("\nFido's all done...");
                                                                                   to press a button to close
                     -remote.pressButton() +
                                                                                   the door. That will happen
                                                                                   automatically now.
Since the door's
                      System.out.println("\nFido's back inside...");
on a timer, Fido
                      remote.pressButton();
has plenty of
time to get back
                                                    Here's another spot where we can get rid of some code... the door closes automatically.
inside before the
 door closes. Gina
 doesn't need to
 open the door to
 let Fido back in.
```

You lost me on that timer code. What's going on there again?

A: That's OK... you don't need to get too hung up on Java here. The point is that our use case helped us write good requirements, and our requirements made it easy to figure out how to write a working dog door. That's a lot more important than how—or even in what language—you write the dog door code.

Q: So the new simulator tests out the main path we figured out, right?

A: That's right. Flip back to page 78 and review what the dog door does... that's what the new DogDoorSimulator tests out. We want to make sure that Todd and Gina's new door works just like they want it to.

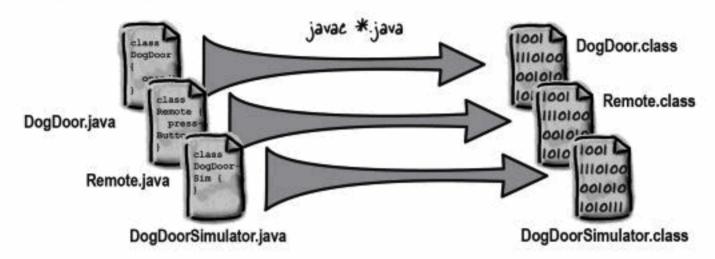
Q: Why aren't we testing out that alternate path we found?

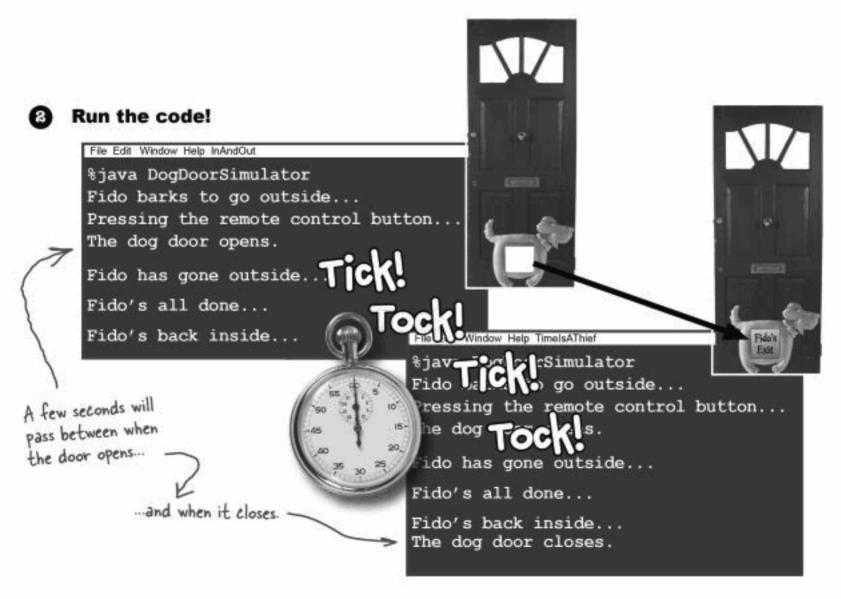
A: That's a very good question. Let's test this version of the door, and then we'll talk more about that...

Test drive, version 2.0

It's time to see if all our hard work is going to pay off. Let's test out the new and improved dog door.

Compile all your Java source code into classes.





It works! Let's go show Todd and Gina...

Your system must work in the real world...

But I don't think we're ready to show Todd and Gina yet... what about that alternate path, when Fido stays outside and the door closes behind him?

Good catch... we need to test alternate paths as well as the main path.

Wouldn't it be great if things worked just like you expected them to every time? Of course, in the real world, that almost never happens. Before we can show the new door off to Todd and Gina, let's take a little extra time to make sure the door works when Fido doesn't come right back inside after doing his business.



...so <u>plan</u>
and <u>test</u>
for when
<u>things</u> go
<u>wrong</u>.



How would you change the DogDoorSimulator class to test for Fido staying outside longer?



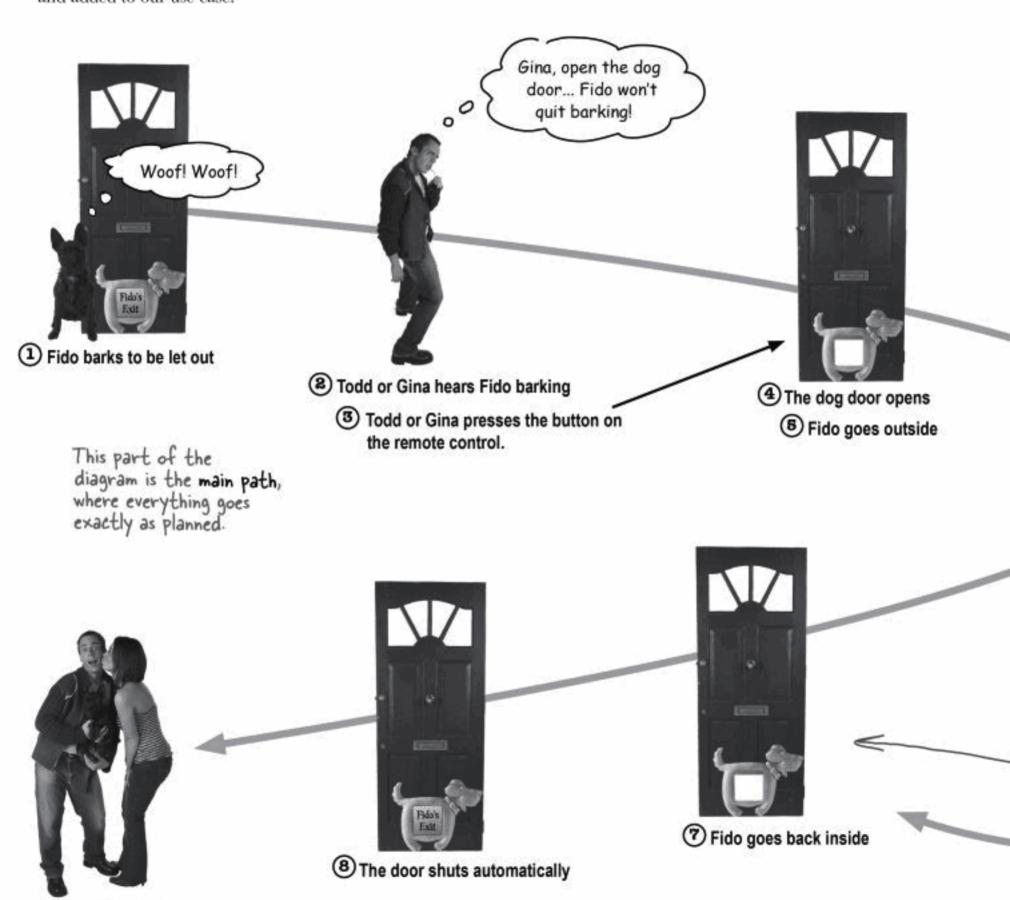
Can you come up with at least one more alternate path for Todd and Gina's dog door? Write out the use case and update the requirements list for your new alternate path, too.

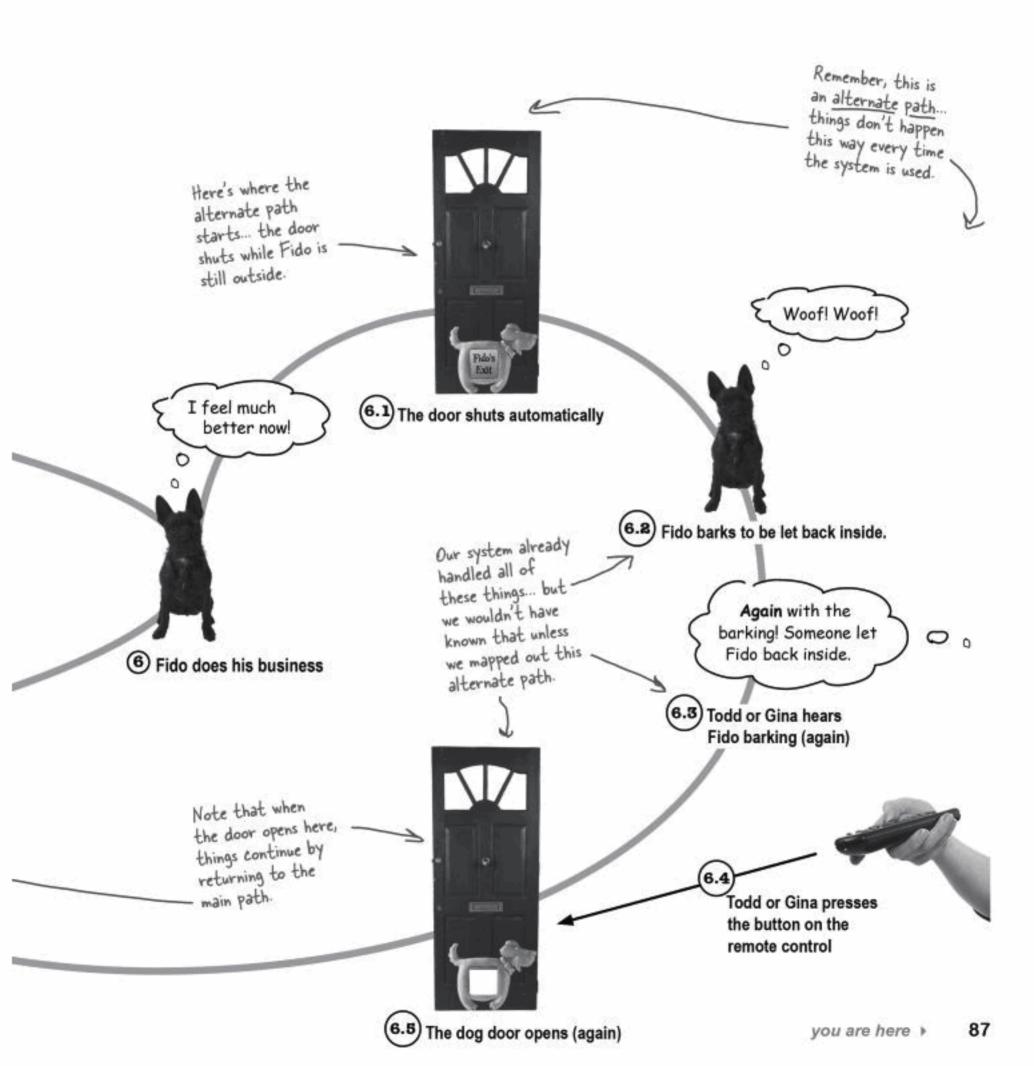
86

Chapter 2

Reviewing the alternate path

Let's make sure we understand exactly what happens on the alternate path, and then we can update **DogDoorSimulator** to test the new path out. Here's the original main path diagram from page 68, along with the alternate path we figured out and added to our use case:





Code Magnets

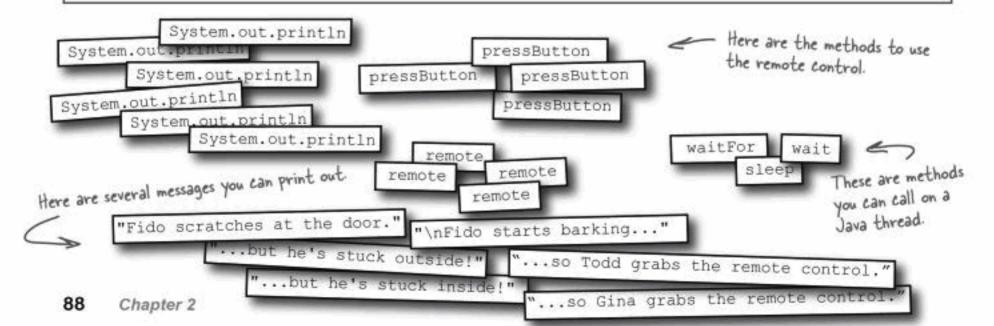
It's time to update the simulator, but this time it's your job to actually write some code. Below is what we have so far for DogDoorSimulator.



DogDoorSimulator.java

Your job is to match the code magnets at the bottom of the page to where they belong in the simulator. If you get stuck, check the diagram on the last page to see what's going on at each step of the way. Oh, and there's a twist... all the magents for periods, semicolons, and parentheses fell off the fridge, so you'll have to add those wherever they're needed, too.

```
public class DogDoorSimulator {
         public static void main(String[] args) {
           DogDoor door = new DogDoor();
           Remote remote = new Remote(door);
Here's where
           System.out.println("\nFido has gone outside...");
the alternate System.out.println("\nFido's all done...");
path begins.
                                                              We want the program to
      try (
                                                              pause and let the door
             Thread.currentThread().
                                                  (10000);
                                                             close automatically.
           } catch (InterruptedException e) { }
           System.out.println("\nFido's back inside...");
                                                                   The alternate path
                                                                  returns to the main
                                                                   Path right here.
```



Test drive, version 2.1

Make the changes to your copy of **DogDoorSimulator.java**, and then recompile your test class. Now you're ready to test out the alternate path of your use case:

File Edit Window Help InLikeFlynn
% java DogDoorSimulator
Fido barks to go outside...
Pressing the remote control button...
The dog door opens.

Fido has gone outside...
Fido's all done...

The door opens, and Fido goes outside to do his business.

But Fido starts chasing bugs, and the dog door closes while he's still outside.

Fido barks to get back inside, and Gina uses her remote control...

va DogDoorSimulator

b barks to go outside...

essing the remote control button...

The dog door opens.

Fido has gone outside...

Edit Window Help TheOutsiders

Fido's all done...
The dog door closes.
...but he's stuck outside!

Fido starts barking...
...so Gina grabs the remote control.
Pressing the remote control button...
The dog door opens.

Fido's back inside ...

File Edit Window Help ThereAndBackAgain

%java DogDoorSimulator

Fido barks to go outside...

Pressing the remote control butty

The dog door opens.

Fido has gone outside...

Fido's all done... The dog door closes.

...but he's stuck outside!

Fido starts barking...

...so Gina grabs the remote control. Pressing the remote control button... The dog door opens.

Fido's back inside... The dog door closes. Tick!

...and Fido gets to return to air conditioning.

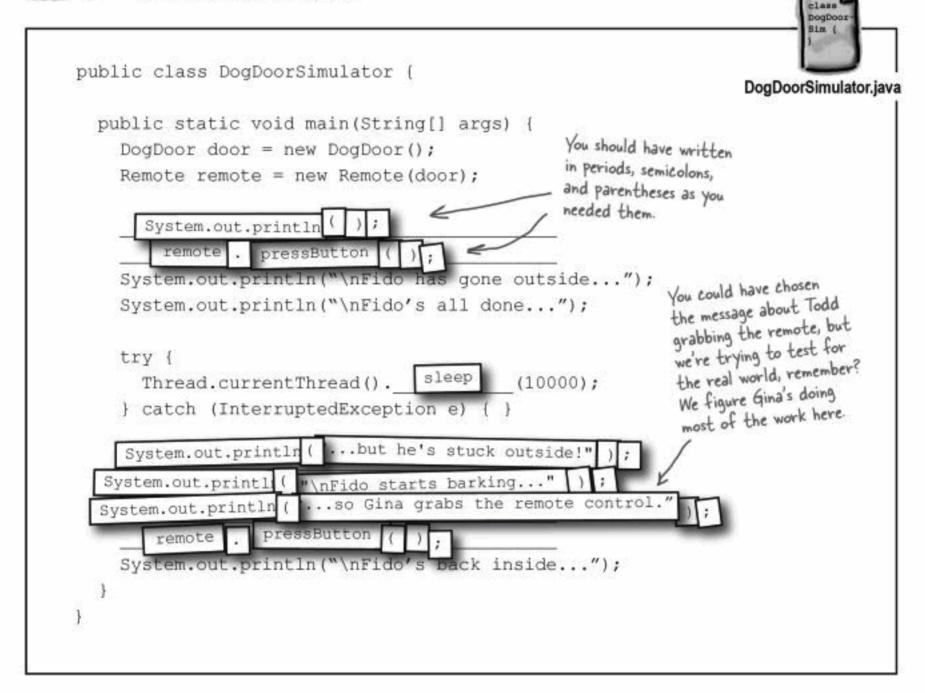
reald

Before long, the door closes again, keeping rabbits, rodents, and bugs safely outside.



Code Magnets Solution

Here's what we did to complete the simulator. Make sure you got the same answers that we did.



Delivering the new dog door

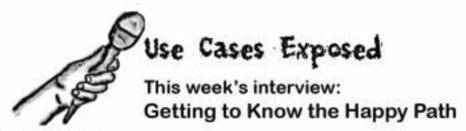
Good use cases, requirements, main paths, alternate paths, and a working simulator; we're definitely on the road to great software. Let's take the new dog door to Todd and Gina.



This was exactly the outcome we were hoping for way back on page 60. What a difference good requirements make, huh?

Working app, happy customers

Not only did we turn Todd and Gina into satisfied customers, we made sure their door worked when Fido did something they didn't expect—like stay outside playing.



HeadFirst: Hello there, Main Path.

Happy Path: Actually, I prefer to be called "Happy Path." I know a lot of books refer to me as "Main Path," but I find lots more people remember who I am when I go by "Happy Path."

HeadFirst: Oh, I apologize. Well, in any case, it's great to have you with us today, Happy Path, and you're right on time, too.

Happy Path: Thanks... I'm always on time, that's really important to me.

HeadFirst: Is that right? You're never late?

Happy Path: Nope, not a single time. I never miss an appointment, either. I never make a mistake, nothing ever goes unexpectedly... you can really count on me to come through just like you want, every time.

HeadFirst: That's quite a statement to make.

Happy Path: Well, it's just part of who I am.

HeadFirst: And that's how you got your name? You make people happy by always being on time and never making a mistake?

Happy Path: No, but that's close. They call me "Happy Path" because when you're hanging out with me, everything goes just as you'd hope. Nothing ever goes wrong when the "Happy Path" is at the wheel.

HeadFirst: I have to admit, I'm still a bit amazed that nothing ever goes wrong around you. Are you sure you're living in the real world?

Happy Path: Well, don't get me wrong... things definitely go wrong in the real world. But when that happens, I just hand things off to my buddy, Alternate Path.

HeadFirst: Oh, I think I see now... so things can go wrong, but that's Alternate Path's job to handle.

Happy Path: Yeah, pretty much. But I don't worry too much about that. My job is to take care of things when the sun is shining and things are going just like people expect.

HeadFirst: Wow, that must be really satisfying.

Happy Path: Well, most of the time it is. But things do tend to go wrong a lot. It seems like hardly anyone sticks with me from start to finish. Alternate Path usually gets involved at some point, but we get along well, so it's no big deal.

HeadFirst: Do you ever feel like Alternate Path is butting in? I could imagine some tension there...

Happy Path: No, not at all. I mean, we're all after the same thing: getting the customer to their goal, and making sure they're satisfied. And once we're defined well, actually coding an application is a lot simpler.

HeadFirst: Well, you heard it here folks. Next week, we'll try and catch up with Alternate Path, and get her side of the story. Until then, try and stay on the Happy Path, but remember to plan for problems!



Below on the left are some of the new terms you've learned in this chapter. On the right are descriptions of what those terms mean and how they're used. Your job is to match the term on the left with that term's purpose on the right.

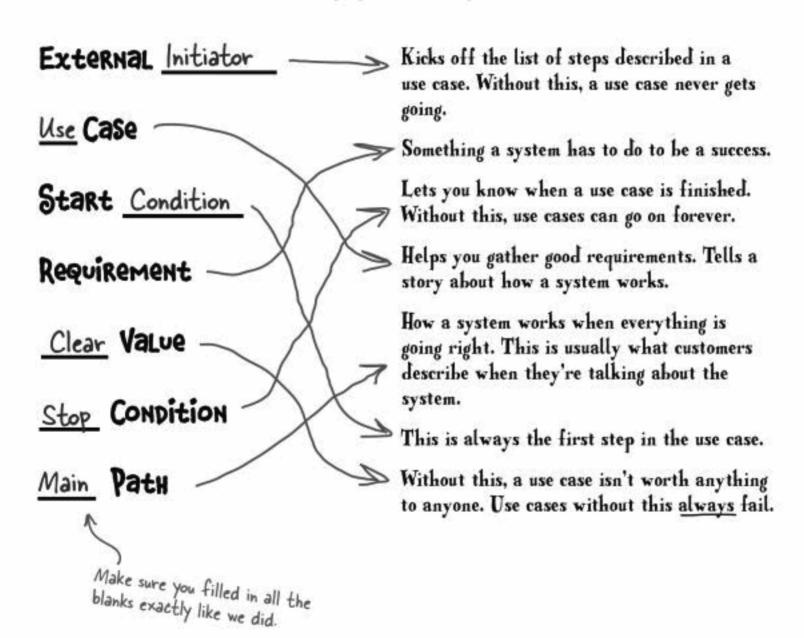
External	Kicks off the list of steps described in a use case never gets going.
Case	Something a system needs to do to be a success.
Start	Lets you know when a use case is finished. Without this, use cases can go on forever.
Requirement	Helps you gather good requirements. Tells a story about what a system does.
Value	What a system does when everything is going right. This is usually what customers
Condition	describe when they're talking about the system.
Path	This is always the first step in the use case.
РАСН	Without this, a use case isn't worth anything to anyone. Use cases without this always fail.

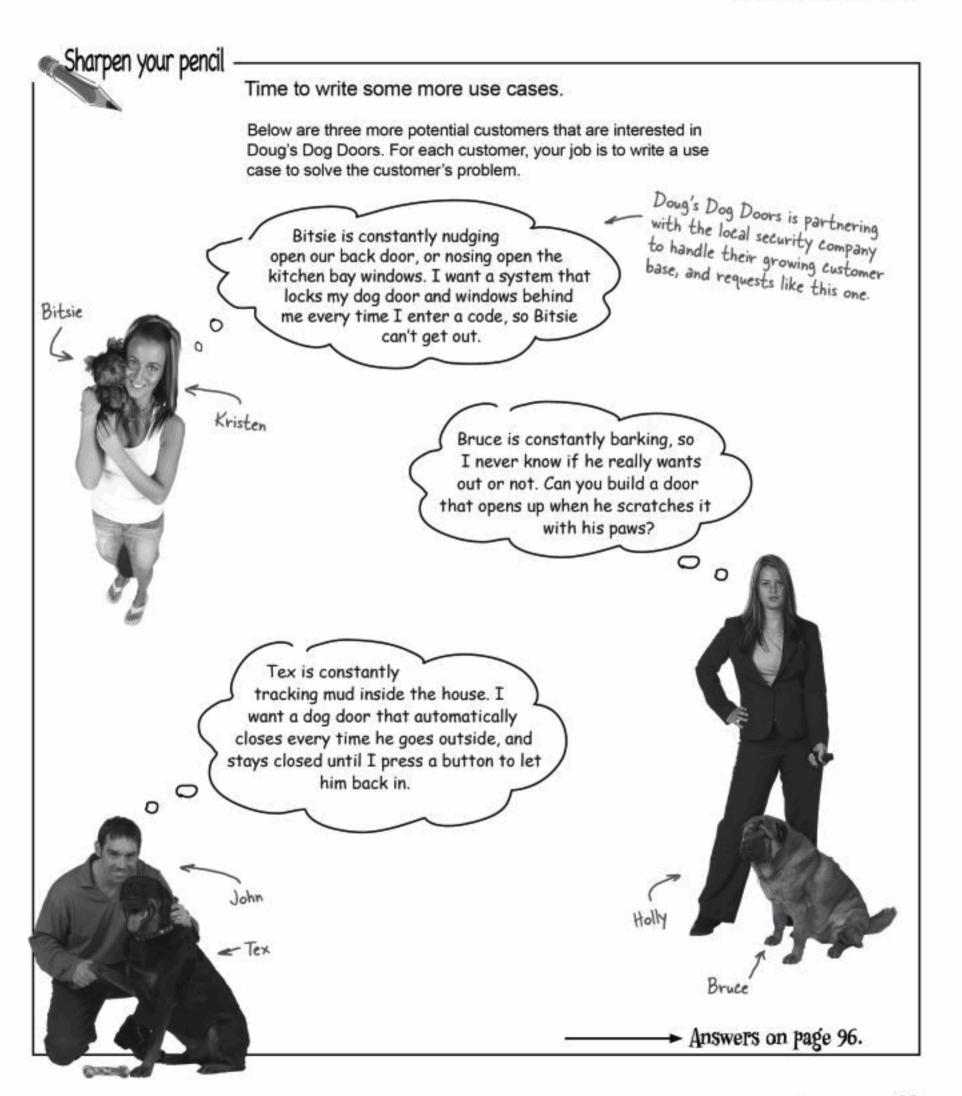
Uh oh ... parts of some of the terms on the left have gone missing. You've got to use the definitions on the right to match to a term, and fill in the missing part of the term.





Below on the left are some of the new terms you've learned in this chapter. On the right are descriptions of what those terms mean, and how they're used. Your job is to match the term on the left with what that term's purpose is on the right.





Bitsie

Sharpen your pencil answers

Time to write some more use cases!

You've seen the customers; now let's look at the use cases. Here is how we wrote our use cases for the dog-loving folks on page 95. See if your use cases look anything like ours.

Bitsie is constantly nudging open our back door, or nosing open the kitchen bay windows. I want a system that locks my dog door and windows behind me every time I enter a code, so Bitsie can't get out.

Kristen's use case is just two steps: she enters a code, and then the dog door and the windows lock.

S KIT

Kristen

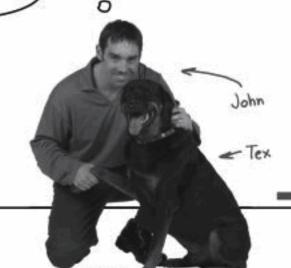
Kristen and Bitsie's Pog Poor

- 1. Kristen enters a code on a keypad.
- The dog door and all the windows in the house lock.

Even though this is a dog door, Bitsie actually has no effect on how the system behaves!

Tex is constantly tracking mud inside the house. I want a dog door that automatically closes every time he goes outside, and stays closed until I press a button to let him back in.

John's request turns out to be very similar to what Todd and Gina wanted. Part of gathering good requirements is recognizing when you've already built something similar to what a customer wants.



Bruce is constantly barking, so I never know if he really wants out or not. Can you build a door that opens up when he scratches it with his paws?

Holly and Bruce's Dog Door

- 1. Bruce scratches at the dog door.
- 2. The dog door opens.
- 3. Bruce goes outside.
- 4. The dog door closes automatically.
- 4. Bruce does his business.
- 5. Bruce scratches at the door again.
- 6. The dog door opens up again.
- 7. Bruce comes back inside.
- 8. The door closes automatically.



Even though John said Tex usually gets muddy, he doesn't have to get muddy ... so that's really an alternate path.

We really need more information to write this use case... looks like we need to ask John some additional questions.

Some of this really wasn't

laid out in

what Holly said, but you should

have figured it out when you

thought through how her system will be used.

John and Tex's Dog Door

- 1. (Somehow) the dog door opens.
- 2. Tex goes outside.
- 3. The dog door closes automatically.

- 4. Tex does his business.
 - 4.1 Tex gets muddy
 - 4.2 John cleans Tex up
- 5. John presses a button.
- 6. The dog door opens.
- 7. Tex comes back inside.



More Use Case Magnets

Remember the three parts of a use case? It's time to put what you've learned into action. On these pages, you'll find several use cases; your job is to match the use case magnets on the bottom of the page to the correct parts of each use case.

Clear Value Super Buy Start and Stop STOP

External Initiator

You can review all of these by flipping back to page 74.

Holly and Bruce's Dog Door

Bruce scratches at the dog door to be let out. The dog door automatically opens, and Bruce goes outside. The dog door closes after a preset time. Bruce goes to the bathroom, and then scratches at the door again. The dog door opens automatically, and Bruce returns inside. The dog door then closes automatically.

If Bruce scratches at the door but stays inside (or stays outside), he can scratch at the door again to re-open it, from inside or outside. Kri

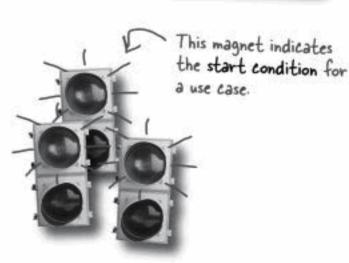
You should be able to follow these alternate use case
formats without much trouble.
If you get confused, check out
Appendix I for the scoop on
alternate use case formats.

Kristen and Bitsie's Dog Door

- 1. Kristen enters a code on a keypad.
- The dog door and all the windows in the house lock.



Use these magnets to indicate the clear value of a use case.



John and Tex's Dog Door

Primary Actor: Tex

Secondary Actor: John

Preconditions: The dog door is open for Tex to go outside.

Goal: Tex uses the bathroom and comes back inside, without getting mud inside the house.

Main Path

- 1. Tex goes outside.
- 2. The dog door closes automatically.
- 3. Tex does his business.
- 4. John presses a button.
- 5. The dog door opens.
- 6 Tex comes back inside.
- 7. The door closes automatically.

Extensions

- 3.1 Tex gets muddy.
- 3.2 John cleans Tex up.

Use this
magnet for the
stop condition —
of a use case.
How do you
know when
the use case is
finished?





Fido here represents the external initiator of a use case, which kicks things off.



Use Case Magnets Solutions

Remember the three parts of a use case? It's time to put what you've learned into action. On these pages, you'll find several use cases (in different formats, no less!); your job is to match the use case magnets on the bottom of the page up to the correct parts of each use case.



Start and Stop





External Initiator

Holly and Bruce's Pog Poor

Broce scratches at the dog door to be let out.
Ine dog door automatically opens, and Bruce
goes outside. The dog door closes after a preset
time. Bruce goes to the bathroom, and then
scratches at the door again. The dog door opens
automatically, and Bruce returns inside. The dog
STOP for then closes automatically.

If Bruce scratches at the door but stays inside (or stays outside), he can scratch at the door again to re-open it, from inside or outside.

Bruce can get
outside to use the
bathroom without
Holly having to open
and close the dog door
(or even listen for
Bruce to bark)

The clear value of a use case—in most formats—isn't stated in the use case, so you'll need to figure it out on your own.

Look closely for the stop condition in this style of use cases; it's usually not the last sentence if there are any alternate paths.

The start condition and external initiator are usually both part of the first step of a use case.

Bitsie can't get outside with Kristen letting her out.

Krist n and Bitsie's Dog Door

. Kristen enters a code on a keypad.

2. The dog door and all the windows in the house lock.

The stop condition is almost always the last step in the use case. In this use case format, the external initiator is always the primary actor.

John and Tex's Do loor

Primary Actor: Tex

Secondary Actor: John

Preconditions: The dog door is open for Tex to go outside.

Goal: Tex uses the bathroom and comes back inside, without getting mud minimale the house.

Main Path

- 1. Tex goes outside.
- 2. The dog door closes automatically.
- 3. Tex does his business.
- 4. John presses a button.
- 5. The dog door opens.
- 6 Tex comes back inside.
- 7. The door closes automatically.

311

Extensions

- 3.1 Tex gets muddy.
- 3.2 John cleans Tex up.

Anytime the goal of a use case is explicitly stated, you've got your clear value.

Look for the last step in the main path, not the last step of the extensions.

Sharpen your pencil

What's the real power of use cases?

You've already seen how use cases help you build a complete requirements list. Below are several more use cases to check out. Your job is to figure out if the requirements list next to each use case covers everything, or if you need to add in additional requirements.

Kristen and Bitsie's Pog Poor Use Case

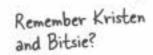
- 1. Kristen enters a code on a keypad.
- 2. The dog door and all the windows in the house lock.

Kristen and Bitsie's Dog Door Requirements List

- 1. The keypad must accept a 4-digit code.
- 2. The keypad must be able to lock the dog door.



Here's the requirements list for Kristen's dog door. Is anything missing or incomplete based on the use case? If so, write in the extra requirements you think the door needs to handle.



Holly and Bruce's Dog Door

Use Case

- 1. Bruce scratches at the dog door.
- 2. The dog door opens.
- 3. Bruce goes outside.
- 4. The dog door closes automatically.
- 4. Bruce does his business.
- 5. Bruce scratches at the door again.
- 6. The dog door opens up again.
- 7. Bruce comes back inside.
- 8. The door closes automatically.

Holly is psyched about life with her new dog door. It just needs to work, and she's all set!



Holly and Bruce's Dog Door Requirements List

- The dog door must detect scratching from a dog.
- The door should be able to open on a command (from #1).

Is anything missing? It's up to you to make sure Holly is a satisfied customer.

→ Answers on page 104

Sharpen your pencil -

What's the real power of use cases?

In each situation below, the use case describes how the dog door should work-but the requirements aren't complete. Here are the things we saw that were missing from the requirement list, based on the ever-helpful use case.

Kristen and Bitsie's Pog Poor Use Case

- 1. Kristen enters a code on a keypad.
- 2. The dog door and all the windows in the house lock.

This one was a little trickier...
the use case doesn't mention
anything about Bitsie getting
back in, so really the use case
and the requirements list are
incomplete. Kristen wouldn't
be too happy if she couldn't
unlock everything, would she?

Kristen and Bitsie's Dog Door Requirements List

- The keypad must accept a 4-digit code.
- The keypad must be able to lock the dog door and all the windows.
- 3. The keypad must be able to unlock the dog door and all the windows in the house.

This
requirement
is incomplete...
Kristen wants
to be able to
lock the doors
and windows.



Be careful! Good use cases make for good requirements, but a bad-or incomplete-use case can result in BAD requirements!

Holly and Bruce's Dog Door

Use Case

- 1. Bruce scratches at the dog door.
- 2. The dog door opens.
- 3. Bruce goes outside.
- 4. The dog door closes automatically.
- 4. Bruce does his business.
- 5. Bruce scratches at the door again.
- 6. The dog door opens up again.
- 7. Bruce comes back inside.
- 8. The door closes automatically.



Holly and Bruce's Dog Door Requirements List

- The dog door must detect scratching from a dog.
- 2. The door should be able to open on a command (from #1).
- The dog door should close automatically.

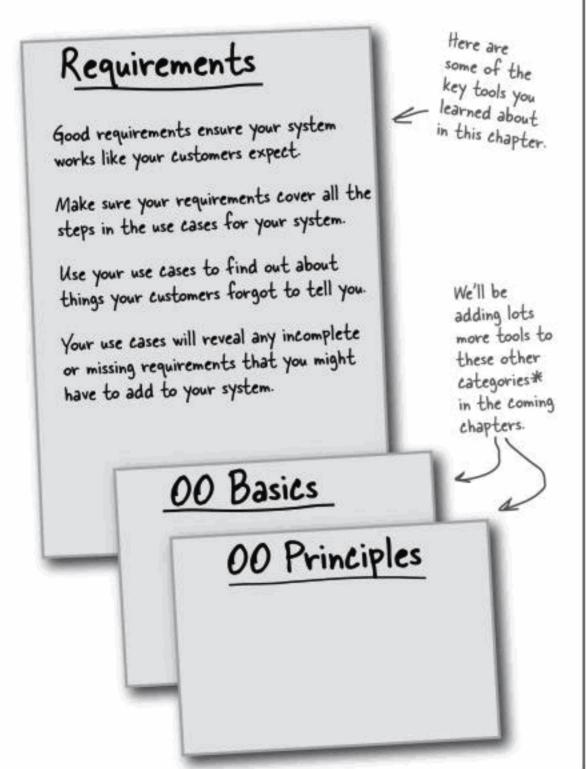
This is one of the same requirements as for Todd and Gina's dog door.



Tools for your OOA&D Toolbox

OOA&D is all about writing great software, and you can't do that without making sure your apps do exactly what customers want them to.

In this chapter, you learned several tools for making sure your customers are smiling when you show them the systems you've built. Here are some key tools to keep handy:



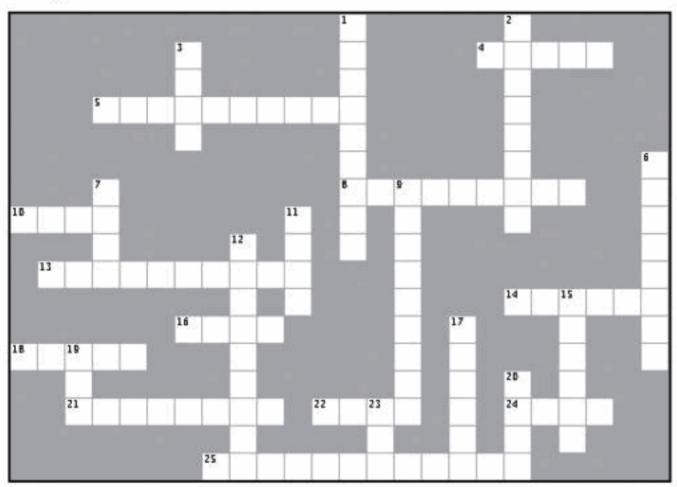


- Requirements are things your system must do to work correctly.
- Your initial requirements usually come from your customer.
- To make sure you have a good set of requirements, you should develop use cases for your system.
- Use cases detail exactly what your system should do.
- A use case has a single goal, but can have multiple paths to reach that goal.
- A good use case has a starting and stopping condition, an external initiator, and clear value to the user.
- A use case is simply a story about how your system works.
- You will have at least one use case for each goal that your system must accomplish.
- After your use cases are complete, you can refine and add to your requirements.
- A requirements list that makes all your use cases possible is a good set of requirements.
- Your system must work in the real world, not just when everything goes as you expect it to.
- When things go wrong, your system must have alternate paths to reach the system's goals.

^{*} Readers of Head First Design Patterns will find these categories familiar... that's because OOAFD and design patterns go hand in hand.



OOA&D Cross



Across

- The main path is sometimes called the _____ path.
- A use case must have this (two words) to the user.
- 8. Requirements ensure that your system works
- 10. In the dog door system, who was the external initiator?
- 13. Use cases focus on a _____ user goal.
- When Fido is here, the dog door has hit its stop condition.
- A use case is just a list of things that a system _____.
- 18. A use case tells a _____ about how a system works.
- Use cases are easeist to understand when they're in this kind of language.
- 22. Good use cases make for _____ requirements.
- A use case helps you understand how a system will be _____.
- 25. Use cases help you gather _____

Down

- A use case details how a system _____
 with users or other systems.
- 2. When things go right, you're on this.
- Use cases are all about the "____" of your system.
- Without use cases, you won't know if your requirements are ______.
- If you have four goals in a system, you'll have at least this many use cases.
- 9. Good systems work in the _____
- 11. Fido does this to signal the start of the dog door system's use case.
- When things go wrong, you end up on an path.
- 15. Fido isn't part of this, but his dog door is.
- This is what you should do to the customer to gather an initial set of requirements.
- 19. How many use cases are there in Todd and Gina's dog door?
- Fido was chasing these when he got stuck outside.
- 23. A requirement documents this many needs.



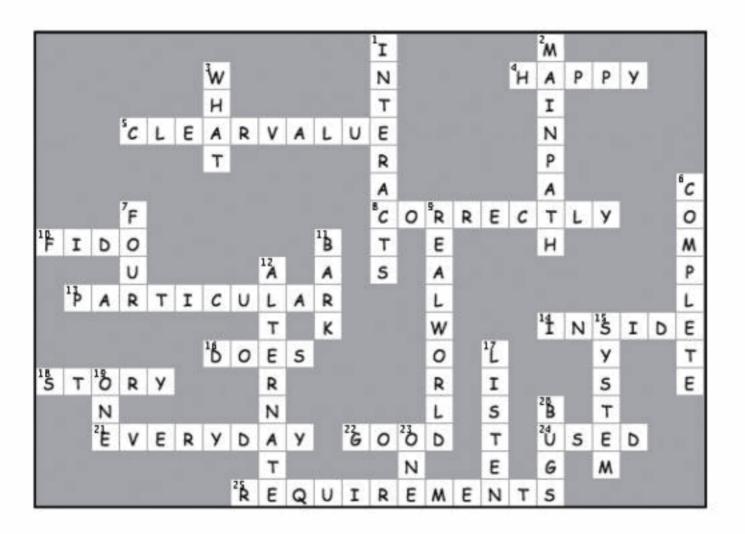
Code Magnets Solutions

The DogDoor class is done, so all you need now is to write a class for the remote control. We've started this class below, but it's your job to finish things up. Using the code magnets at the bottom of the page, complete the code for the Remote class.

Be careful... you may not need all the magnets.

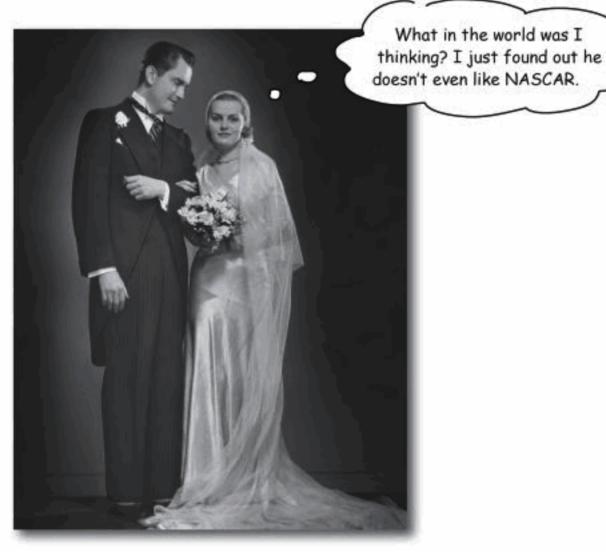
```
public class Remote {
            DogDoor
  private
                        door;
  public Remote(
                   DogDoor
    this.door = door;
  public void pressButton() {
    System.out.println("Pressing the remote control button...");
        (door
      door.
               close
                                                                  boolean
    } else {
               open
      door.
                                                                      true
                                      Here's what's leftover.
                                                               false
                                                                     boolean
                                                          clos
```





3 requirements change

I Love You, You're Perfect... Now Change



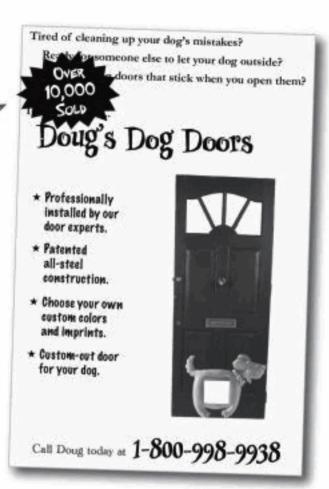
Think you've got just what the customer wanted?

Not so fast... So you've talked to your customer, gathered requirements, written out your use cases, and delivered a killer application. It's time for a nice relaxing cocktail, right? Right... until your customer decides that they really wanted something different than what they told you. They love what you've done, really, but it's not quite good enough anymore. In the real world, requirements are always changing, and it's up to you to roll with these changes and keep your customer satisfied.

You're a hero!

A nice piña colada to sip on, the sun shining down on you, a roll of hundred dollar bills stuffed into your swim trunks... this is the life of a programmer who's just made Doug's Dog Doors a successful venture. The door you built for Todd and Gina was a huge success, and now Doug's selling it to customers all across the world.

Doug's making some serious bucks with your code.



But then came a phone call...

Listen, our dog door's been working great, but we'd like you to come work on it some more...

Todd and Gina, happily interrupting your vacation.

You: Oh, has something gone wrong?

Todd and Gina: No, not at all. The door works just like you said it would.

You: But there must be a problem, right? Is the door not closing quickly enough? Is the button on the remote not functioning?

Todd and Gina: No, really... it's working just as well as the day you installed it and showed everything to us.

You: Is Fido not barking to be let out anymore? Oh, have you checked the batteries in the remote?

Todd and Gina: No, we swear, the door is great. We just have a few ideas about some changes we'd like you to make...

You: But if everything is working, then what's the problem?

We're both tired of having to listen for Fido all the time.

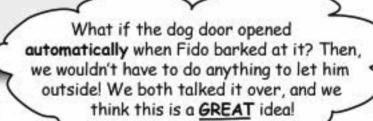
Sometimes, we don't even hear him barking, and he pees inside.

0

And we're
constantly losing that
remote, or leaving it in
another room. I'm tired of
having to push a button to
open the door.



- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- 3. Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1. The door shuts automatically.
 - 6.2. Fido barks to be let back inside.
 - 6.3. Todd or Gina hears Fido barking (again).
 - 6.4. Todd or Gina presses the button on the remote control.
 - 6.5. The dog door opens (again).
- 7. Fido goes back inside.







Back to the drawing board

Time to get working on fixing up Todd and Gina's dog door again. We need to figure out a way to open the door whenever Fido barks. Let's start out by...

Wait a minute... this totally sucks! We already built them a working door, and they said it was fine. And now, just because they had some new idea, we have to make more changes to the door?

The customer is always right

Even when requirements change, you've got to be ready to update your application and make sure it works like your customers expect. When your customer has a new need, it's up to you to change your applications to meet those new needs.

> Doug loves it when this happens, since he gets to charge Todd and Gina for the changes you make.





You've just discovered the one constant in software analysis and design. What do you think that constant is?

The one constant in software analysis and design*

Okay, what's the one thing you can always count on in writing software?

No matter where you work, what you're building, or what language you are programming in, what's the one true constant that will always be with you?



(use a mirror to see the answer)

No matter how well you design an application, over time the application will always grow and change. You'll discover new solutions to problems, programming languages will evolve, or your friendly customers will come up with crazy new requirements that force you to "fix" working applications.

Sharpen	your	pencil
	1	1

Requirements change all the time... sometimes in the middle of a project, and sometimes when you think everything is complete. Write down some reasons that the requirements might change in the applications you currently are working on.

My	eustomer	decided	that	they	wanted	the	application	to	work	differenth	y
----	----------	---------	------	------	--------	-----	-------------	----	------	------------	---

My boss	s thinks my	application	would be	better as	a web app	lication th	an a desktop a

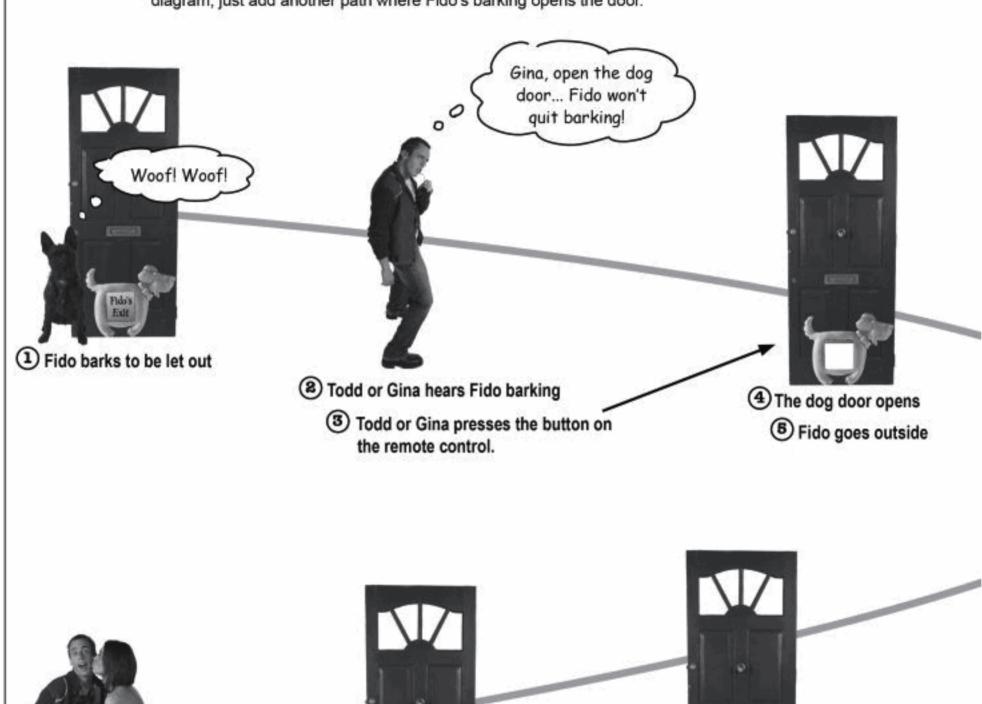
Requirements
always change.
If you've got
good use cases,
though, you can
usually change
your software
quickly to adjust
to those new
requirements.

*If you've read Head First Design Patterns, this page might look a bit familiar. They did such a good job describing change that we decided to just rip off their ideas, and just CHANGE a few things here and there. Thanks, Beth and Eric!

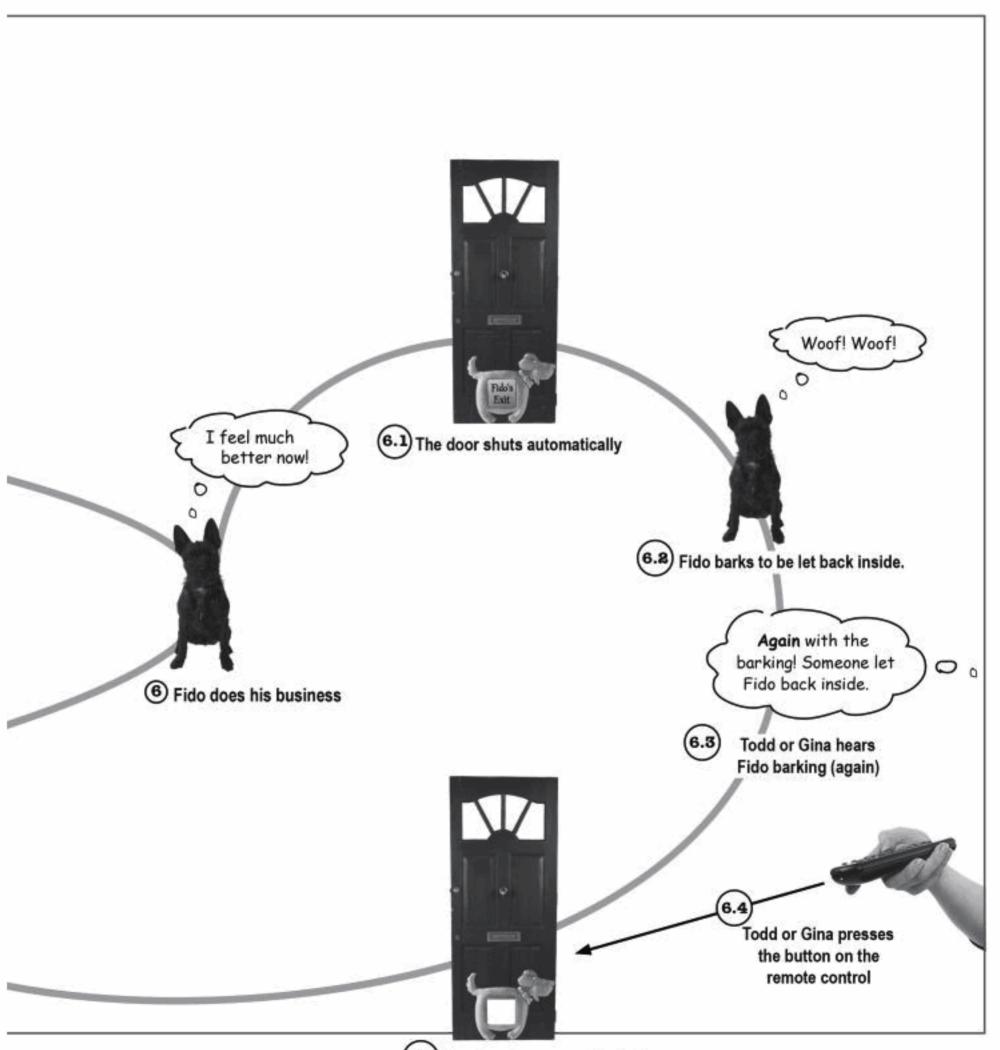


Add bark recognition to Todd and Gina's dog door.

Update the diagram, and add an alternate path where Fido barks, Doug's new bark recognizer hears Fido, and the dog door automatically opens. The remote control should still work, too, so don't remove anything from the diagram; just add another path where Fido's barking opens the door.



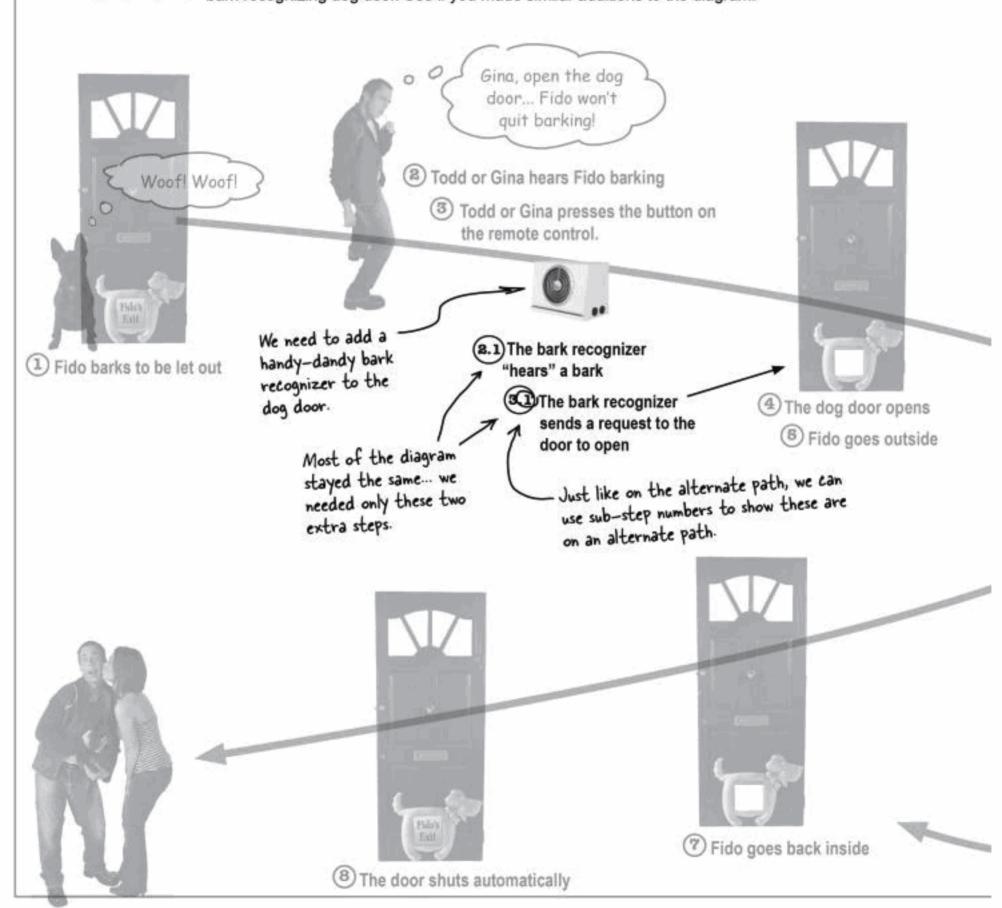


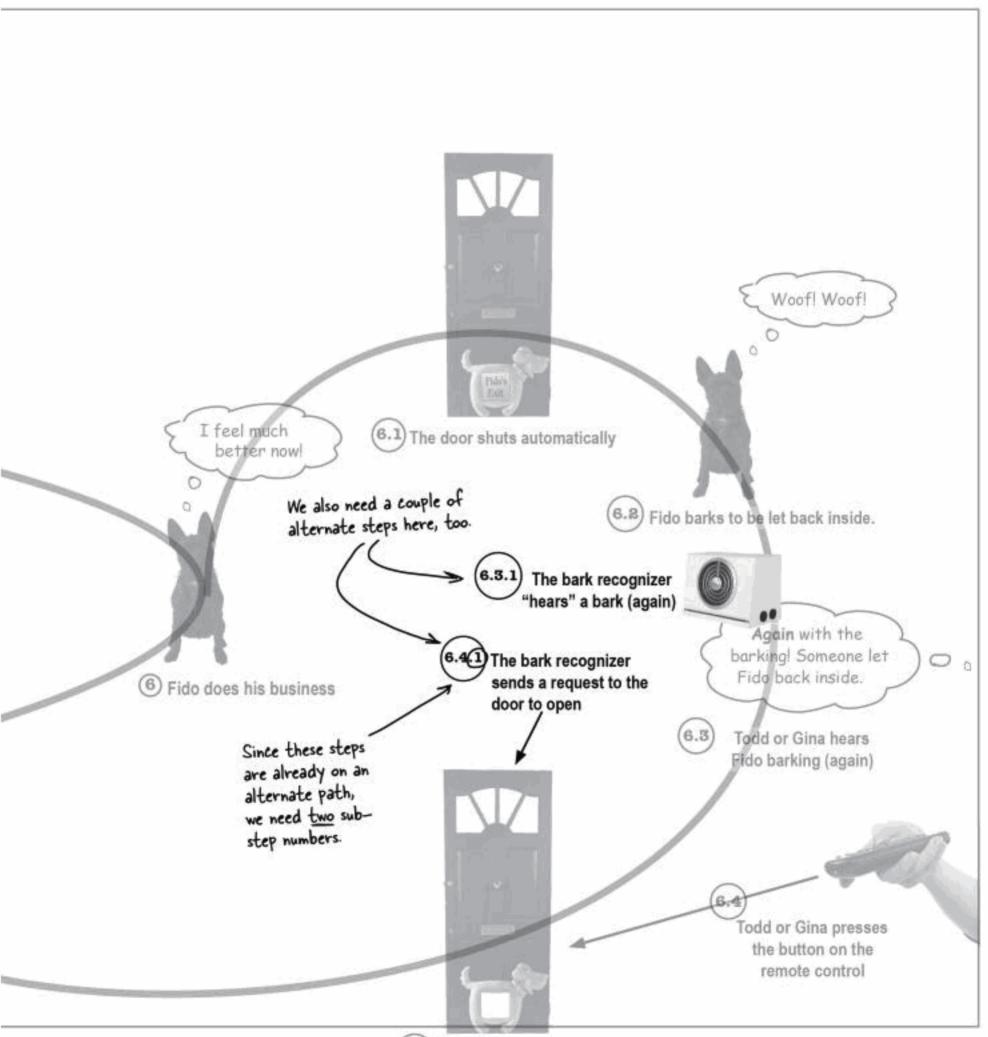




Doug's invented hardware to recognize barks, but it's up to you to figure out how to use his new hardware in the dog door system.

Here's how we solved Todd and Gina's problem, and implemented their bark-recognizing dog door. See if you made similar additions to the diagram.





(6.5) The dog door opens (again)

But now my use case is totally confusing. All these alternate paths make it hard to tell what in the world is going on!

Optional Path? Alternate Path? Who can tell?

Todd and Gina's Pog Poor, version 2.1 What the Poor Poes

- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
 - 2.1. The bark recognizer "hears" a bark.
- 3. Todd or Gina presses the button on the remote control.
 - 3.1. The bark recognizer sends a request to the door to <
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1. The door shuts automatically.
 - 6.2. Fido barks to be let back inside.
 - 6.3. Todd or Gina hears Fido barking (again).
 - 6.3.1. The bark recognizer "hears" a bark (again).
 - 6.4. Todd or Gina presses the button on the remote control.
 - 6.4.1. The bark recognizer sends a request to the door to open.
 - 6.5. The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.



0 0

These are listed as substeps, but they really are providing a completely different path through the use case.

These sub-steps
provide an <u>additional</u>
set of steps that can
be followed...

...but these sub-steps are really a different way to work through the use case.

Even the alternate steps now have alternate steps.

There

are now alternate

steps for

both #2

and #3.

I still think this use
case is confusing. It looks
like Todd and Gina always hear Fido
barking, but the bark recognizer only
hears him sometimes. But that's not
what Todd and Gina want...

Do you see what Gerald is talking about? Todd and Gina's big idea was that they wouldn't have to listen for Fido's barking anymore.

Todd and Gina's Pog Poor, version 2.1 What the Poor Poes

1. Fido barks to be let out.

2. Todd or Gina hears Fido barking.

2.1. The bark recognizer "hears" a bark.

3. Todd or Gina presses the button on the remote control.

3.1. The bark recognizer sends a request to the door to open.

4. The dog door opens.

5. Fido goes outside.

6. Fido does his business.

6.1. The door shuts automatically.

6.2. Fido barks to be let back inside.

6.3. Todd or Gina hears Fido barking (again).

6.3.1. The bark recognizer "hears" a bark (again).

6.4. Todd or Gina presses the button on the remote control.

 6.4.1. The bark recognizer sends a request to the door to open.

6.5. The dog door opens (again).

7. Fido goes back inside.

8. The door shuts automatically.

In the new use case, we really want to say - that either Step 2 or Step 2.1 happens...

0

...and then either Step 3 or Step 3.1 happens.

Here, either Step 6.3 or 6.3.1 happens...

or 6.4.1 happens.

Use cases have to make sense to you

If a use case is confusing to you, you can simply rewrite it. There are tons of different ways that people write use cases, but the important thing is that it makes sense to you, your team, and the people you have to explain it to. So let's rewrite the use case from page 121 so it's not so confusing.

We've moved the steps that can occur instead of the steps on the main path over here to the right.

Todd and Gina's Pog Poor, version 2.2 What the Poor Poes

Now we've added a label—to tell us that these steps on the left are part of the main path.

Main Path

1. Fido barks to be let out.

2. Todd or Gina hears Fido barking.

3. Todd or Gina presses the button on the remote control.

4. The dog door opens.

5. Fido goes outside.

6. Fido does his business.

6.1. The door shuts automatically.

6.2. Fido barks to be let back inside.

6.3. Todd or Gina hears Fido barking (again).

6.4. Todd or Gina presses the button on the remote control.

6.5. The dog door opens (again).

7. Fido goes back inside.

8. The door shuts automatically.

Alternate Paths

2.1. The bark recognizer "hears" a bark.

3.1. The bark recognizer sends a request to the door to open.

This is a little clearer: we can use Step 2, OR Step 2.1, and then Step 3, OR Step 3.1.

6.3.1. The bark recognizer "hears" a bark (again).

6.4.1. The bark recognizer sends a request to the door to open.

These steps on the right can replace Steps 6.3 and 6.4. You can only take one step to work through the use case: either the step on the left, OR the step on the right.

No matter how you work through this use case, you'll always end up at Step 8 on the main path.

the use case.

These sub-steps
are optional... you
may use them, but
you don't have
to. But they're
still on the left,
because they don't

replace steps on

the main path.

When there's

only a single step,

we'll always use

that step when

we go through

If we can really write the use case however we want, can we make the bark recognizer part of the main path?
That's really the path we want to follow most of the time, right?



Excellent idea!

The main path should be what you want to have happen most of the time. Since Todd and Gina probably want the bark recognizer to handle Fido more than they want to use the remote, let's put those steps on the main path:

Todd and Gina's Pog Poor, version 2.3 What the Poor Poes

Main Path

- 1. Fido barks to be let out.
- 2. The bark recognizer "hears" a bark.
- 3. The bark recognizer sends a request to the door to open.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1. The door shuts automatically.
 - 6.2. Fido barks to be let back inside.
 - 6.3. The bark recognizer "hears" a bark (again).
- 6.4. The bark recognizer sends a request to the door to open.
 - 6.5. The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

Alternate Paths

- 2.1. Todd or Gina hears Fido barking.
- 3.1. Todd or Gina presses the button on the remote control.

Todd and Gina won't use the remote most of the time, so the steps related to the remote are better as an alternate path.



- 6.3.1. Todd or Gina hears Fido barking (again).
- 6.4.1. Todd or Gina presses the button on the remote control.

Now the steps that involve the bark recognizer are on the main path, instead of an alternate path.

Start to finish: a single scenario

With all the alternate paths in the new use case, there are lots of different ways to get Fido outside to use the bathroom, and then back in again. Here's one particular path through the use case:

Each path through this use case starts with Step 1.

Todd and Gina's Dog Door, version 2.3 What the Poor Poes

Main Path

Alternate Paths

1. Fido barks to be let out.

2. The bark recognizer "hears" a bark.

- 3. The bark recognizer sends a request to the door to open.
- 4. The dog door opens. $<\!\!<$
- Fido goes outside.
- 6. Fido does his business.
 - 6.1. The door shuts automatically.
 - 6.2. Fido barks to be let back inside.
 - 6.3. The bark recognizer "hears" a bark (again).
 - 6.4. The bark recognizer sends a request to the door to open.
 - 6.5. The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

2.1. Todd or Gina hears Fido barking.

3.1. Todd or Gina presses the button on the remote control.

We'll take the optional sub-path here, where Fido gets stuck outside.

- 6.3.1. Todd or Gina hears Fido barking (again).
- 6.4.1. Todd or Gina presses the button on the remote control.

We're letting Todd and Gina handle opening the door again, on the alternate path.

Following the arrows gives you a particular path through the use case. A path like this is called a scenario There are usually several possible scenarios in a single use case.

You'll always end up at Step 8, with Fido back inside.

Let's take this alternate path, and let Todd and Gina handle opening the door with the remote.

Dumb Questions

Q: I understand the main path of a use case, but can you explain what an alternate path is again?

A: An alternate path is one or more steps that a use case has that are optional, or provide alternate ways to work through the use case. Alternate paths can be additional steps added to the main path, or provide steps that allow you to get to the goal in a totally different way than parts of the main path.

So when Fido goes outside and gets stuck, that's part of an alternate path, right?

A: Right. In the use case, Steps 6.1, 6.2, 6.3, 6.4, and 6.5 are an alternate path. Those are additional steps that the system may go through, and are needed only when Fido gets stuck outside. But it's an alternate path because Fido doesn't always get stuck outside—the system could go from Step 6 directly on to Step 7.

Q: And we use sub-steps for that, like 6.1 and 6.2?

A: Exactly. Because an alternate path that has additional steps is just a set of steps that can occur as part of another step on the use case's main path. When Fido gets stuck outside, the main path steps are 6 and 7, so the alternate path steps start at 6.1 and go through 6.5; they're an optional part of Step 6.

Q: So what do you call it when you have two different paths through part of a use case?

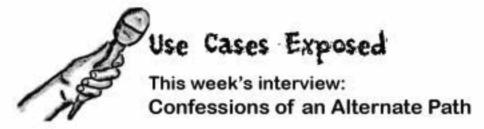
A: Well, that's actually just another kind of alternate path. When Fido barks, there's one path that involves Todd and Gina hearing Fido and opening the door, and another path that involves the bark recognizer hearing a bark and opening the door. But the system is designed for one or the other—either the remote opens the door, or the bark recognizer does—not both.

Q: Can you have more than one alternate path in the same use case?

A: Absolutely. You can have alternate paths that provide additional steps, and multiple ways to get from the starting condition to the ending condition. You can even have an alternate path that ends the use case early... but we don't need anything that complicated for Todd and Gina's dog door.

A complete path through a use case, from the first step to the last, is called a scenario.

Most use cases have several different scenarios, but they always share the same user goal.



HeadFirst: Hello, Alternate Path. We've been hearing that you're really unhappy these days. Tell us what's going on.

Alternate Path: I just don't feel very included sometimes. I mean, you can hardly put together a decent use case without me, but I still seem to get ignored all the time.

HeadFirst: Ignored? But you just said you're part of almost every use case. It sounds like you're quite important, really.

Alternate Path: Sure, it may sound that way. But even when I'm part of a use case, I can get skipped over for some other set of steps. It really sucks... it's like I'm not even there!

HeadFirst: Can you give us an example?

Alternate Path: Just the other day, I was part of a use case for buying a CD at this great new online store, Musicology. I was so excited... but it turned out that I handled the situation when the customer's credit card was rejected.

HeadFirst: Well, that sounds like a really important job! So what's the problem?

Alternate Path: Well, yeah, I guess it's important, but I always get passed over. It seems like everyone was ordering CDs, but their credit cards were all getting accepted. Even though I was part of the use case, I wasn't part of the most common scenarios.

HeadFirst: Oh, I see. So unless someone's credit card was rejected, you were never involved.

Alternate Path: Exactly! And the finance and security guys loved me, they just went on and on about how much I'm worth to the company, but who wants to sit there unused all the time?

HeadFirst: I'm starting to get the picture. But you're still helping the use case, right? Even if you're not used all the time, you're bound to get called on once in a while.

Alternate Path: That's true; we all do have the same goal. I just didn't realize that I could be important to the use case and still hardly ever get noticed.

HeadFirst: Well, just think... the use case wouldn't be complete without you.

Alternate Path: Yeah, that's what 3.1 and 4.1 keep telling me. Of course, they're part of the alternate path for when customers already have an account on the system, so they get used constantly. Easy for them to say!

HeadFirst: Hang in there, Alternate Path. We know you're an important part of the use case!

Sharpen your pencil

How many scenarios are in Todd and Gina's use case?

How many different ways can you work your way through Todd and Gina's use case? Remember, sometimes you have to take one of multiple alternate paths, and sometimes you can skip an alternate path altogether.

Todd and Gina's Pog Poor, version 2.3 What the Door Does Main Path Alternate Paths 1. Fido barks to be let out. 2. The bark recognizer "hears" a bark. 2.1. Todd or Gina hears Fido barking. 3. The bark recognizer sends a request 3.1. Todd or Gina presses the button to the door to open. on the remote control. 4. The dog door opens. < 5. Fido goes outside. 6. Fido does his business. 6.1. The door shuts automatically. 6.2. Fido barks to be let back inside. 6.3. The bark recognizer "hears" a 6.3.1. Todd or Gina hears Fido bark (again). barking (again). 6.4. The bark recognizer sends a 6.4.1. Todd or Gina presses the request to the door to open. button on the remote control. 6.5. The dog door opens (again). 7. Fido goes back inside. 8. The door shuts automatically.

We've written
out the steps we
followed for the
scenario highlighted
above to help get
you started.

1. 1, 21, 31, 4, 5, 6, 6.1, 6.2, 6.3.1, 6.4.1, 6.5, 7, 8	5
2	6
3	7

4	8	

Check out our answers on the next page



How many scenarios are in Todd and Gina's use case?

How many different ways can you work your way through Todd and Gina's use case? Remember, sometimes you have to take one of multiple alternate paths, and sometimes you can skip an alternate path altogether.

Todd and Gina's Pog Poor, version 2.3 What the Poor Poes

Main Path

1. Fido barks to be let out.

- 2. The bark recognizer "hears" a bark.
- 3. The bark recognizer sends a request to the door to open.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1. The door shuts automatically.
 - 6.2. Fido barks to be let back inside.
 - 6.3. The bark recognizer "hears" a bark (again).
 - 6.4. The bark recognizer sends a request to the door to open.
 - 6.5. The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

Alternate Paths

- 2.1. Todd or Gina hears Fido barking.
- 31. Todd or Gina presses the button on the remote control.

- 6.3.1. Todd or Gina hears Fido barking (again).
- 6.4.1. Todd or Gina presses the button on the remote control.

This is just the use case's main path.

These two

don't take

the optional ~

path where

alternate

Fido gets stuck outside.

4. 1, 2.1, 3.1, 4, 5, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 7, 8

If you take Step 2.1, you'll always also take Step 3.1.

When you take 6.3.1, you'll also take Step 6.4.1.

5. 1, 2, 3, 4, 5, 6, 6.1, 6.2, 6.3.1, 6.4.1, 6.5, 7, 8

6. 1, 2.1, 3.1, 4, 5, 6, 6.1, 6.2, 6.3.1, 6.4.1, 6.5, 7, 8

7. 1, 2, 3, 4, 5, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 7, 8

8 < nothing else>

Let's get ready to code...

Now that our use case is finished up, and we've figured out all the possible scenarios for using the dog door, we're ready to write code to handle Todd and Gina's new requirements. Let's figure out what we need to do...

I think we should recheck our requirements list against the new use case. If Todd and Gina's requirements changed, then our requirements list might change too, right?

Any time you change your use case, you need to go back and check your requirements.

Remember, the whole point of a good use case is to get good requirements. If your use case changes, that may mean that your requirements change, too. Let's review the requirements and see if we need to add anything to them.



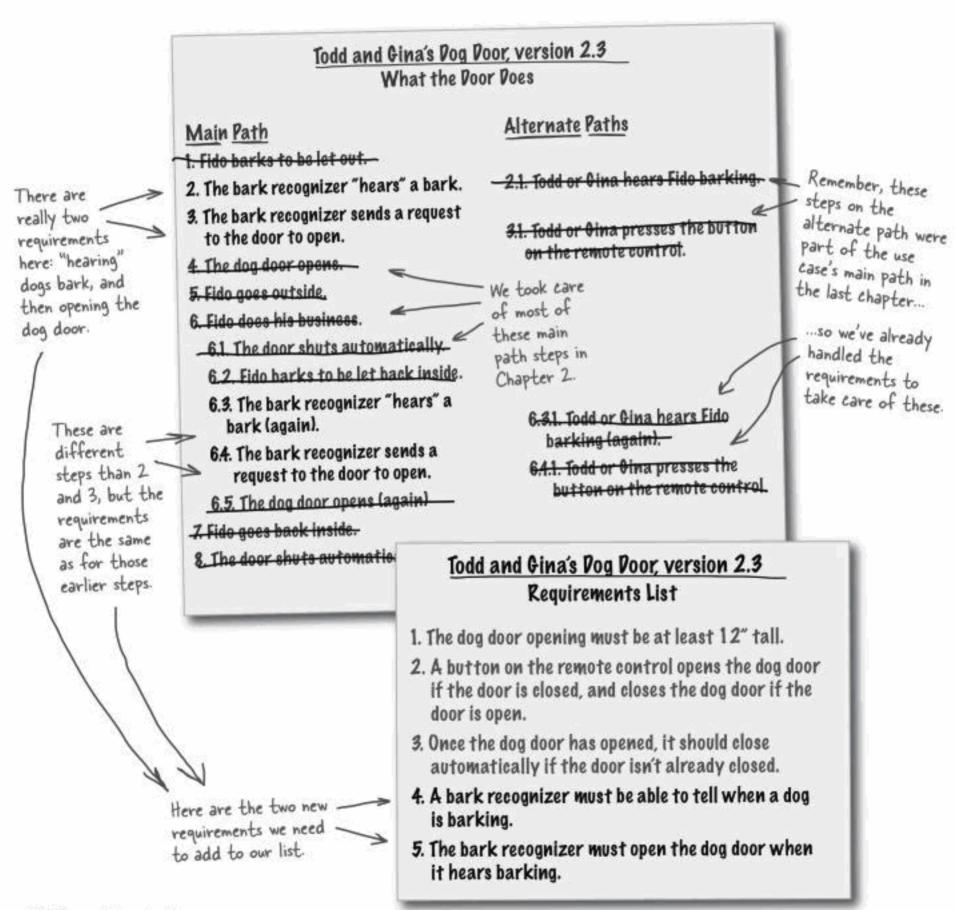
- 1. The dog door opening must be at least 12" tall.
- A button on the remote control opens the dog door if the door is closed, and closes the dog door if the door is open.
- 3. Once the dog door has opened, it should close automatically if the door isn't already closed.

Go ahead and write in any additional requirements that you've discovered working through the scenarios for the new dog door on page 128.



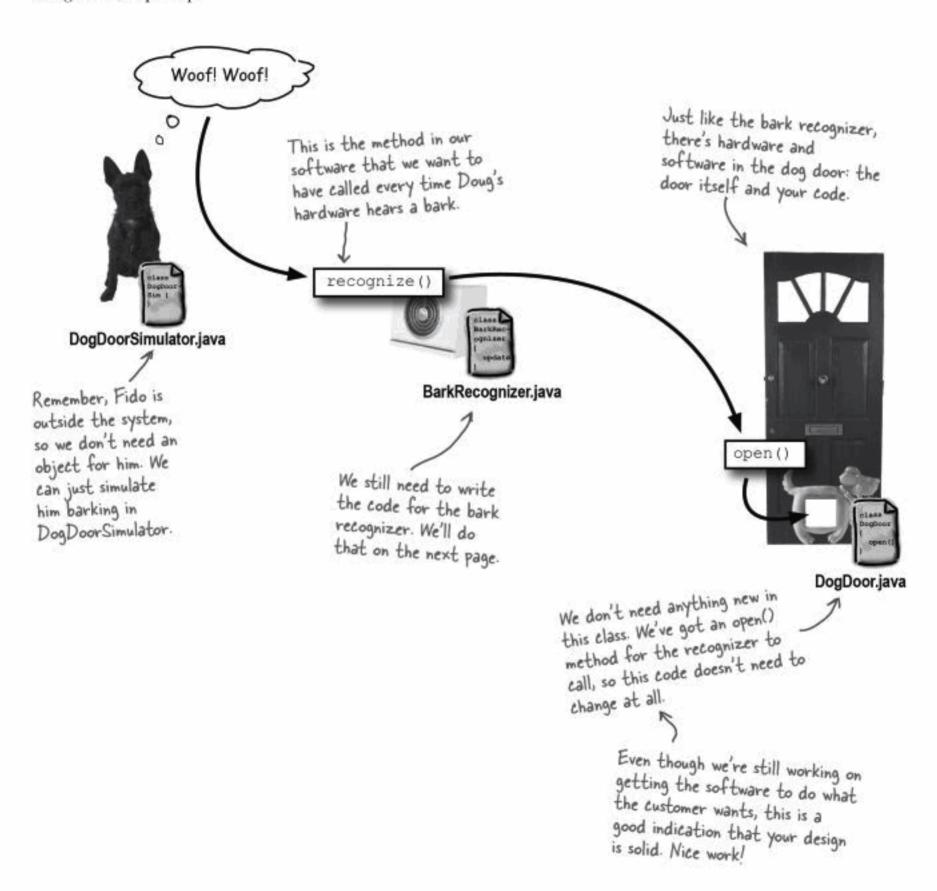
Finishing up the requirements list

So we need to handle the two new alternate paths by adding a couple extra requirements to our requirements list. We've gone ahead and crossed off the steps that our requirements already handle, and it looks like we need a few additions to our requirements list:



Now we can start coding the dog door again

With new requirements comes new code. We need some barking, a bark recognizer to listen for barking, and then a dog door to open up:



Was that a "woof" I heard?

We need some software to run when Doug's hardware "hears" a bark. Let's create a **BarkRecognizer** class, and write a method that we can use to respond to barks:



```
We'll store the dog door that this
                                           bark recognizer is attached to in
                                           this member variable.
public class BarkRecognizer {
                                                   The BarkRecognizer needs to know
  private DogDoor door;
                                                 which door it will open-
  public BarkRecognizer (DogDoor door)
                                                          Every time the hardware hears a bark, it will call this method with
     this.door = door;
                                                          the sound of the bark it heard.
  public void recognize (String bark) {
                                    BarkRecognizer: Heard a " +
     System.out.println("
          bark + "'");
                               All we need to do is output a
     door.open();
                               message letting the system know
                               we heard a bark ...
                           - ... and then open up
                             the dog door.
```

Dumb Questions

Q: That's it? It sure seems like the BarkRecognizer doesn't do very much.

A: Right now, it doesn't. Since the requirements are simple—when a dog barks, open the door—your code is pretty simple, too. Any time the hardware hears a bark, it calls recognize() in our new BarkRecognizer class, and we open the dog door. Remember, keep things as simple as you can; there's no need to add complexity if you don't need it.

Q: But what happens if a dog other than Fido is barking? Shouldn't the BarkRecognizer make sure it's Fido that is barking before opening the dog door?

A: Very interesting question! The BarkRecognizer hears all barks, but we really don't want it to open the door for just any dog, do we? We may have to come back and fix this later. Maybe you should think some more about this while we're testing things out.

I think with this new class, we've got everything we need. Let's test out the BarkRecognizer and see if we can make Todd and Gina happy again.

First, let's make sure we've taken care of Todd and Gina's new requirements for their door:

This is another hardware requirement for Doug. For now, we can use the simulator to get a bark to the recognizer, and test the software we wrote.

Todd and Gina's Pog Poor, version 2.3 Requirements List

- 1. The dog door opening must be at least 12" tall.
- A button on the remote control opens the dog door if the door is closed, and closes the dog door if the door is open.
- 3. Once the dog door has opened, it should close automatically if the door isn't already closed.
- A bark recognizer must be able to tell when a dog is barking.
- The bark recognizer must open the dog door when it hears barking.



Hmmm... our bark recognizer isn't really "recognizing" a bark, is it? It's opening the door for ANY bark. We may have to come back to this later.



Power up the new dog door

Use cases, requirements, and code have all led up to this. Let's see if everything works like it should.

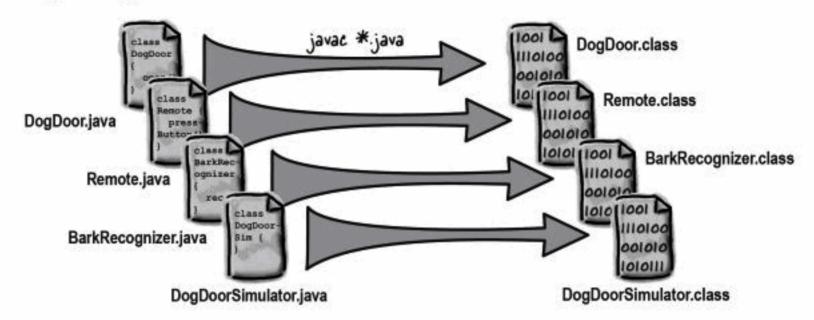


1 Update the DogDoorSimulator source code:

```
public class DogDoorSimulator (
           public static void main(String[] args) {
                                                                           Create the
              DogDoor door = new DogDoor();
                                                                            BarkRecognizer,
             BarkRecognizer recognizer = new BarkRecognizer (door); connect it to
                                                                            the door, and
              Remote remote = new Remote(door);
                                                                            let it listen for
                 Simulate the hardware hearing a bark
                                                                            some barking.
We don't have
              System.out.println("Fido starts barking.");
real hardware,
              recognizer.recognize("Woof"); <
                                                                           Here's where
so we'll just
                                                                           our new
simulate the
              System.out.println("\nFido has gone outside...");
                                                                           BarkRecognizer
hardware
                                                                          software gets to
hearing a
              System.out.println("\nFido's all done...");
                                                                          go into action.
 bark.*
              try {
                Thread.currentThread().sleep(10000);
              } catch (InterruptedException e) { }
 We simulate
 some time
              System.out.println("...but he's stuck outside!");
 passing here.
                                                                          Fido's outside,
              // Simulate the hardware hearing a bark again
              System.out.println("Fido starts barking.");
                                                                           everything works
              recognizer.recognize("Woof");
              System.out.println("\nFido's back inside...");
                                                                 Notice that Todd and
                                                                 Gina never press a
                                                                 button on the remote
                                                                 this time around.
```

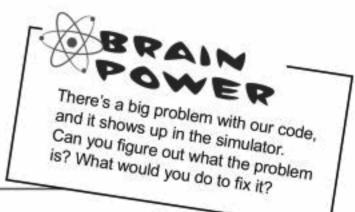
*The authors of this book sincerely wanted to include hardware that could hear dogs barking... but marketing insists that nobody would buy a book priced at \$299.95. Go figure!

Recompile all your Java source code into classes.



Run the code and watch the humanless dog door go into action.





Sharpen your pencil

pass here

while Fido

plays outside.

Which scenario are we testing?

Can you figure out which scenario from the use case we're testing? Write down the steps this simulator follows (flip back to page 123 to see the use case again):

Sharpen your pencil _ answers

Which scenario are we testing?

Did you figure out which scenario from the use case we're testing? Here are the steps from the use case on page 123 that we followed:

1, 2, 3, 4, 5, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 7, 8



There's a big problem with our code, and it shows up in the simulator.
Can you figure out what the problem is? What would you do to fix it?

Did you figure out what was wrong with our latest version of the dog door?

In our new version of the dog door, the door doesn't automatically close!

In the scenarios where Todd and Gina press the button on the remote control, here's the code that runs:

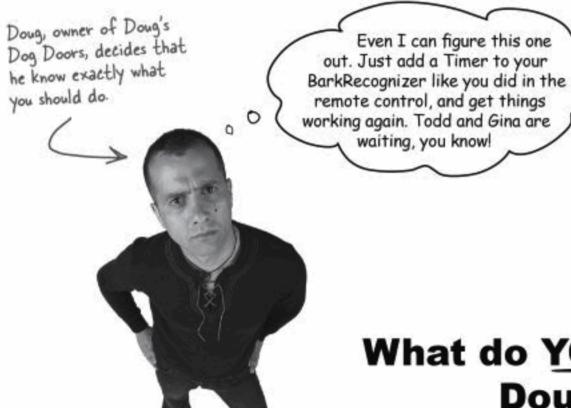
```
public void pressButton() {
                   System.out.println("Pressing the remote control button...");
                   if (door.isOpen()) {
                     door.close();
                   ) else {
                     door.open();
                     final Timer timer = new Timer();
                                                                 Remember, this timer waits
                     timer.schedule(new TimerTask() {
                                                                 5 seconds, and the sends a
When Todd
                                                                 request to the dog door to
and Gina press
                        public void run() {
the button on
                          door.close();
                                                                 close itself.
                          timer.cancel();
the remote,
this code
                      }, 5000);
also sets up
a timer to
 close the door
 automatically.
```

But in **BarkRecognizer**, we open the door, and never close it:

```
public void recognize(String bark) {
   System.out.println(" BarkRecognizer: " +
    "Heard a '" + bark + "'");
   door.open();

   We open the door,
   but never close it.

BarkRecognizer.java
```



What do <u>YOU</u> think about Doug's idea?

I think Doug's lame. I don't want to put the same code in the remote and in the bark recognizer.



Duplicate code is a bad idea. But where <u>should</u> the code that closes the door go?

Well, closing the door is really something that the **door** should do, not the remote control or the BarkRecognizer. Why don't we have the DogDoor close itself?

Let's have the dog door close automatically <u>all</u> the time.

Since Gina never wants the dog door left open, the dog door should always close automatically. So we can move the code to close the door automatically into the **DogDoor** class. Then, no matter what opens the door, it will always close itself.

Even though this is a design decision, it's part of getting the software to work like the customer wants it to. Remember, it's OK to use good design as you're working on your system's functionality.

Updating the dog door

Let's take the code that closed the door from the **Remote** class, and put it into our **DogDoor** code:



```
You'll have to add
imports for java.util.
Timer and java.util.
TimerTask, too.
```

```
public class DogDoor {
  public void open() {
    System.out.println("The dog door opens.");
    open = true;
                                               This is the same code
    final Timer timer = new Timer();
                                               that used to be in
    timer.schedule(new TimerTask()
                                               Remote java.
      public void run() {
         close();
         timer.cancel();
                              Now the door closes
                              itself ... even if we add
    }, 5000);
                              new devices that can
                              open the door. Nice!
  public void close() {
    System.out.println("The dog door closes.");
    open = false;
```

Simplifying the remote control

You'll need to take this same code out of **Remote** now, since the dog door handles automatically closing itself:

A final test drive

You've made a lot of changes to Todd and Gina's dog door since they first called you up. Let's test things out and see if everything works. Make the changes to **Remote.java** and **DogDoor.java** so that the door closes itself, compile all your classes again, and run the simulator:

File Edit Window Help PestControl
% java DogDoorSimulator
Fido starts barking.
BarkRecognizer: Heard a 'Woof'
The dog door opens.
Fido has gone outside...
Fido's all done...
The dog door closes.
...but he's stuck outside!
Fido starts barking.
BarkRecognizer: Heard a 'Woof'
The dog door opens.
Fido's back inside...
Fido's back inside...
The dog door closes.



What would happen if Todd and Gina decided they wanted the door to stay open longer? Or to close more quickly? See if you can think of a way to change the DogDoor so that the amount of time that passes before the door automatically closes can be set by the customer.

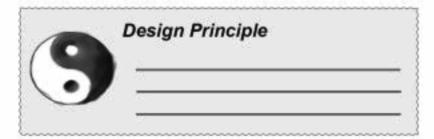
Sometimes a change in requirements reveals problems with your system that you didn't even know were there.

Change is constant, and your system should always <u>improve</u> every time you work on it.

-			- 4
Chan	non	MINI	noncil
TO ICE	Den	wu	pencil
		1000	

Write your own design principle!

You've used an important design principle in this chapter related to duplicating code, and the dog door closing itself. Try and summarize the design principle that you think you've learned:



You won't find an answer to this puzzle in the chapter, but we're going to come back to this a little later. Still, take your best guess!



More

Tools for your OOA&D Toolbox

You've learned a lot in this chapter, and now it's time to add what you've picked up to your OOA&D toolbox. Review what you've learned on this page, and then get ready to put it all to use in the OOA&D cross on the next page.

Requirements

Good requirements ensure your system works like your customers expect.

Make sure your requirements cover all the steps in the use cases for your system.

Use your use cases to find out about things your customers forgot to tell you.

Your use cases will reveal any incomplete or missing requirements that you might have to add to your system.

Your requirements will always change (and grow) over time.

There was
just one new
requirement
principle you
learned, but it's
an important one!

00 Principles

Encapsulate what varies.

Encapsulation helped us realize that the dog door should handle closing itself. We separated the door's behavior from the rest of the code in our app.

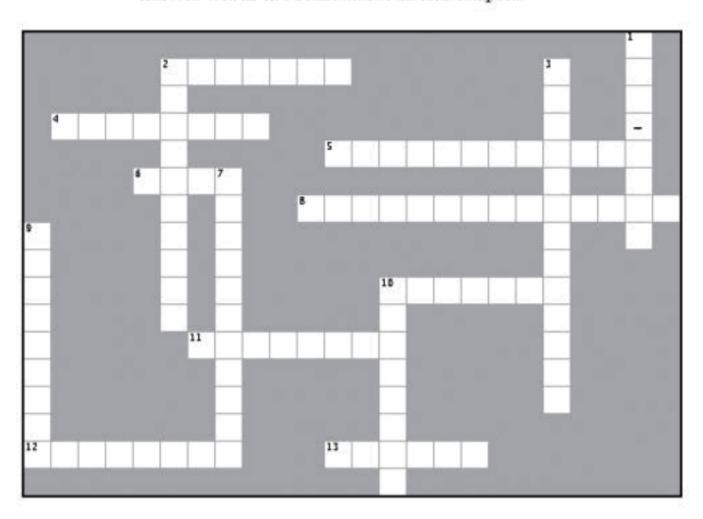
BULLET POINTS

- Requirements will always change as a project progresses.
- When requirements change, your system has to evolve to handle the new requirements.
- When your system needs to work in a new or different way, begin by updating your use case.
- A scenario is a single path through a use case, from start to finish.
- A single use case can have multiple scenarios, as long as each scenario has the same customer goal.
- Alternate paths can be steps that occur only some of the time, or provide completely different paths through parts of a use case.
- If a step is optional in how a system works, or a step provides an alternate path through a system, use numbered substeps, like 3.1, 4.1, and 5.1, or 2.1.1, 2.2.1, and 2.3.1.
- You should almost always try to avoid duplicate code. It's a maintenance nightmare, and usually points to problems in how you've designed your system.



OOA&D Cross

The puzzles keep coming. Make sure you've gotten all the key concepts in this chapter by working this crossword. All the answer words are somewhere in this chapter.



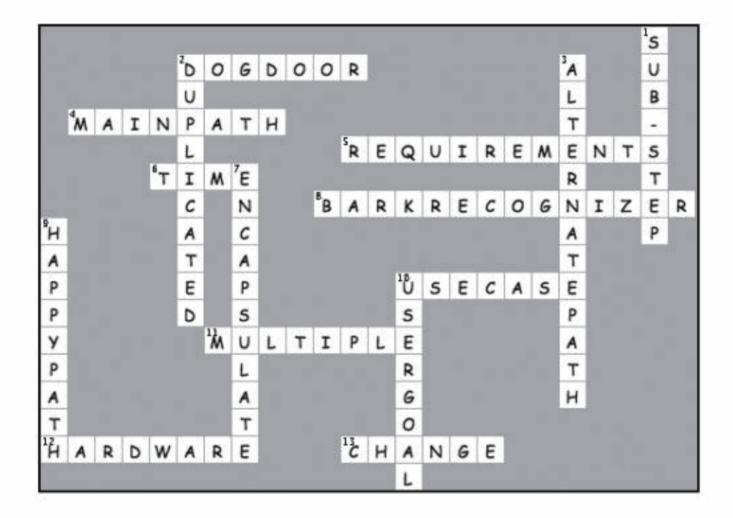
Across

- We made this responsible for closing the dog door.
- This is what you follow in a use case most of the time.
- When your use case changes, these often change as well.
- Requirements always change over _____
- We had to add this to our dog door to satisfy Todd and Gina.
- When your system changes, you should always update this before writing code.
- 11. Use cases often have ______ scenarios.
- Many real-world applications involve both software and this.
- The one constant in software analysis and design.

Down

- If a step is optional, use this in your use case.
- 2. Always avoid _____ code
- A set of steps that don't always occur in your use case.
- 7. Do this to things that vary.
- 9. The main path is also called this.
- Every scenario in a use case shares the same _____





4 analysis

Taking Your Software into the Real World



It's time to graduate to real-world applications.

Your application has to do more than work on your own personal development machine, finely tuned and perfectly set up; your apps have to work when real people use them. This chapter is all about making sure that your software works in a real-world context. You'll learn how textual analysis can take that use case you've been working on and turn it into classes and methods that you know are what your customers want. And when you're done, you too can say: "I did it! My software is ready for the real world!"

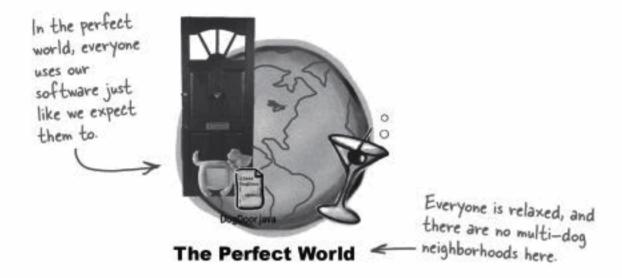
One dog, two dog, three dog, four...

Things are going well at Doug's Dog Doors. The version of the dog door you just developed in Chapter 3 is selling like crazy... but as more doors get installed, complaints have started coming in:

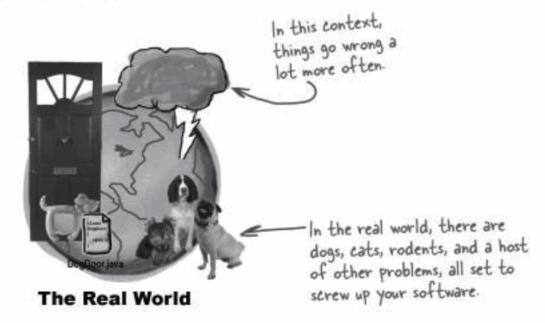


Your software has a context

So far, we've worked on writing software in a vacuum, and haven't really thought much about the context that our software is running in. In other words, we've been thinking about our software like this:

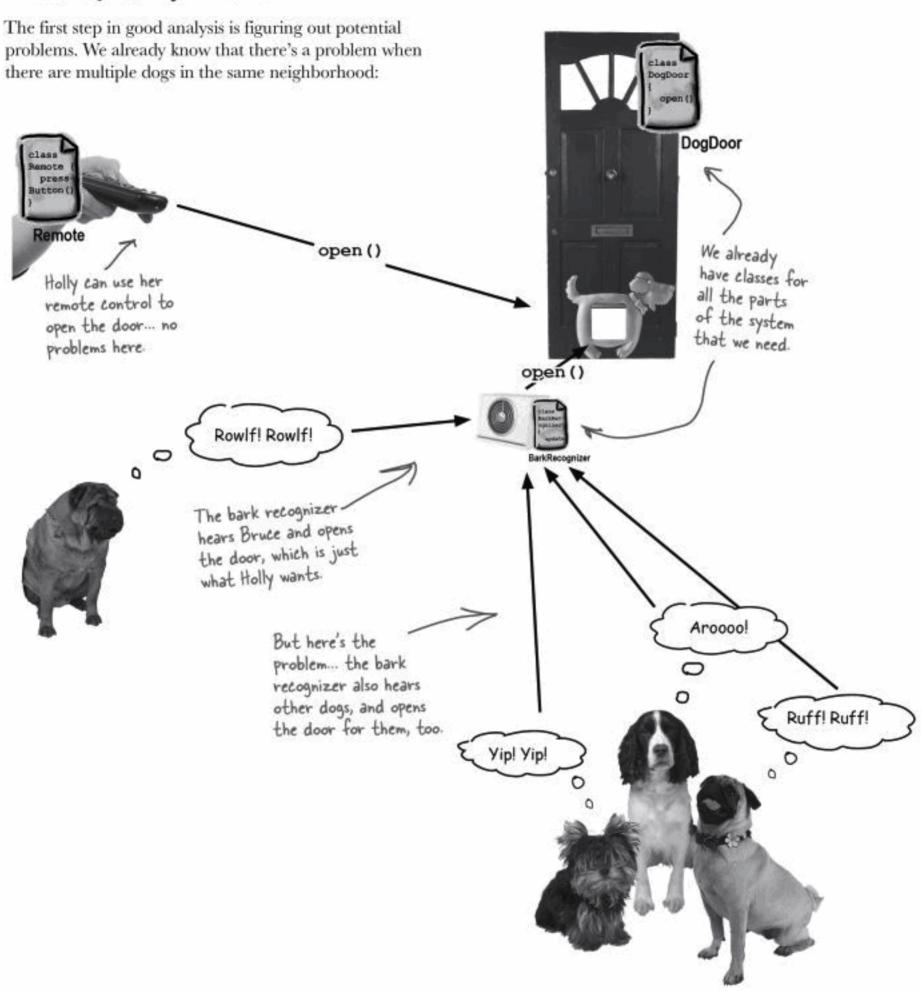


But our software has to **work in the real world**, not just in a perfect world. That means we have to think about our software in a different context:

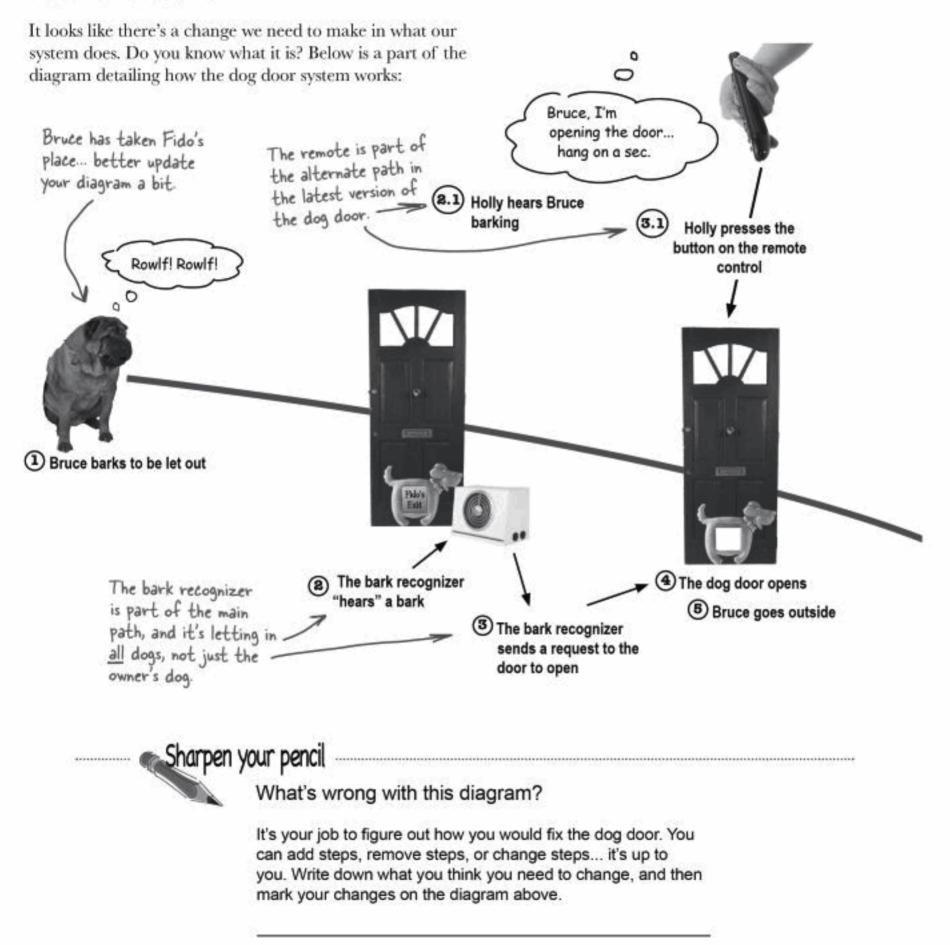


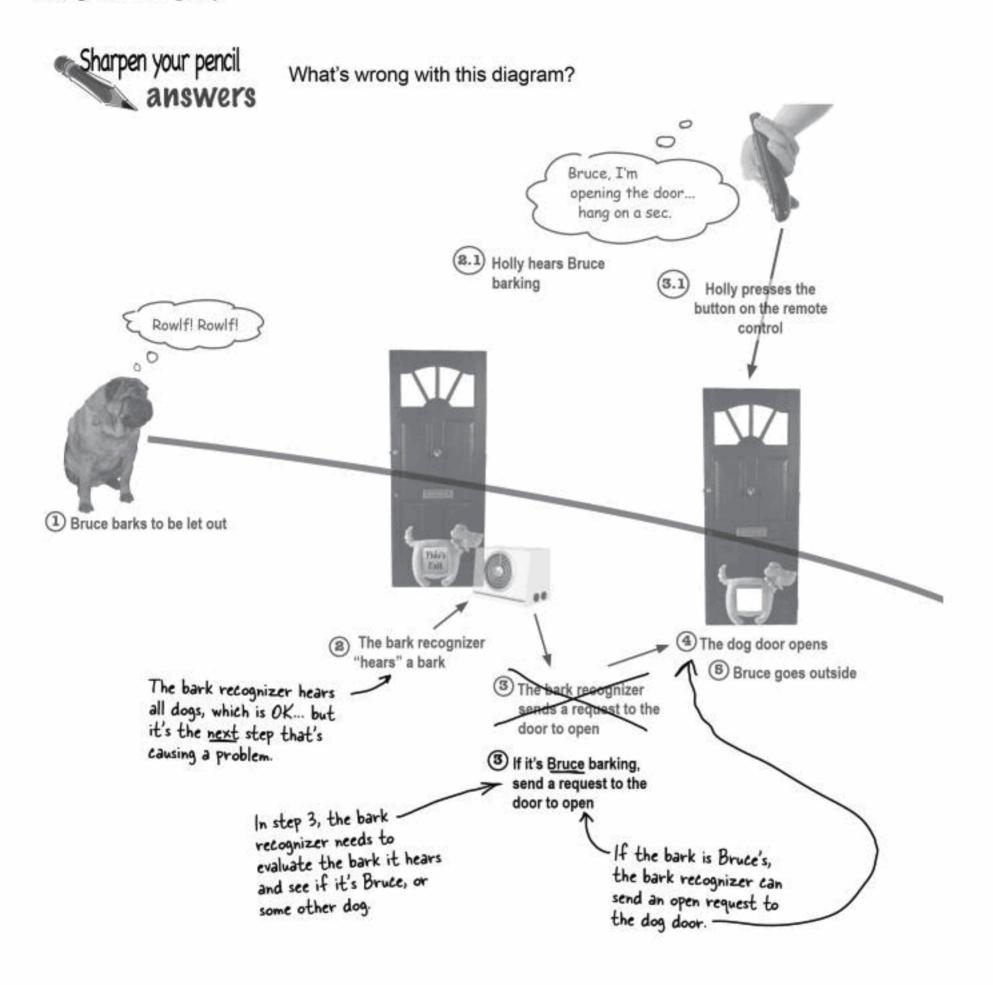
The key to making sure things work and that the real world doesn't screw up your application is **analysis**: figuring out potential problems, and then solving those problems—before you release your app out into the real world. Analysis helps
you ensure
your system
works in a
real-world
context.

Identify the problem



Plan a solution





Dumb Questions

Q: I came up with a different solution.

Does that mean my solution is wrong?

A: No, as long as your solution kept all the dogs except for Bruce from going in and out of the dog door. That's what makes talking about software so tricky: there's usually more than one way to solve a problem, and there's not always just one "right" solution.

O: In my solution, I turned step 3 of the original use case into two steps, instead of just replacing the existing step. Where did I go wrong?

A: You didn't go wrong. Just as there is usually more than one solution to a problem, there is usually more than one way to write that solution in a use case. If you use more than one step, but have the scenario with other dogs barking handled, then you've got a working use case.

Q: So these use cases really aren't that precise, are they?

A: Actually, use cases are very precise. If your use case doesn't detail exactly what your system is supposed to do, then you could miss an important requirement or two and end up with unhappy customers.

But, use cases don't have to be very formal; in other words, your use case may not look like ours, and ours might not look like anyone else's. The important thing is that your use case makes sense to you, and that you can explain it to your co-workers, boss, and customers. Write your use cases in a way that makes sense to you, your boss, and your customers.

Analysis and your use cases let you show customers, managers, and other developers how your system works in a <u>real world</u> context.



There's an important addition that needs to be made to the dog door system, in addition to what's shown on page 150. What is it?

Update your use case

Since we've changed our dog door diagram, we need to go back to the dog door use case, and update it with the new steps we've figured out. Then, over the next few pages, we'll figure out what changes we need to make to our code.

We've removed all the references to specific owners and dogs, so now this use case will work for all of Doug's customers.

Bye bye, Fido. Let's use "the owner's dog" from now on.

Here is the

with only

in and out

the door.

allowing the owner's dog

updated step that deals

The Ultimate Pog Poor, version 3.0 What the Poor Poes

Main Path

- 1. The owner's dog barks to be let out.
- 2. The bark recognizer "hears" a bark.

3. If it's the owner's dog barking, the bark recognizer sends a request to the door to open.

- 4. The dog door opens.
- 5. The owner's dog goes outside.
- 6. The owner's dog does his business.
 - 6.1. The door shuts automatically.
 - 6.2. The owner's dog barks to be let back inside.
 - 6.3. The bark recognizer "hears" a bark (again).
- 6.4. If it's the owner's dog barking, the bark recognizer sends a request to the door to open.
 - 6.5. The dog door opens (again).
- 7. The owner's dog goes back inside.
- 8. The door shuts automatically.

Alternate Paths

- 2.1. The owner hears her dog barking.
- 3.1. The owner presses the button on the remote control.

Instead of Todd and Gina, or Holly, let's just use "The owner."

Don't forget to change this substep, too.

- 6.3.1. The owner hears her dog barking (again).
- 6.4.1. The owner presses the button on the remote control.

Don't we need to store the owner's dog's bark in our dog door?
Otherwise, we won't have anything to compare to the bark that our bark recognizer gives us.

We need a new use case to store the owner's dog's bark.

Our analysis has made us realize we need to make some changes to our use case and those changes mean that we need to make some additions to our system, too.

If we're comparing a bark from our bark recognizer to the owner's dog's bark, then we actually need to store the owner's dog's bark somewhere. And that means we need another use case.



Sharpen your pencil

Add a new use case to store a bark.

You need a use case to store the owner's dog's bark; let's store the sound of the dog in the dog door itself (Doug's hardware guys tell us that's no problem for their door technology). Use the use case template below to write a new use case for this task.

	The Ultimate Pog Poor, version 3.0 Storing a dog bark			
You should need only two steps for this use case, and there aren't any alternate paths to worry about	1			

Since this is our second use case, let's label it according to what it describes.



Add a new use case to store a bark.

You need a use case to store the owner's dog's bark; let's store the sound of the dog in the dog door itself (Doug's hardware guys tell us that's no problem for their door technology). Use the use case template below to write a new use case for this task.

We don't need to know the exact details of this, since it's a hardware issue.

I he Ultimate Dog Door, version 3.0

Storing a dog bark

The owner's dog barks "into" the dog door.

The dog door stores the owner's dog's bark.

Owner's dog's bark.

Dumb Questions

Q: Do we really need a whole new use case for storing the owner's dog's bark?

DogDoor to store the owner's dog's bark.

A: Yes. Each use case should detail one particular user goal. The user goal for our original use case was to get a dog outside and back in without using the bathroom in the house, and the user goal of this new use case is to store a dog's bark. Since those aren't the same user goal, you need two different use cases.

Is this really the result of good analysis, or just something we should have thought about in the last two chapters?

A: Probably a bit of both. Sure, we probably should have figured out that we needed to store the owner's dog's bark much earlier, but that's what analysis is really about: making sure that you didn't forget anything that will help your software work in a real world context.

Q: How are we representing the dog's bark?

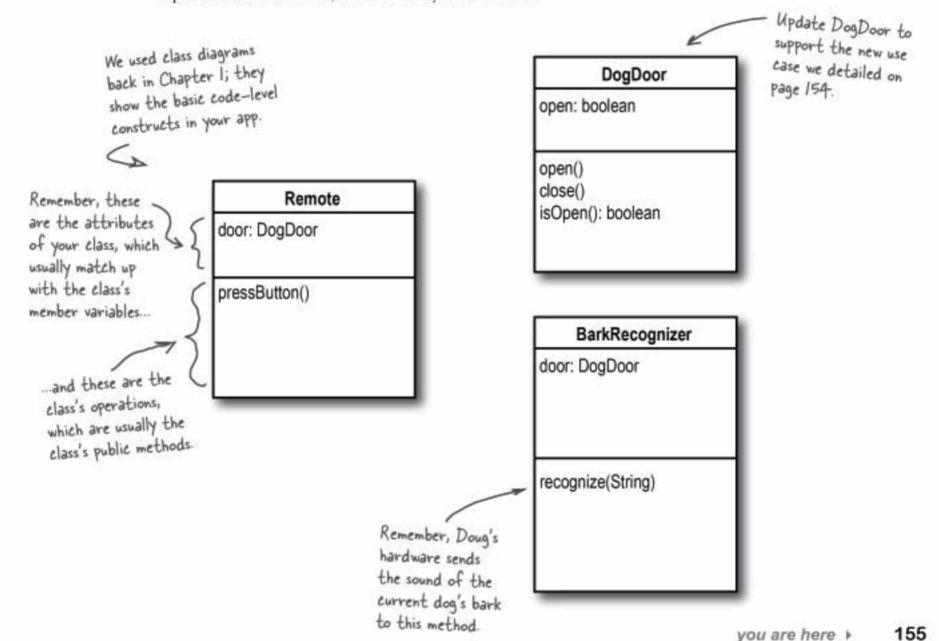
A: That's a good question, and it's one you're going to have to answer next...



You know what classes you already have, and you've got two use cases that tell you what your code has to be able to do. Now it's up to you to figure out how your code needs to change:

Your task:

- Add any new objects you think you might need for the new dog door.
- Add a new method to the **DogDoor** class that will store a dog's bark, and another new method to allow other classes to access the bark.
- If you need to make changes to any other classes or methods, write in those changes in the class diagram below.
- Add notes to the class diagram to remind you what any tricky attributes or operations are used for, and how they should work.



A tale of two coders

There are lots of ways you could solve the design puzzle on page 155. In fact, Randy and Sam, two developers who Doug's Dog Doors just hired, both have some pretty good ideas. But there's more at stake here than just programmer pride—Doug's offered the programmer with the best design a sparkling new Apple MacBook Pro!

Randy: simple is best, right?

Randy doesn't waste any time with unnecessary code. He starts thinking about how he can compare barks:

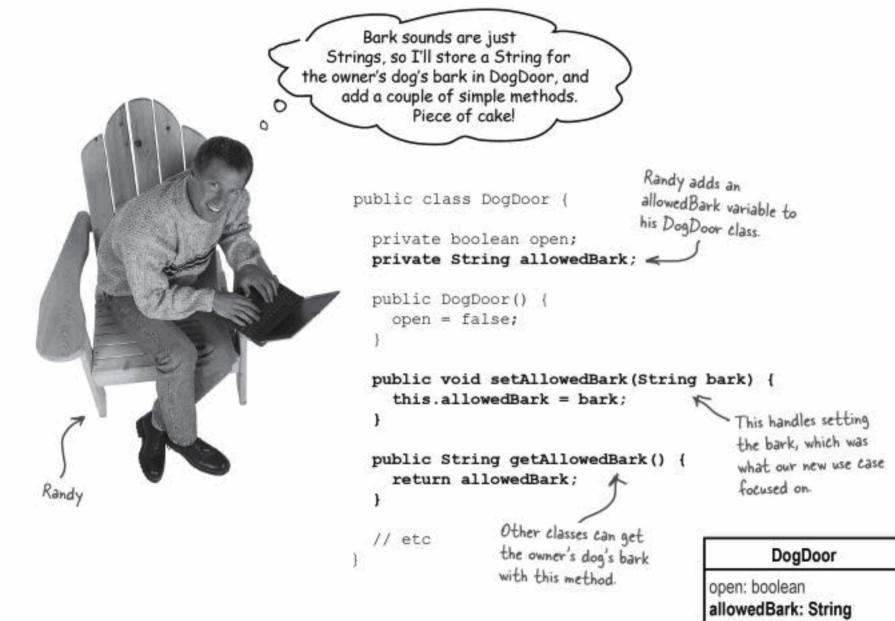


open() close()

isOpen(): boolean

setAllowedBark(String)

getAllowedBark(): String

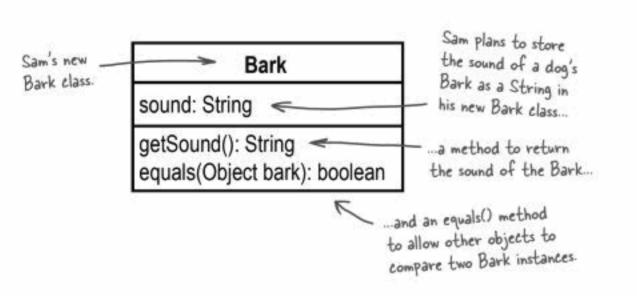


Here's Randy's class

diagram for DogDoor.

Sam: object lover extraordinaire

Sam may not be as fast as Randy, but he loves his objects, so he figures that a new class devoted to dog barks is just the ticket:



Sharpen your pencil Writing code based on a class diagram is a piece of cake.

You've already seen that class diagrams give you a lot of information about the attributes and operations of a class. Your job is to write the code for Sam's Bark class based on his class diagram. We've written just a bit of the code to help get you started.

I've got the power

of objects!



Writing code based on a class diagram is a piece of cake.

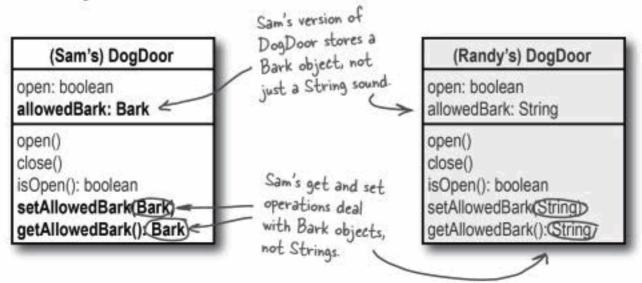
Randy's Bark class diagram.

Your job was to write the code for Sam's Bark class based on his class diagram. Here's what we did:

Bark Just like Randy public class sound: String did, Sam is using String private sound getSound(): String a String to store the actual equals(Object bark): boolean Bark public String sound bark sound ... sound this. sound ... but he's wrapped the Sam is planning on other classes getSound String public sound up in a delegating Bark comparison to sound return Bark object the Bark class's equals() method. public boolean equals Object bark) (This method bark instanceof Bark makes sure it has Bark otherBark = (Bark bark another Bark if (this. sound .equalsIgnoreCase(otherBark . sound)) { object to compare itself against ... return true ...and then compares the two Bark sounds. false return

Sam: updating the PogPoor class

Since Sam created a new **Bark** object, he takes a slightly different path than Randy did in updating his version of the **DogDoor** class:



Comparing barks

All that's left to do is add a comparison of barks into **BarkRecognizer**'s **recognize()** method.

Randy: I'll just compare two strings The argument sent to When the **BarkRecognizer** class gets a signal from the recognize() is a String with the hardware that a dog is barking, it also gets the bark, and compares it to what's stored in the door: dog's bark. Compare the bark we public class BarkRecognizer { get from the recognizer public void recognize (String bark) hardware to the bark System.out.println(" BarkRecognizer: " stored in the door. "Heard a '" + bark + "'"); if (door.getAllowedBark().equals(bark)) { < door.open(); } else { System.out.println("This dog is " + "not allowed."); // etc Sam: I'll delegate bark comparison Sam has the hardware Sam is using a Bark object, and he lets that object take care of all the sound comparisons: guys make sure he gets sent a Bark object now, not just the String public class BarkRecognizer { bark sound, like Randy. public void recognize (Bark bark) { System.out.println(" BarkRecognizer: " "Heard a '" + bark.getSound() + "'"); if (door.getAllowedBark().equals(bark)) { Sam's code lets the bark door.open(); stored in the DogDoor handle } else { comparisons. His BarkRecognizer System.out.println("This dog is not allowed."); delegates bark comparison to } the Bark object // etc

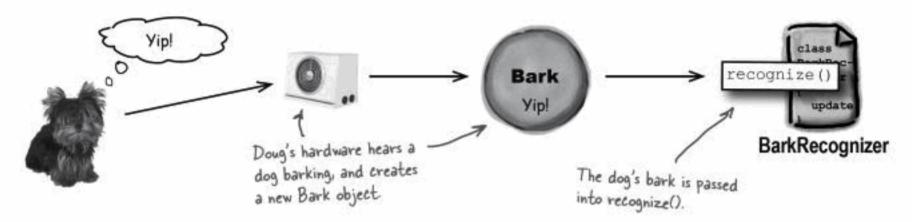


Delegation in Sam's dog door: an in-depth look

Sam is doing something very similar in his **Bark** and **DogDoor** classes. Let's see exactly what's going on:

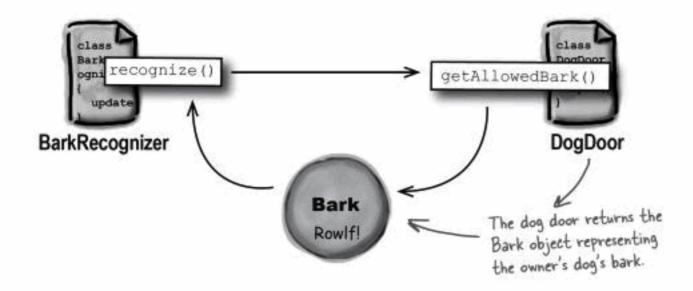
1 The BarkRecognizer gets a Bark to evaluate.

Doug's hardware hears a dog barking, wraps the sound of the dog's bark in a new **Bark** object, and delivers that **Bark** instance to the **recognize()** method.



BarkRecognizer gets the owner's dog's bark from DogDoor

The reconize() method calls getAllowedBark() on the dog door it's attached to, and retrieves a Bark object representing the owner's dog's bark.



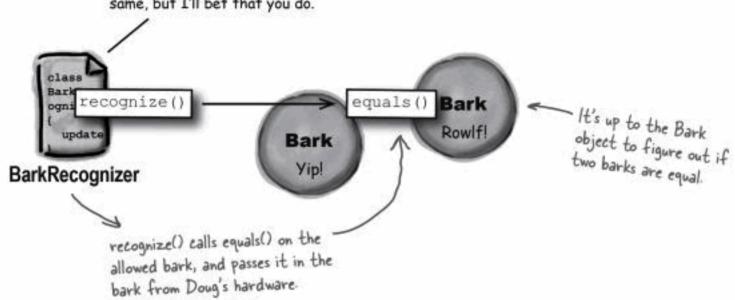


We'll come back to Sam and Randy's attemps to win the MacBook Pro once we've got a handle on delegation.

BarkRecognizer delegates bark comparison to Bark

The **recognize()** method asks the owner's dog's **Bark** object to see if it is equal to the **Bark** instance supplied by Doug's hardware, using **Bark.equals()**.

Hey there, allowedBark. Can you see if this other Bark that I have matches you? I really don't know much about what makes Barks the same, but I'll bet that you do.



Bark decides if it's equal to the bark from Doug's hardware

The Bark object representing the owner's dog's bark figures out if it is equal to the Bark object from Doug's hardware... however that needs to happen.

It really takes one Bark to understand another
Bark, you know? So let's see if we're really equal.

You got that right. Let's compare properties.

Bark
Rowlf!

It's up to Bark to handle comparisons...
and then just tell the object that called equals() if these two barks are the same.

The details of how this comparison happens are hidden from all the other objects in the dog door application.



The power of loosely coupled applications

In Chapter 1, we said that delegation helps our applications stay loosely coupled. That means that your objects are independent of each other; in other words, changes to one object don't require you to make a bunch of changes to other objects.

By delegating comparison of barks to the Bark object, we abstract the details about what makes two barks the same away from the BarkRecognizer class. Look again at the code that calls equals () on Bark:

```
public void recognize (Bark bark) {
    System.out.println(" BarkRecognizer: "
        "Heard a '" + bark.getSound() + "'");
    if (door.getAllowedBark().equals(bark)) {
        door.open();
    } else {
        System.out.println("This dog is not allowed.");
    }

The details of how equals() works are shielded away from the
```

Now suppose that we started storing the sound of a dog barking as a WAV file in **Bark**. We'd need to change the **equals()** method in the **Bark** class to do a more advanced comparison of sounds and account for the WAV files. But, since the **recognize()** method delegates bark comparison, no code in **BarkRecognizer** would have to change.

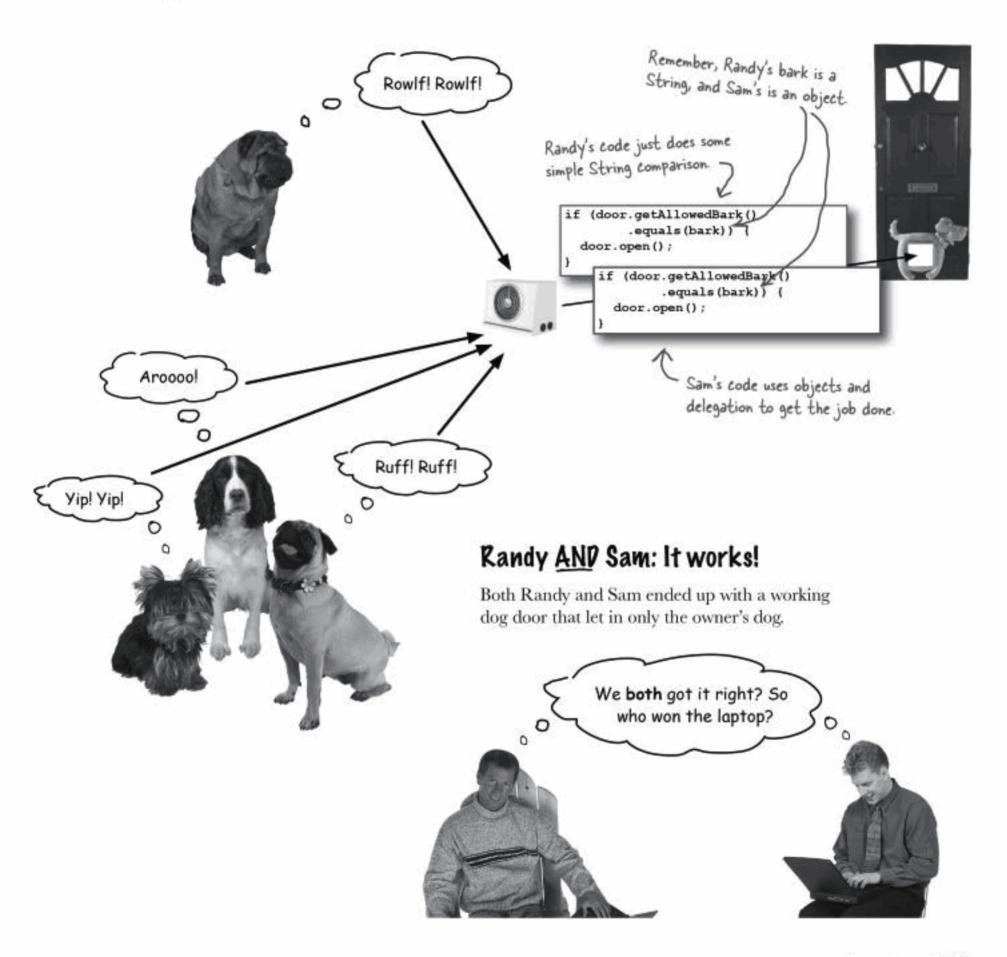
So with delegation and a loosely coupled application, you can change the implementation of one object, like **Bark**, and you won't have to change all the other objects in your application. Your objects are **shielded** from implementation changes in other objects.

Delegation shields your objects from implementation changes to other objects in your software.

recognize() method.

Back to Sam, Randy, and the contest...

With Randy's quick solution, and Sam's more object-oriented one, let's see how their applications are working out:



Maria won the MacBook Pro!

To both Randy and Sam's surprise, Doug announces that Maria, a junior programmer he got to work for the company as a summer intern, has won the laptop.

This is Maria. Try not to hate her guts too much ... maybe you can borrow her MacBook Pro when she's on vacation.

Randy: Oh, this is ridiculous. My solution worked! That laptop is mine, not some intern's!

Sam: Whatever, man. My solution worked, too, and I used objects. Didn't you read Head First Java? An object-oriented solution is the way to go... the laptop's mine!

Maria: Umm, guys, I don't mean to interrupt, but I'm not sure either one of your dog doors really worked.

Sam: What do you mean? We tested it. Bruce barked, "Rowlf!" and the door opened up... but it stayed shut for the other dogs. Sounds like a working solution to me.

Maria: But did you do any analysis on your solution? Does your door truly work in the real world?

Randy: What are you talking about? Are you some sort of philosophy major? Is this like a "there is no spoon" sort of thing?

Maria: No, not at all. I'm just wondering... what if Bruce were to make a different sound? Like "Woof" or "Ruff"?

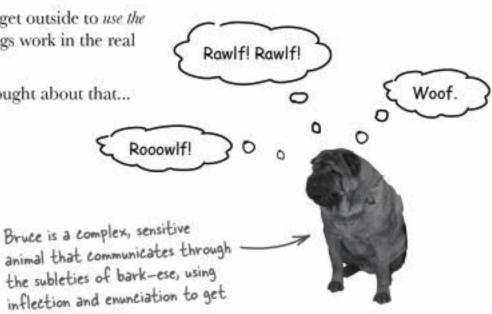
Sam: A different sound? Like if he's hungry...

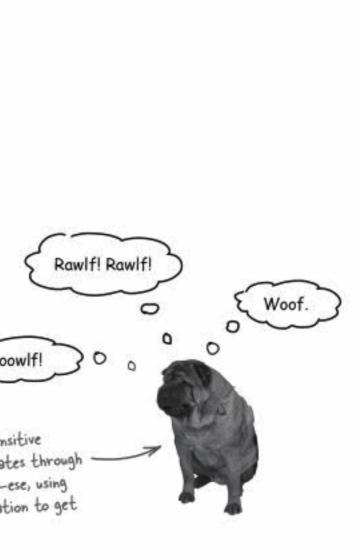
Randy: ...or excited...

Maria: ...or maybe... he really needs to get outside to use the bathroom. That's, ummm, sort of how things work in the real world, isn't it?

Randy and Sam: I guess we hadn't thought about that...

his point across.





So what did Maria do differently?

Maria started out a lot like Sam did. She created a Bark object to represent the bark of a dog.

I knew objects and delegation were important!

Maria knew she'd need delegation via the equals() method, just as Sam did.

But Maria went even further: she decided that since a dog might have different barks, the dog door should store multiple Bark objects. That way, no matter how the owner's dog barks, it still gets outside:



Here's where Maria really went down a different path. She decided that the dog door should store more than just one bark, since the owner's dog can bark in different ways.

Wondering about this asterisks? Check this out ...



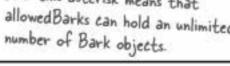
We've added something new to our class diagrams:

Anytime you see brackets, it indicates the multiplicity of an attribute: how many of a certain type that the attribute can hold.

allowedBarks: Bark [*]

The type of the allowed Barks attribute is Bark.

And this asterisk means that allowedBarks can hold an unlimited



How in the world did you know to store multiple barks? I never would have thought about a dog having multiple barks.



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Randy's not thrilled he lost either, but figures Maria might be his ticket to winning the <u>next</u> programming contest.

It's the <u>dog</u> that is the focus here, not just a specific bark. in the use case...

It's right here

We're focusing on our main use case here, not the new one we developed earlier in this chapter.

The Ultimate Pog Poor, version 3.0 Opening/closing the door

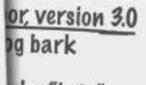
Main Path

- 1. The owner's dog barks to be let out.
- 2. The bark recognizer "hears" a bark.
- 3. If it's the owner's dog barking, the bark recognizer sends a request to the door to open.
- 4. The dog door opens.
- 5. The owner's dog goes outside.
- 6. The owner's dog does his business.
 - 6.1. The door shuts automatically.
 - 6.2. The owner's dog barks to be let back inside.
 - 6.3. The bark recognizer "hears" a bark (again).
 - 6.4. If it's the owner's dog barking,

Alternate Paths

- 2.1. The owner hears her dog barking.
- 3.1. The owner presses the button on the remote control.

- 6.3.1. The owner hears her dog barking (again).
- 6.4.1. The owner presses the hutton on the remote control.

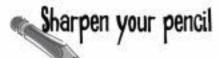


rks "into"

the

Pay attention to the nouns in your use case

Maria's figured out something really important: the nouns in a use case are usually the classes you need to write and focus on in your system.



Your job is to circle each noun (that's a person, place, or thing) in the use case below. Then, in the blanks at the bottom of the page, list all the nouns that you found (just write each one a single time; don't duplicate any nouns). Be sure to do this exercise before turning the page!

The Ultimate Pog Poor, version 3.0 Opening/closing the door

Main Path

- 1. The owner's dog barks to be let out.
- 2. The bark recognizer "hears" a bark.

3. If it's the owner dog parking, the bark recognizer sends a request to the door to open.

- 4. The dog door opens.
- 5. The owner's dog goes outside.
- 6. The owner's dog does his business.
 - 6.1. The door shuts automatically.
 - 6.2. The owner's dog barks to be let back inside.
 - 6.3. The bark recognizer "hears" a bark (again).
 - 6.4. If it's the owner dog barking, the bark recognizer sends a request to the door to open.
 - 6.5. The dog door opens (again).
- 7. The owner's dog goes back inside.
- 8. The door shuts automatically.

Alternate Paths

- 2.1. The owner hears her dog barking.
- 3.1. The owner presses the button on the remote control.

- 6.3.1. The owner hears her dog barking (again).
- 6.4.1. The owner presses the button on the remote control.

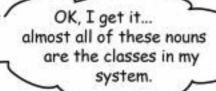
Write the nouns that you circled in the use case in these blanks.



Your job was to circle each noun (that's a person, place, or thing) in the use case below. Here's the use case with all the nouns circled.

The Ultimate Pog Poor, version 3.0 Opening/closing the door Alternate Paths Main Path 1. The owner's dog barks to be let out. 2.1. The owner hears her dog) 2. The bark recognizer hears a bark. barking. 3.1. The owner presses the button 3. If it's the owner stoog parking, the Chark recognizer ends a request to on the remote control. the door to open. 4. The dog door opens. 5. The owner's dog noes outside 6. The owner stood oes his business. 6.1. The door shuts automatically. 6.2. The owner's dog barks to be let backinside 6.3.1. The owner hears her dog 6.3. The bark recognized "hears" a barking (again). Gar Clagain). 6.4.1. The owner presses the 64. If it's the owner's dog barking. outton on the cemote control. the bark recognized sends a requesto the dood to open 6.5. The dog door opens (again) 7. The owner's dog goes back inside. 8. The door shuts automatically.

the (owner's) dog	bark recognizer	dog door remote control	
the owner	request		
the button	inside/outside	bark	
	Here are all circled in t	the nouns we	





Maria: That's right. That's how I figured out I needed a Bark class... it showed up in the use case as a noun in Steps 2 and 6.3. So I created a Bark class.

Randy: So that's where I went wrong... if I had looked at the use case and circled the nouns, I would have known to create a Bark class, too.

Maria: Probably. A lot of times, even if I think I know what classes I need, I double-check my ideas with the nouns in my use case to make sure I didn't forget anything.

Sam: But you don't need a class for some of those nouns, like "the owner" or "request," or even "inside."

Maria: That's true... you still have to have some common sense, and understand the system that you're building. Remember, you need classes only for the parts of the system you have to represent. We don't need a class for "outside" or "inside" or "the owner" because our software doesn't have to represent those things.

Randy: And you don't need a class for "the button" because it's part of the remote control—and we already do have a class for that.

Sam: This is all great, but I was just thinking... I came up with a **Bark** class, too, and I didn't need the use case to figure that out.

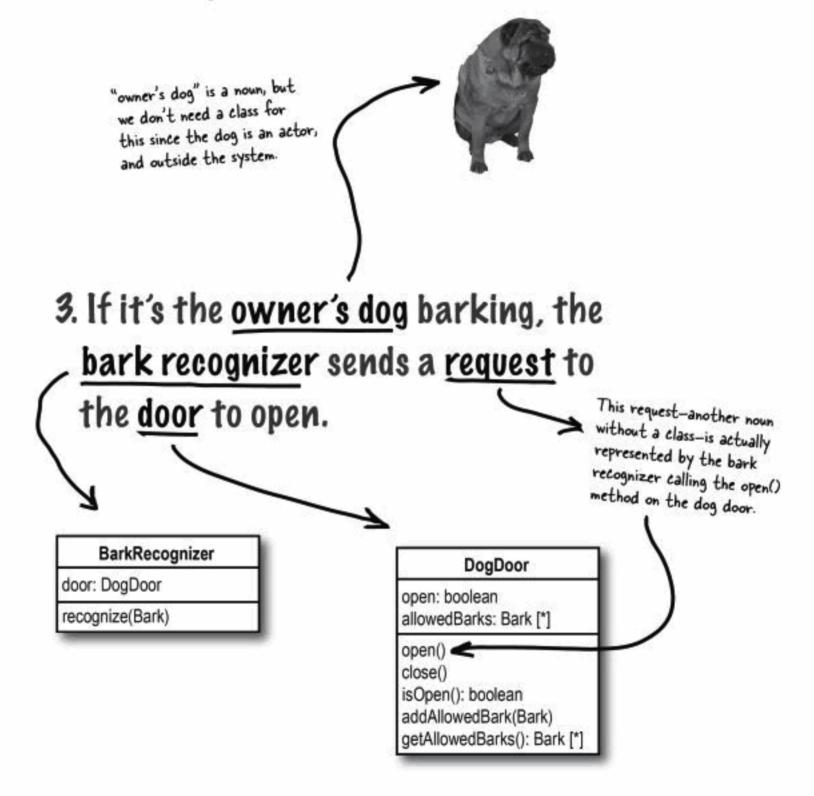
Maria: Yeah... but then you didn't end up with a dog door that really worked, did you?

Sam: Well, no... but that's just because you stored more than one **Bark** object in the dog door. What does that have to do with the use case?

Looking at the nouns (and verbs) in your use case to figure out classes and methods is called textual analysis.

It's all about the use case

Take a close look at Step 3 in the use case, and see exactly which classes are being used:



There is no Bark class here!

The classes in use here in Step 3 are BarkRecognizer and DogDoor... not Bark!

Wait a second... I don't buy that. What if I happened to use just a slightly different wording?



3. If the owner's dog's bark matches the bark heard by the bark recognizer, the dog door should open.

Here's Step 3 from the use ease that Randy wrote for his dog door. In his Step 3, "bark" is a noun.

Step 3 in Randy's use case looks a lot like Step 3 in our use case... but in his step, the focus is on the noun "bark", and not "the owner's dog." So is Randy right? Does this whole textual analysis thing fall apart if you use a few different words in your use case?

What do you think?

- HINT: Look closely at Randy's Step 3. Does it describe a system that works exactly the same as the system on page 170?

One of these things is not like the other...

It looks like Randy's Step 3 is actually just a little bit different than our original Step 3... so where did Randy go wrong?

Here's our Step 3, from the original use case we wrote back in Chapter 3.

3. If it's the owner's dog barking, the bark recognizer sends a request to the door to open.

And here's Step 3 from the use case that Randy came up with for the same dog door.

3. If the owner's dog's bark matches the bark heard by the bark recognizer, the dog door should open.

Focus: owner's dog

Our original Step 3 focuses on the owner's dog...

no matter how the dog sounds when it barks. So if the
owner's dog barks with a loud "Rowlf!" one
day, but a quiet "ruff" the next, the system will
let the dog in, either way. That's because we're
focusing on the dog, not a particular bark.



Focus: owner's dog's bark

Randy's use case focuses on the owner's dog's bark... but what if the dog has more than one sound it makes? And what if two dogs bark in a really similar way? This step looks similar to the original Step 3, but it's really not the same at all!



Dumb Questions

O: So you're telling me as long as I write use cases, all my software will work like it should?

A: Well, use cases are certainly a good start towards writing good software. But there's a lot more to it than that. Remember, analysis helps you figure out the classes from your use case, and in the next chapter, we'll spend some time talking about good design principles in writing those classes.

Q: I've never used use cases before, and I've never had any problems. Are you sawing that I have to write use cases to create good software?

A: No, not at all. There are plenty of programmers who are good at their jobs, and don't even know what a use case is. But if you want your software to satisfy the customer more often, and you want your code to work correctly with less rework, then use cases can really help you nail your requirements down... before you make embarassing mistakes in front of your boss or a customer.

O: It seems like this stuff about nouns and analysis is pretty tricky, and I'm not any good at English grammar. What can I do?

A: You really don't need to focus too much on grammar. Just write your use cases in conversational English (or whatever language you speak and write in). Then figure out what the "things" are in your use case—those are generally the nouns. For each noun, think about if you need a class to represent it, and you've got a good start on a real-world analysis of your system.

Q: But what if I make a mistake like Randy did, and use a noun in my use case when I shouldn't?

A: Randy's mistake—using "bark" as a noun in step 3 of his use case—had nothing to do with Randy's grammar. He didn't think through the use case, and how his system would work in the real world. Instead of focusing on getting the owner's dog outside, he was worrying about one specific bark. He focused on the wrong thing!

When you write your use case, reread it, and make sure that it makes sense to you. You might even want to let a couple of friends or co-workers read through it, too, and make sure it will work in the real world, not just in a controlled environment.

A good use case clearly and accurately explains what a system does, in language that's easily understood.

With a good use case complete, textual analysis is a quick and easy way to figure out the classes in your system.

OK, I see what Randy's mistake was:
he got hung up on a bark, not the owner's
dog. But even in the correct use case, we
don't have a Dog object. So what's the
point of all this, if our analysis doesn't tell
us what classes to create and use?



Textual analysis tells you what to focus on, not just what classes you should create.

Even though we don't have a **Dog** class, textual analysis gave us an important clue about what our system really needs to do: get the owner's dog in and out of the door, regardless of how he barks. In other words, our analysis helped us understand what to focus on... and it's not a specific bark.

Once you've figured that out, it makes sense to think about what a dog really does. Does a dog always bark the same way? That's when Maria figured out her real-world solution: she realized that if the owner's dog could bark in more than one way, and the point was getting the owner's dog outside, then the dog door needed to store all the ways that the dog could bark, not just one of them. But Maria would have never figured this out if she hadn't really analyzed her use case.

Sharpen your pencil

Why is there no Dog class?

When you picked the nouns out of the use case, one that kept showing up was "the owner's dog." But Maria decided not to create a Dog object. Why not? Below, write down three reasons you think Maria didn't create a Dog class in her system.

1			
2			
3			

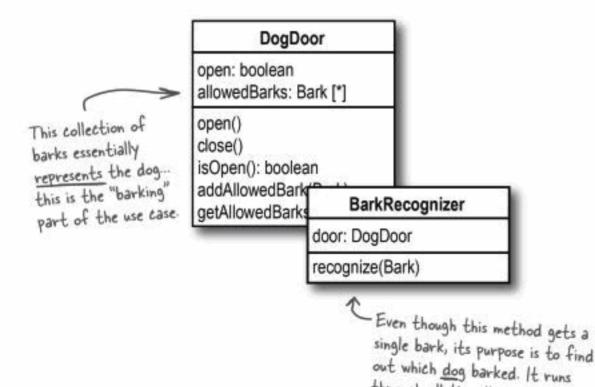
Remember: pay attention to those nouns!

Even if the nouns in your use case don't get turned into classes in your system, they're always important to making your system work like it should.



3. If it's the owner's dog barking, the bark recognizer sends a request to the door to open.

The point is that the <u>nouns</u> are what you should focus on. If you focus on the dog in this step, you'll figure out that you need to make sure the dog gets in and out of the dog door—whether he has one bark, or multiple barks.



through all the allowed barks in the dog door to see if this bark comes

from the owner's dog.

Pay attention to the <u>nouns</u> in your use case, even when they aren't classes in your system.

Think about how the classes you do have can support the behavior your use case describes.

It seems like if the nouns in the use case are usually the classes in my system, then the **verbs** in my use case are my methods. Doesn't that make sense?

The verbs in your use case are (usually) the methods of the objects in your system.

You've already seen how the nouns in your use case usually are a good starting point for figuring out what **classes** you might need in your system. If you look at the verbs in your use case, you can usually figure out what **methods** you'll need for the objects that those classes represent:



Main Path

- 1. The owner's dog barks to be let out.
- 2. The bark recognizer "hears" a bark.
- If it's the owner's dog barking, the bark recognizer sends a request to the door to open.
- 4. The dog door opens
- 5. The owner's dog goes outside.
- 6. The owner's dog does his business.
 - 6.1. The door shuts automatically.
- 6.2. The owner's dog barks to be let back inside.
- 6.3. The bark recognizer "hears" a bark (again).
- 6A. If it's the owner's dog barking, the bark recognizer sends a request to the door to open.
- 6.5. The dog door opens (again).
- 7. The owner's dog goes back inside.
- \$. The door shuts automatically.

Alternate Paths

- 2.1. The owner hears her dog barking.
- 3.1. The owner presses the button on the remote control.

6.3.1. The owner hears her dog barking (again).

6.4.1. The owner presses the button on the remote control.

Here's another verb fragment: "presses the button." Our Remote class has a pressButton() method that matches up perfectly.



method to support these verb actions

The Dog Door

class needs to

have an open()

and close()



Code Magnets

It's time to do some more textual analysis. Below is the use case for the dog door you've been developing. At the bottom of the page are magnets for most of the classes and methods we've got in our system so far. Your job is to match the class magnets up with the nouns in the use case, and the method magnets up with the verbs in the use case. See how closely the methods line up with the verbs.

The Ultimate Pog Poor, version 3.0 Opening/closing the door

Main Path

- 1. The owner's dog barks to be let out.
- 2. The bark recognizer "hears" a bark.
- If it's the owner's dog barking, the bark recognizer sends a request to the door to open.
- 4. The dog door opens.
- 5. The owner's dog goes outside.
- 6. The owner's dog does his business.
 - 6.1. The door shuts automatically.
 - 6.2. The owner's dog barks to be let back inside.
 - 6.3. The bark recognizer "hears" a bark (again).
 - 6.4. If it's the owner's dog barking, the bark recognizer sends a request to the door to open.
 - 6.5. The dog door opens (again).
- 7. The owner's dog goes back inside.
- 8. The door shuts automatically.

Alternate Paths

- 2.1. The owner hears her dog barking.
- The owner presses the button on the remote control.

- 6.3.1. The owner hears her dog barking (again).
- 6.4.1. The owner presses the button on the remote control.

There are lots of classes and methods at this point, so take your time.

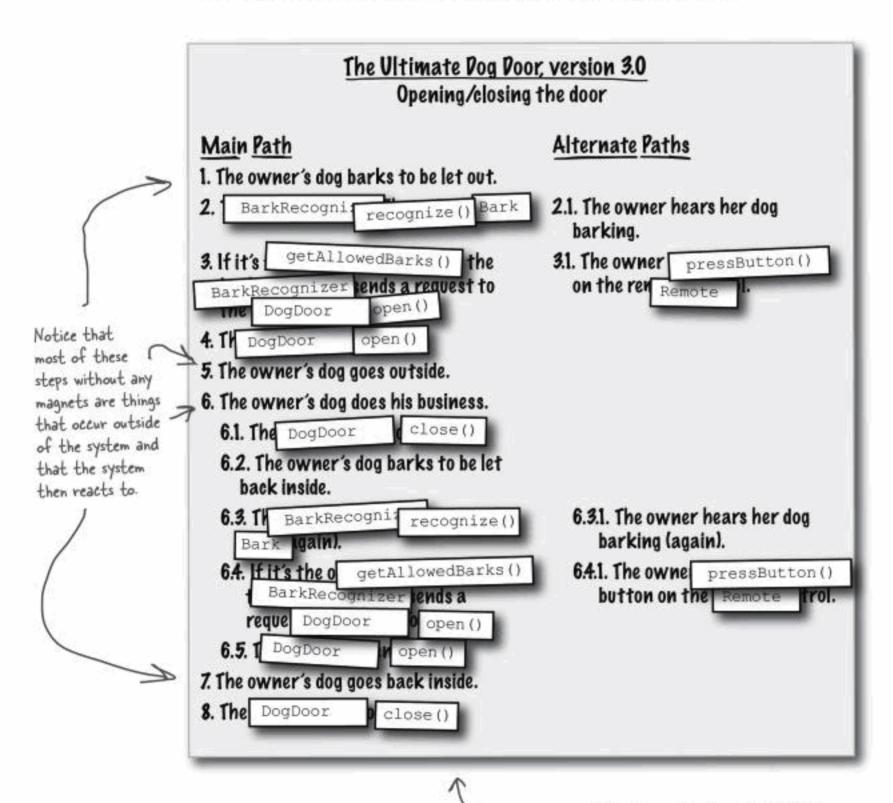






Code Magnets Solutions

It's time to do some more textual analysis. Below is the use case for the dog door you've been developing. At the bottom of the page are magnets for most of the classes and methods we've got in our system so far. Your job is to match the class magnets up with the nouns in the use case, and the method magnets up with the verbs in the use case. See how closely the methods line up with the verbs.



The use case still makes a lot of sense with the magnets in place! That's a good sign that our classes and methods are doing exactly what they're supposed to so that the system will be a success.



Why didn't Maria create a Dog class?

When you picked the nouns out of the use case, one that kept showing up was "the owner's dog." But Maria decided not to create a Dog object. Why not? Here are three reasons we think Maria made the right choice.

There are times when you might do this, but usually only when you 2... need to interact with those external things.
We don't need to interact with the dog. 3...

1. The dog is external to the system, and you usually don't need

to represent things external to the system.

2. <u>Pog isn't a software object (and shouldn't be)... you usually don't represent living things</u> with a class unless the system is going to store long-term information about that thing.

3. Even if you had a Pog class, it wouldn't help the rest of the system. For example, you can't really "store" a Pog in the dog door; that doesn't make any sense.

You could have a reference to the Dog class in your DogDoor object, but how do you store a dog within a door in the real world? Remember, what works in software doesn't always work in real life. Make sure your applications are real-world compatible!

You'll often see classes like User or Manager, but these represent roles in a system, or store credit cards or addresses. A dog doesn't fit any of those patterns.

——Dumb Questions

Q: So the nouns in the use case turn into classes, and the verbs turn into methods?

A: That's almost it. Actually, the nouns are candidates for classes... not every noun will be a class. For instance, "the owner" is a noun in the use case (check out Steps 2.1 and 3.1, for example), but we don't need a class for that noun. So even though "the owner" is a candidate for a class, it doesn't become a class in the actual system.

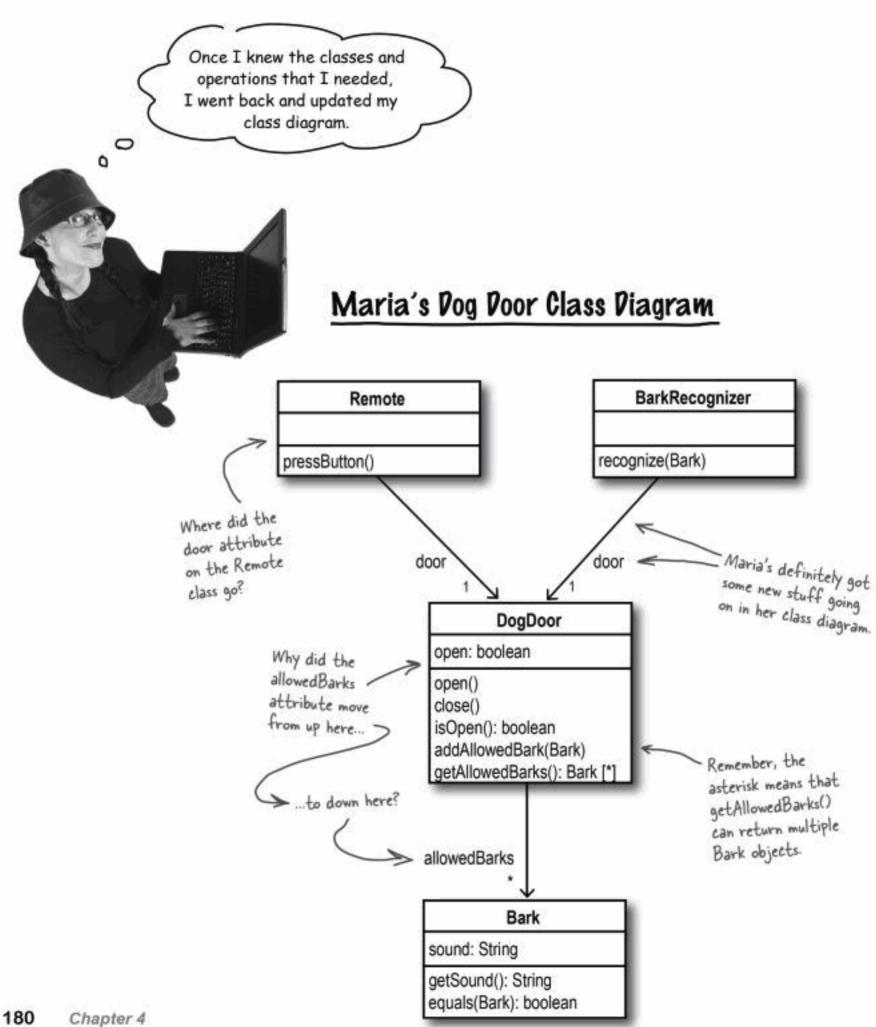
In the same way, the verbs are candidates for operations. For example, one verb phrase is "does his business," but we just couldn't bear to write a **pee()** or **poop()** method. We hope you'll agree that we made the right choice! Still, textual analysis is a really good start to figuring out the classes and methods you'll need in your system.

Q: It looks like the nouns that are outside the system don't get turned into classes. Is that always true?

A: Most of the time it is. The only common exception is when you have to interact with something outside the system—like when there's some state or behavior that the system needs to work with on a recurring basis.

In the dog door system, for example, we didn't need a class for the owner because the **Remote** class took care of all the owner-related activity. If we ever needed to track owner state, though—like if the owner was asleep or awake—then we might have to create an **Owner** class.

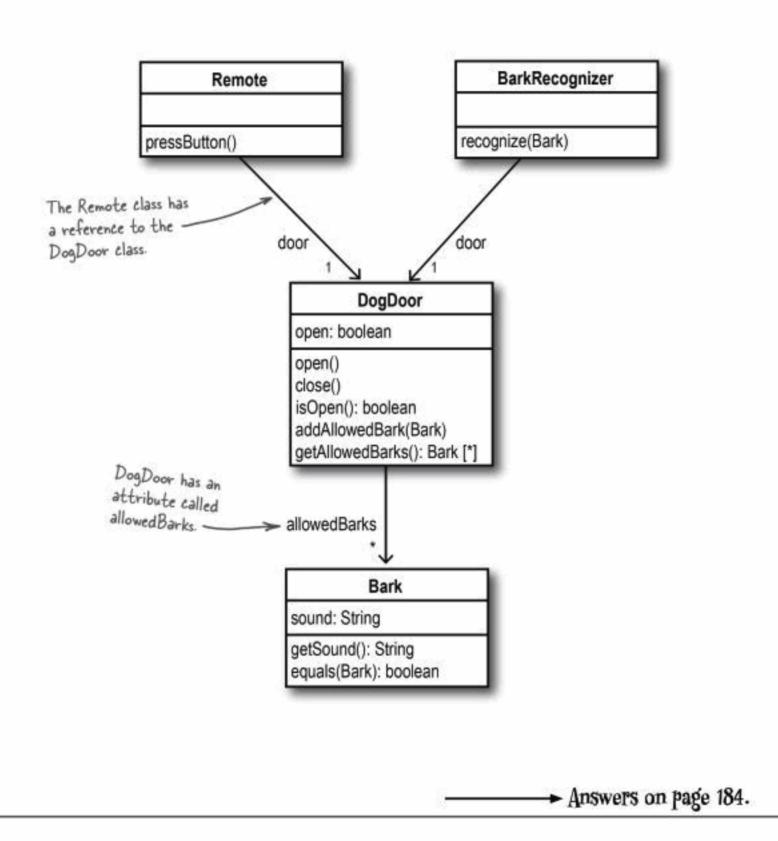
From good analysis to good classes...





-UML Investigation

Maria's gone pretty crazy with her UML diagrams... do you think you can figure out what all she's done? On the diagram below, add notes to all the new things she's added, and try and figure out what the lines, numbers, and additional words all mean. We've written a few notes of our own to get you started.



Class diagrams dissected

There's a lot more to a class diagram than boxes and text. Let's see how some lines and arrows can add a lot more information to your class diagrams.

A solid line from one class to another is called an association. It means that one class is associated with another class, by reference, extension, inheritance, etc.

This line goes from the source class (Remote) to the target class (DogDoor). This means that the source class, Remote, has an attribute of type DogDoor, the target class.

Remote

pressButton()

The DogDoor class has an attribute named allowedBarks, which stores Bark objects.

allowedBarks

Bark

sound: String

getSound(): String

equals(Bark): boolean

The multiplicity of the allowedBarks attribute is unlimited. That means that barks can store an unlimited number of Bark objects.

When you're

to represent

usually do
not write the
attribute that
the association
represents in the
class's attribute

using associations

attributes, you

section. That's why Remote no longer has a door attribute here.



The name of the attribute in the source class is written here, at the target end of the line. So the Remote class has an attribute called door, of type DogDoor.

This number is the multiplicity of this association. It's how many of the target type is stored in the attribute of the source class. In this case, the door attribute stores a single DogDoor.

door

DogDoor

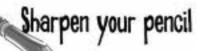
open: boolean

open() close()

isOpen(): boolean addAllowedBark(Bark) getAllowedBarks(): Bark [*]

Compare this diagram to
Maria's on page 180. Even
though the classes are in
different places, it's the SAME
class diagram. So the position
of the classes on the diagram
doesn't matter.

Answers to this exercise are on page 185.

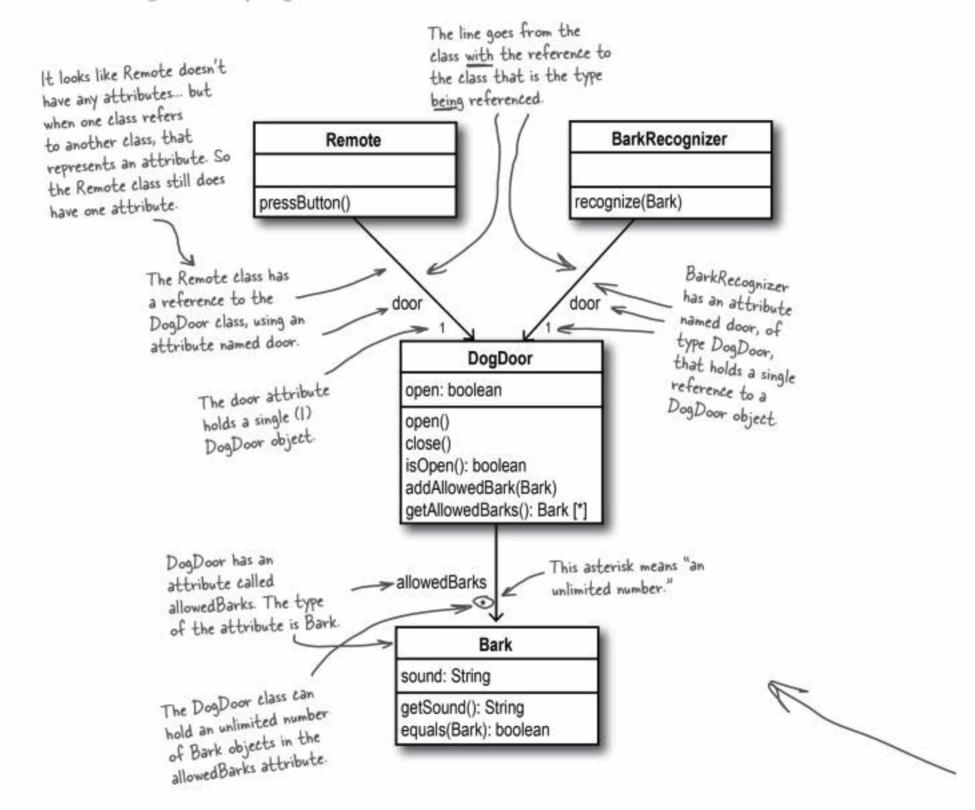


Based on the class diagram above, what types could you use for the allowedBarks attribute in the DogDoor class? Write your ideas below:

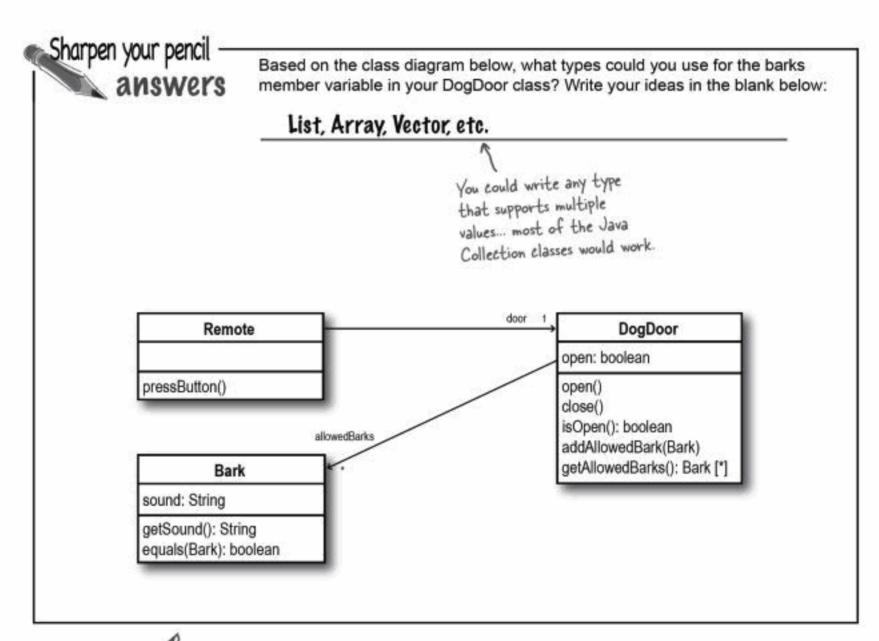


UML Investigation Complete

Maria's gone pretty crazy with her UML diagrams... see if you can figure out everything that she's done.







Notice that this diagram, although positioned very differently, has the same classes and associations as this diagram.

I guess I'm still just not sure why you need all these diagrams...

0

Randy: I may have missed creating a Bark class, but my solution wasn't that bad, and I didn't waste a bunch of my time drawing squares and arrows.

Maria: Haven't you ever heard that a picture is worth a thousand words? Once I had my class diagram, I had a pretty good idea about how my whole system was going to work.

Randy: Well, yeah, I guess I can see that... but I had a good idea of how my system would work, too. It was just in my head, not drawn out on paper.

Sam: I think I'm starting to come around on this UML thing, Randy. I mean, once you've got the use case, it's pretty natural to do some analysis, and turn the nouns into classes. It seems like you wouldn't have to spend as much time worrying about what should be a class, and what shouldn't.

Maria: Exactly! I hate writing a bunch of classes and then finding out I did something wrong. With use cases and class diagrams, if I make a mistake, I can just scribble things out and redraw my diagram.

Randy: Well, I guess that's true. Rewriting code takes a lot more time than rewriting a use case or redrawing a class diagram...

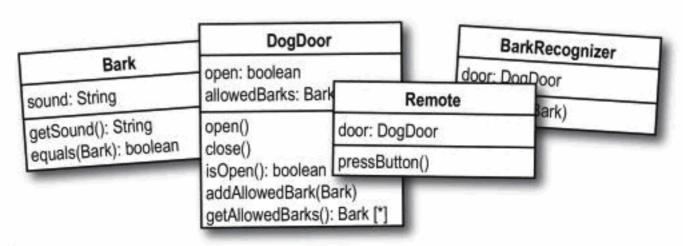
Maria: And you know, if you ever have to work with anyone else, you're going to have to explain that system in your head to them somewhow, right?

Sam: I think she's right, Randy. I've seen your whiteboard when you're trying to explain your ideas... it's a mess!

Randy: OK, even I can't argue with that. But I still think class diagrams don't tell the whole story. Like, how is our code actually going to compare barks and figure out if the dog door should open up?

 \rightarrow

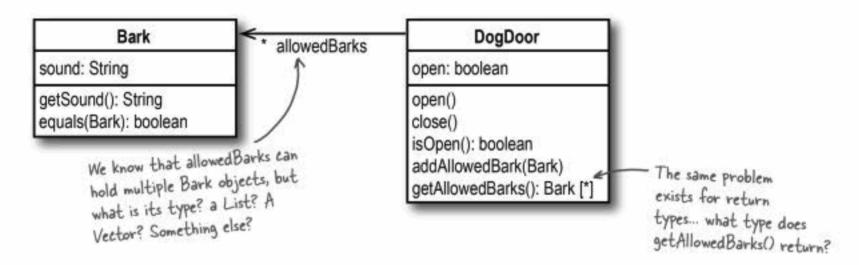
Remember how we said OOA&D helps you write great software, every time? This is one way OOA&D can help you avoid making mistakes in your code.

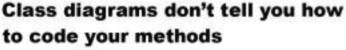


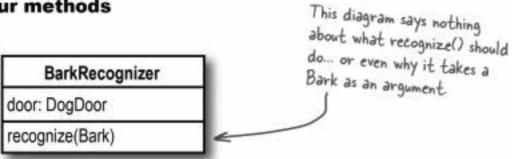
Class diagrams aren't everything

Class diagrams are a great way to get an overview of your system, and show the parts of your system to co-workers and other programmers. But there's still plenty of things that they don't show.

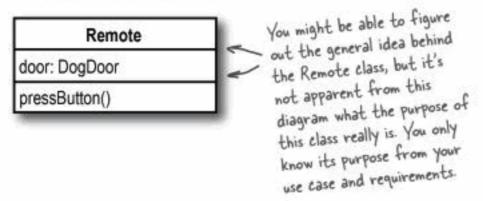
Class diagrams provide limited type information







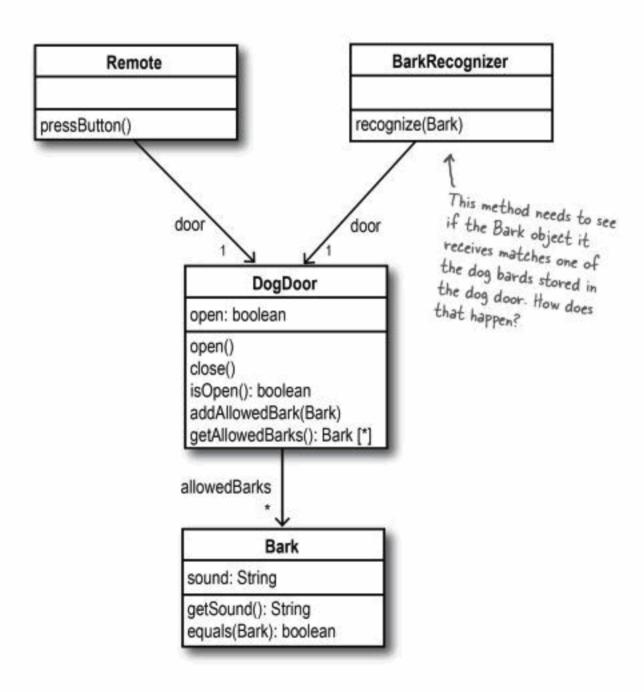
Class diagrams only give you a 10,000 foot view of your sytem





Class diagrams are great for modeling the classes you need to create, but they don't provide all the answers you'll need in programming your system. You've already seen that the dog door class diagram doesn't tell us much about matching up return types; what other things do you think are unclear from this diagram that you might need to know to program the dog door?

Add notes to the diagram below about what you might need to figure out in order to program the door. We've added a note about comparing barks to get you started.



So how does recognize() work now?

Maria's figured out that her **BarkRecognizer** class should be able to compare any bark it receives against multiple allowed barks, but her class diagram doesn't tell us much about how to actually write the **recognize()** method.

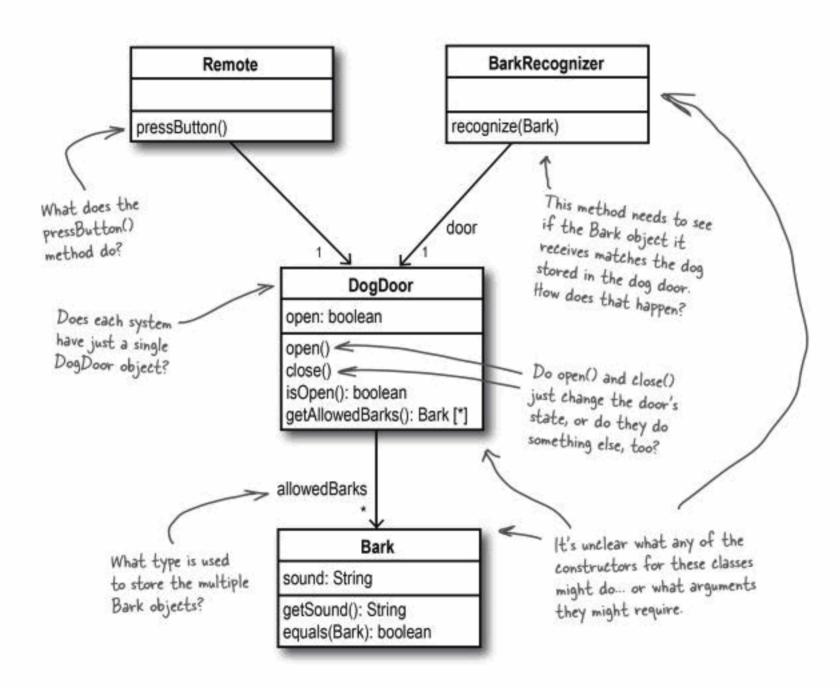
Instead, we have to look at Maria's code. Here's the **recognize()** method of her **BarkRecognizer**, and how she solved the barking problem:

```
Maria's getting a
                public void recognize (Bark bark) {
                                                                                      whole list of Bark
Iterator is a Java
                  System.out.println("
                                               BarkRecognizer: Heard a "" +
                                                                                      objects from the
object that lets us
                       bark.getSound() + "'");
                                                                                      dog door.
walk through each
                  List allowedBarks = door.getAllowedBarks(); <
item in a list. -
                  for (Iterator i = allowedBarks.iterator(); i.hasNext(); ) {
                     Bark allowedBark = (Bark)i.next();
                                                                        We cast each item we get
                     if (allowedBark.equals(bark)) {
                                                                        from the Iterator to a
Just like in Sam's
                       door.open();
code, Maria
                                                                         Bark object.
delegates Bark
                       return;
                                       —This makes sure we don't keep
comparisons to the
                                         looping once we've found a match.
Bark object
                  System.out.println("This dog is not allowed.");
                                                                                  This method represents
                                                                                  an entire dog: all the
                                                                                  barking sounds that
                                                                                  the dog can make
             Maria's textual analysis helped her figure out that
             her BarkRecognizer needed to focus on the dog
                                                                              door.getAllowedBarks()
             involved, rather than the barking of that dog.
                                                  door.getAllowedBark()
                                                                    This method is focused on a single
                                                                    bark ... on one sound the dog makes,
                                                                    rather than the dog itself.
```





Add notes to the diagram about what you might need to figure out to program the door.



* These are just a few of the things we thought of. Your answers may be totally different, if you thought of other things that the class diagram doesn't really show.



- Analysis helps you ensure that your software works in the real world context, and not just in a perfect environment.
- Use cases are meant to be understood by you, your managers, your customers, and other programmers.
- You should write your use cases in whatever format makes them most usable to you and the other people who are looking at them.
- A good use case precisely lays out what a system does, but does not indicate how the system accomplishes that task.
- Each use case should focus on only one customer goal. If you have multiple goals, you will need to write mutiple use cases.

- Class diagrams give you an easy way to show your system and its code constructs at a 10,000-foot view.
- The attributes in a class diagram usually map to the member variables of your classes.
- The operations in a class diagram usually represent the methods of your classes.
- Class diagrams leave lots of detail out, such as class constructors, some type information, and the purpose of operations on your classes.
- Textual analysis helps you translate a use case into code-level classes, attributes, and operations.
- The nouns of a use case are candidates for classes in your system, and the verbs are candidates for methods on your system's classes.



Design Puzzle

I'll bet you expected to find all the code I wrote here, didn't you? I wish... when I was transferring files to my new MacBook Pro, almost all of the code for my dog door got corrupted.

Can you help?

Maria's old computer screwed up all the code she wrote for her dog door except for **DogDoorSimulator.java**, shown on the next page. All we've got to go on are the code fragments from her solution in this chapter, her class diagrams, and what you've learned about good analysis, requirements and OO programming. It's your turn to be a hero...

The problem:

You need to code the dog door application so that it satisfies all of Doug's new customers (that's a lot of potential sales), especially the ones with more than one dog in the neighborhood. The door should operate just as the use cases in this chapter describe the system.

Your task:

- Start out by re-creating the dog door application as it was described in Chapter 3. You can download this code from the Head First Labs web site if you want a jump start.
- ② Copy or download DogDoorSimulator.java, shown on the next page. This is the only file that survived Maria's laptop meltdown.
- Make your code match up with Maria's class diagram, shown on page 180.
- Start coding! First concentrate on getting all of your classes to compile, so you can begin testing.
- Use the DogDoorSimulator class to see if things are working like they should.
- 6 Keep up the analysis and coding until your test class's output matches the output shown on the next page. Don't give up!
- Once you think you've got a working dog door, check your code against ours at the Head First Labs web site. We'll be waiting.



```
public class DogDoorSimulator {
 public static void main(String[] args) {
    DogDoor door = new DogDoor();
    door.addAllowedBark(new Bark("rowlf"));
    door.addAllowedBark(new Bark("rooowlf"));
    door.addAllowedBark(new Bark("rawlf"));
    door.addAllowedBark(new Bark("woof"));
    BarkRecognizer recognizer = new BarkRecognizer(door);
    Remote remote = new Remote(door);
    // Simulate the hardware hearing a bark
    System.out.println("Bruce starts barking.");
    recognizer.recognize(new Bark("rowlf"));
    System.out.println("\nBruce has gone outside...");
   try (
     Thread.currentThread().sleep(10000);
   } catch (InterruptedException e) { }
   System.out.println("\nBruce's all done...");
   System.out.println("...but he's stuck outside!");
   // Simulate the hardware hearing a bark (not Bruce!)
   Bark smallDogBark = new Bark("yip");
   System.out.println("A small dog starts barking.");
   recognizer.recognize(smallDogBark);
   trv {
     Thread.currentThread().sleep(5000);
   } catch (InterruptedException e) { }
   // Simulate the hardware hearing a bark again
   System.out.println("Bruce starts barking.");
   recognizer.recognize(new Bark("rooowlf"));
   System.out.println("\nBruce's back inside...");
 1
```



DogDoorSimulator.java

This is the test class from Maria's old laptop. Use this for your own dog door testing.

```
The dog door opens.

Bruce has gone outside...
The dog door closes.

Bruce's all done...
...but he's stuck outside!
Bitsie starts barking.
BarkRecognizer: Heard a 'yip'
This dog is not allowed.
Bruce starts barking.
BarkRecognizer: Heard a 'rooowlf'
The dog door opens.

Bruce's back inside...
The dog door closes.
```

BarkRecognizer: Heard a 'rowlf'

File Edit Window Help HollyLovesBruce

%java DogDoorSimulator

Bruce starts barking.

Here's the output you want, which proves that the door works for Bruce, but not for other dogs.



UML and use cases have a lot of terms that are similar to, but not quite the same as, the programming terms you're already familiar with. Below are several OOA&D-related terms, and their defintions... but everything is all mixed up. Connect the term to the definition, and unscramble the mess.

Noun Analysis

MultiPlicity

Attribute

CLass Diagram

OPERation

Association

Verb Analysis

Lists all the code-level constructs, along with their attributes and operations.

This is the UML term that usually represents a method in one of your classes.

Helps you figure out the candidates for methods on the objects in your system.

Visually shows that one class has a relation to another class, often through an attribute.

Equivalent to a member variable in a class.

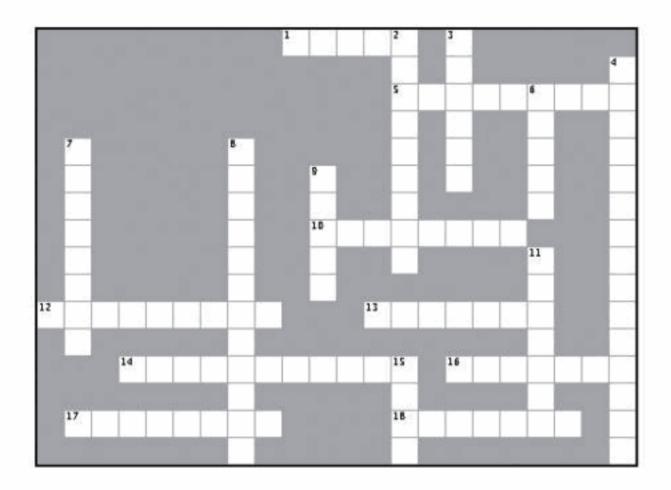
Describes how many of a specific type can be stored in an attribute of a class.

You do this to your use case to figure out what classes you need in your system.



OOA&D Cross

You know you love it... try another puzzling crossword to get those new concepts lodged firmly in your brain.



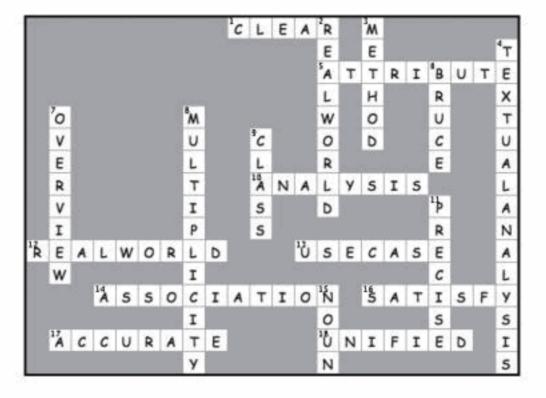
Across

- Use cases should use this kind of language.
- Every class diagram has one of these for each member variable.
- This focuses on putting your application into the correct context.
- Software always works better in the testing lab than here.
- Maria won the laptop because she paid attention to the
- 14. This relates one class to another
- 16. You write your use case so you can your customers
- Use cases should be _____ as well as easily understood.
- 18. UML is this type of modeling language.

Down

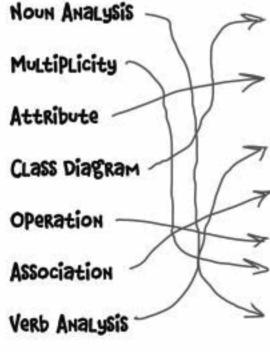
- Analysis makes sure your application works in this place.
- 3. An operation is UML-ese for this.
- You do this to your use cases to figure out the classes and operations in your system.
- 6. He replaced Fido as this chapter's star.
- Class diagrams are a great way to get this of your system.
- How many of a type an attribute can hold is its
- These types of diagrams are worth a thousand words to a programmer.
- 11. Use cases aren't formal, but they are
- 15. Verb is to operation as this is to attribute.







UML and use cases have a lot of terms that are similar to, but not quite the same as, the programming terms you're already familiar with. Below are several OOA&Drelated terms, and their definitions... but everything is all mixed up. Connect the term to the definition, and unscramble the mess.



Lists all the code-level constructs, along with their attributes and operations.

This is the UML term that usually represents a method in one of your classes.

Helps you figure out the candidates for methods on the objects in your system.

Visually shows that one class has a relation to another class, usually through an attribute.

Equivalent to a member variable in a class.

Describes how many of a specific type can be stored in an attribute of a class.

You do this to your use case to figure out what classes you need in your system.

5 (part 1) good design = flexible software

Nothing Ever Stays the Same



Change is inevitable. No matter how much you like your software right now, it's probably going to change tomorrow. And the harder you make it for your software to change, the more difficult it's going to be to respond to your customer's changing needs. In this chapter, we're going to revisit an old friend, try and improve an existing software project, and see how small changes can turn into big problems. In fact, we're going to uncover a problem so big that it will take a TWO-PART chapter to solve it!

Stringed Instruments

Rick's Cuitars is expanding

Fresh off the heels of selling three guitars to the rock group Augustana, Rick's guitar business is doing better than ever—and the search tool you built Rick back in Chapter 1 is the cornerstone of his business.

Your software is the best—I'm selling guitars left and right. I've been getting a lot of business from Nashville, though, and want to start carrying mandolins, too. I figure I can make a killing!





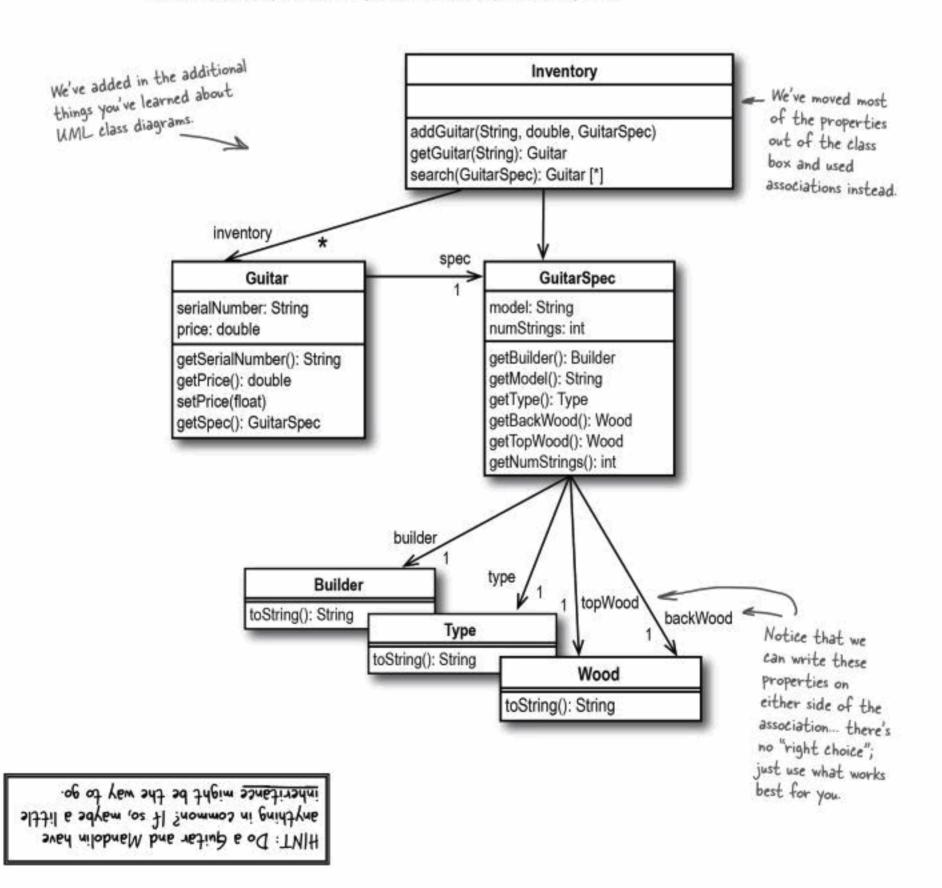
Let's put our design to the test

We've talked a lot about good analysis and design being the key to software that you can reuse and extend... and now it looks like we're going to have to prove that to Rick. Let's figure out how easy it is to restructure his application so that it supports mandolins.

Sharpen your pencil

Add support for mandolins to Rick's search tool.

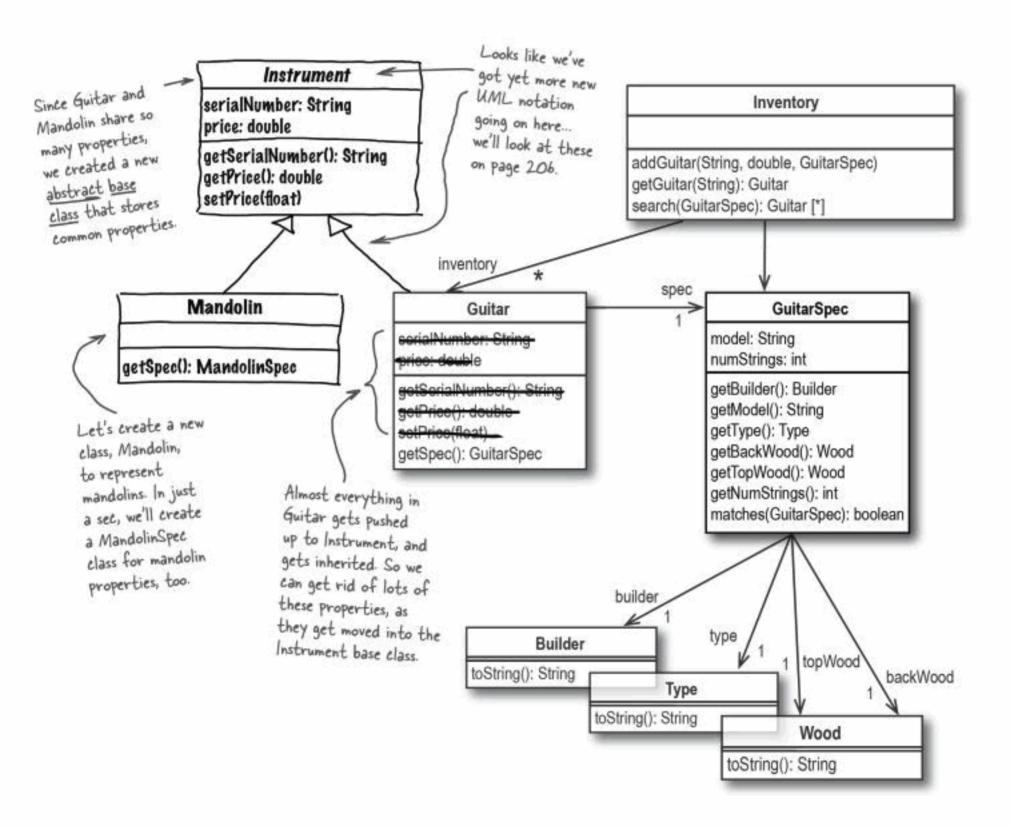
Below is the completed class diagram for Rick's guitar search app, just like it was when we finished up with Chapter 1. It's up to you to add to this diagram so that Rick can start selling mandolins, and your search tool can help him find mandolins that match his clients' preferences, just like he already can with guitars.





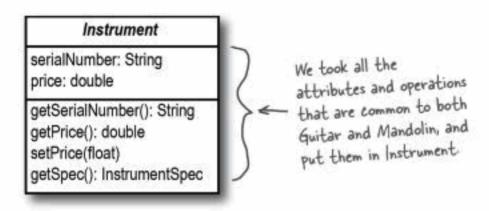
Add support for mandolins to Rick's search tool.

Below is the completed class diagram for Rick's guitar search app, just like it was when we finished up with Chapter 1. Here's what we did first to add support for mandolins (we'll make some more changes over the next few pages).

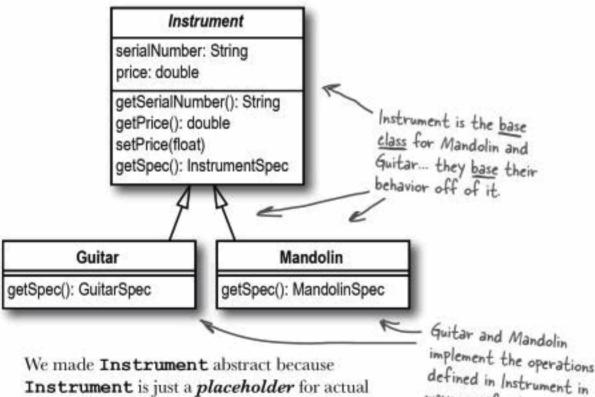


Did you notice that abstract base class?

Take a close look at the new **Instrument** class that we created:



Instrument is an abstract class: that means that you can't create an instance of Instrument. You have to define subclasses of Instrument, like we did with Mandolin and Guitar:



ways specific to a guitar

and mandolin.

We made Instrument abstract because
Instrument is just a placeholder for actual
instruments like Guitar and Mandolin. An
abstract class defines some basic behavior, but it's
really the subclasses of the abstract class that add the
implementation of those behaviors. Instrument
is just a generic class that stands in for your actual
implementation classes.

Abstract classes are placeholders for actual implementation classes.

The abstract class <u>defines</u>

<u>behavior</u>, and the subclasses implement that behavior.

We'll need a MandolinSpec class, too

Mandolins and guitars are similar, but there are just a few things different about mandolins... we can capture those differences in a MandolinSpec class:

GuitarSpec

builder: Builder model: String type: Type backWood: Wood topWood: Wood numStrings: int

getBuilder(): Builder getModel(): String getType(): Type getBackWood(): Wood getTopWood(): Wood getNumStrings(): int matches(GuitarSpec): boolean

MandolinSpec builder: Builder model: String type: Type Style: Style < backWood: Wood topWood: Wood numStringe: int getBuilder(): Builder getModel(): String getType(): Type getStyle(): Style getBackWood(): Wood getTopWood(): Wood getNumStrings(): intmatches(MandolinSpec): boolean

Mandolins can come in several styles, like an "A" style, or an "F" style mandolin.

Most mandolins
have 4 pairs
of strings
(8 total), so
numStrings isn't
needed here.

Just as we used an enumerated type for Wood and Builder, we can create a new type for mandolin styles.

toString(): String

It's OK if you don't know anything about mandolins, or didn't figure out the different properties in the MandolinSpec class. The main thing is that you realized we probably need a new class for mandolins and their specs. If you came up with using an Instrument interface or abstract class, all the better!

Those spec classes sure look a lot alike. How about we use an abstract base class here, too?



What do you think about this design? Will it do what the customer wants it to do? How flexible is it? Do you think software designed like this will be easy to extend and maintain?



——Dumb Questions

We made Instrument abstract because we abstracted the properties common to Guitar and Mandolin into it, right?

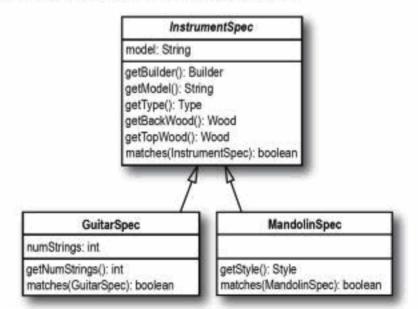
A: No, we made Instrument abstract because in Rick's system right now, there's no such things as an actual "instrument."

All it does is provide a common place to store properties that exist in both the Guitar and Mandolin classes. But since an instrument currently has no behavior outside of its subclasses, it's really just defining common attributes and properties that all instruments need to implement.

So while we did abstract out the properties common to both instrument types, that doesn't necessarily mean that Instrument has to be abstract. In fact, we might later make Instrument a concrete class, if that starts to make sense in our design...

Couldn't we do the same thing with GuitarSpec and MandolinSpec? It looks like they share a lot of common attributes and operations, just like Guitar and Mandolin.

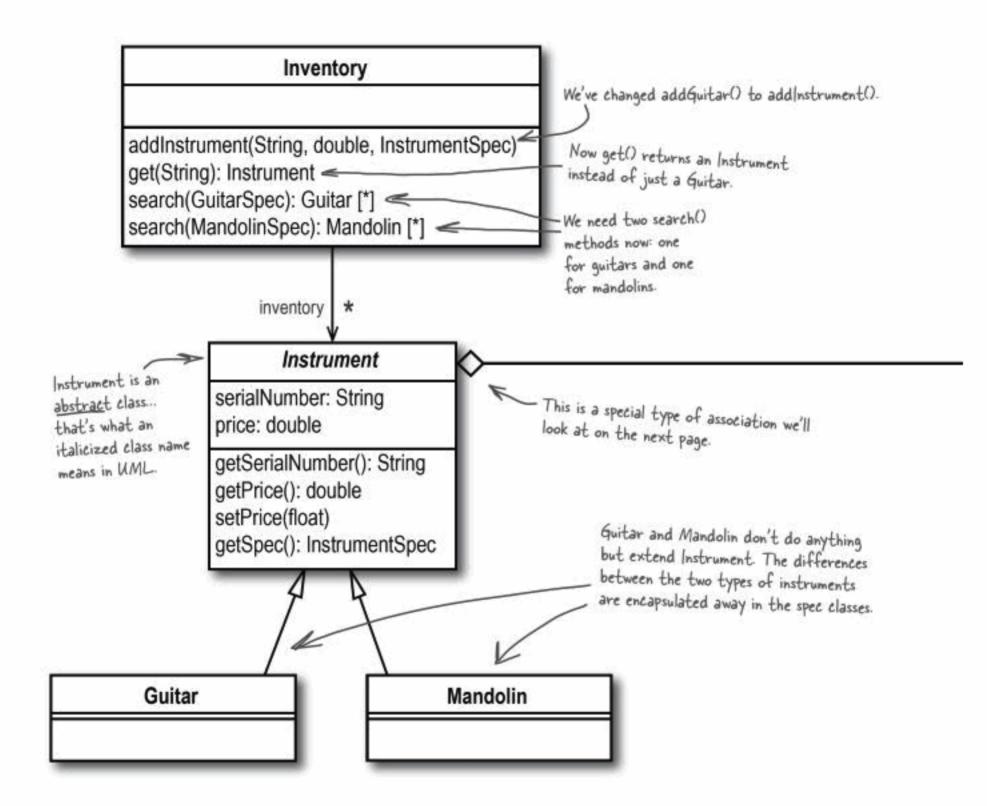
A: Good idea! We can create another abstract base class, called InstrumentSpec, and then have GuitarSpec and MandolinSpec inherit from that base class:



Let's put everything together...

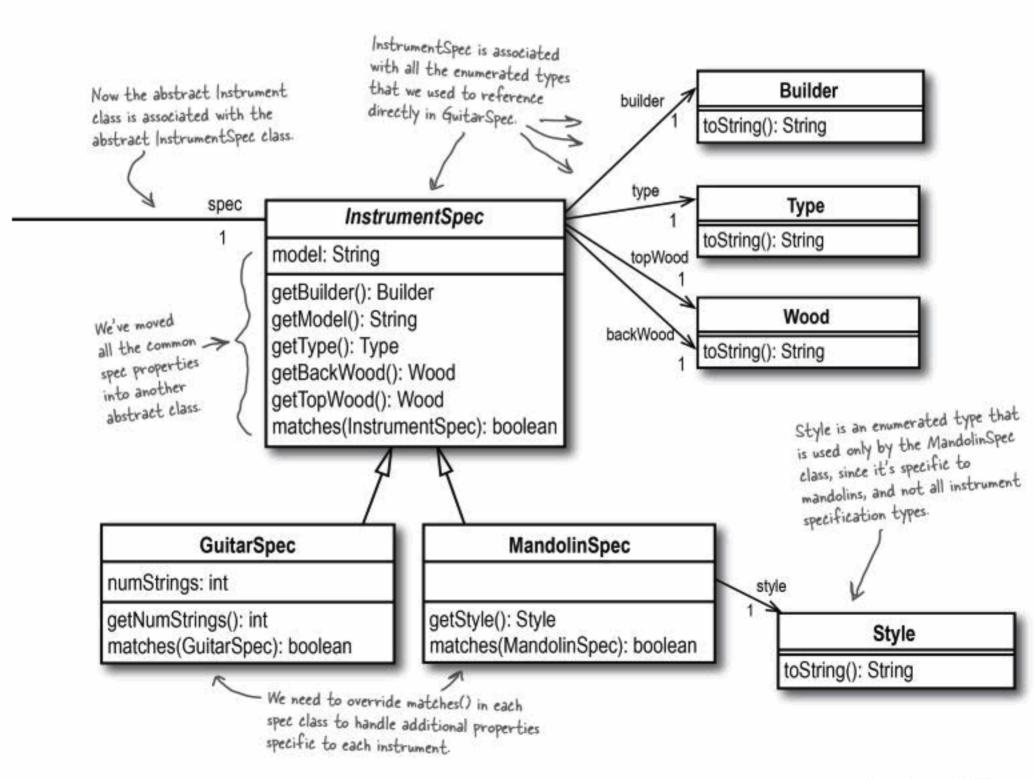
Behold: Rick's new application

It looks like all that work on design back in Chapter 1 has paid off; it took us less than 10 pages to add support for mandolins to Rick's search tool. Here's the completed class diagram:



Whenever you find common behavior in two or more places, look to abstract that behavior into a class, and then reuse that behavior in the common classes.

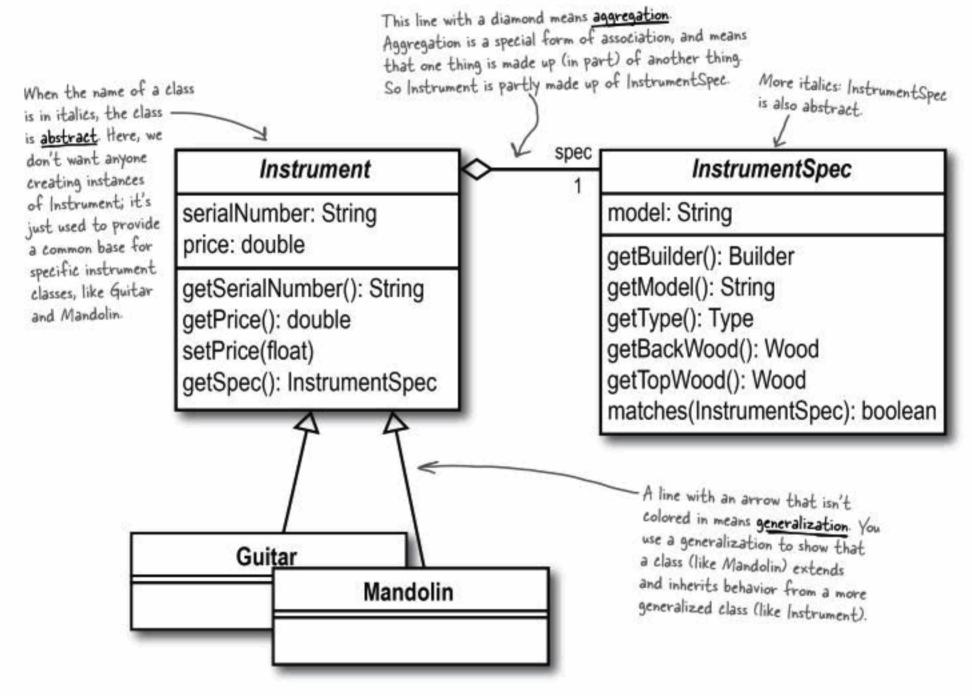
Here's the principle that led to us creating both the Instrument and InstrumentSpec abstract base classes.



Class diagrams dissected (again)

Now that you've added abstract classes, subclasses, and a new kind of association, it's time to upgrade your UML and class diagram skills.





Fold this page down so you can refer back to it when you forget some of UML's notation and symbols.

*UML Cheat Sheet =

What we call it in Java	What we call it in UML	How we show it in UML
Abstract Class	Abstract Class	Italicized Class Name
Relationship	Association	
Inheritance	Generalization	─
Aggregation	Aggregation	

Dumb Questions

Q: Are there lots more types of symbols and notations that I'm going to have to keep up with to use UML?

A: There are a lot more symbols and notations in UML, but it's up to you how many of them you use, let alone memorize. Many people use just the basics you've already learned, and are perfectly happy (as are their customers and managers). But other folks like to really get into UML, and use every trick in the UML toolbox. It's really up to you; as long as you can communicate your design, you've used UML the way it's intended.

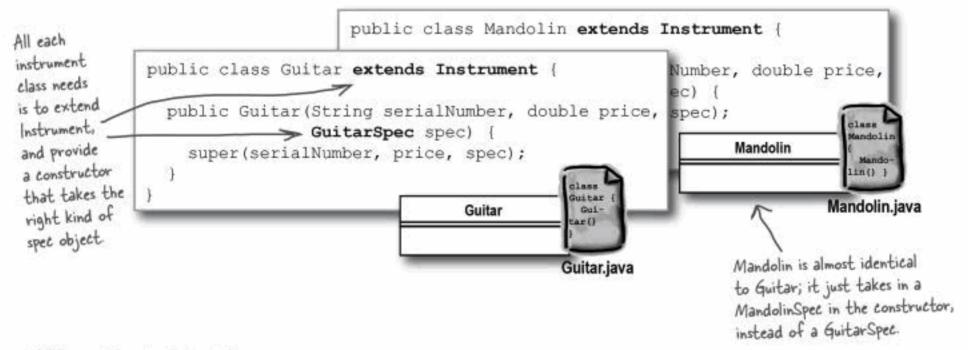
Let's code Rick's new search tool

We can start off be creating a new class, **Instrument**, and making it abstract. Then we put all the properties common to an instrument in this class:

```
form of association because
                                                                                each Instrument is made up
                                                                               of the serial Number and
public abstract class Instrument {
                                        Instrument is abstract. you
                                                                               price member variables, and
                                        have to instantiate subclasses of
  private String serial Number;
                                                                               an InstrumentSpec instance.
                                         this base class, like Guitar.
  private double price;
  private InstrumentSpec spec;
                                                                               Instrument
  public Instrument (String serial Number, double price,
                                                                         serialNumber: String
                         InstrumentSpec spec) (
    this.serialNumber = serialNumber; Most of this is pretty
                                                                         price: double
                                                                         getSerialNumber(): String
    this.price = price;
                                               - simple, and looks a lot
    this.spec = spec;
                                                                         getPrice(): double
                                                like the old Guitar class
                                                                         setPrice(float)
                                                we had.
                                                                         getSpec(): InstrumentSpec
  // Get and set methods for serial number and price
                                                                        strument
  public InstrumentSpec getSpec()
    return spec;
                                                                        rice()
                                                                     Instrument.java
```

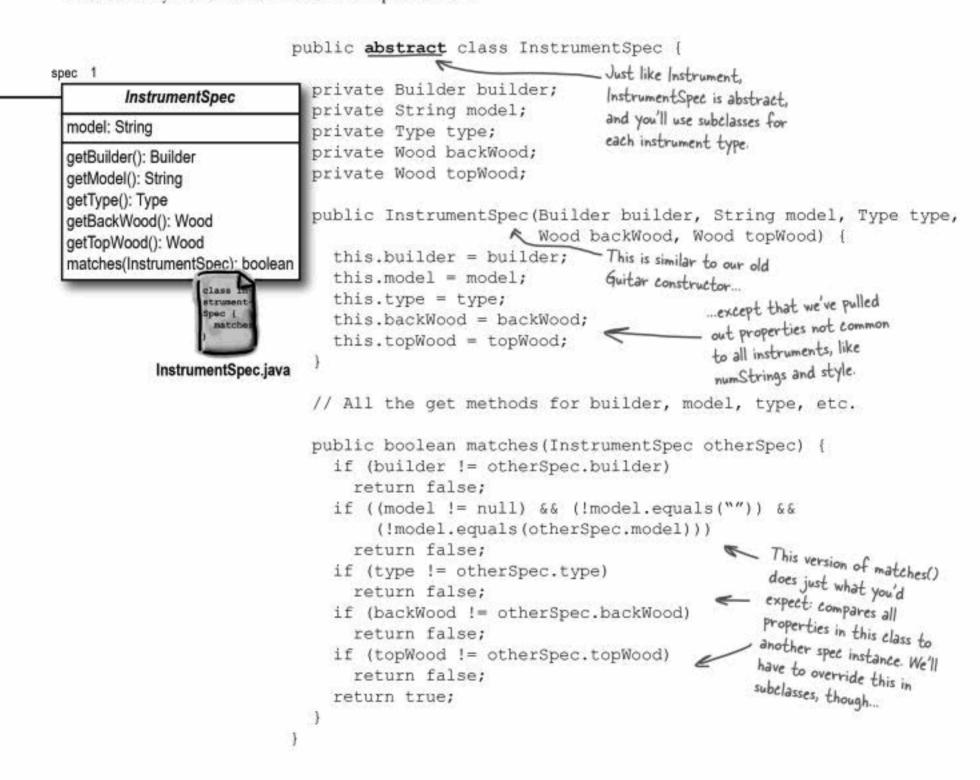
We used the aggregation

Next we need to rework **Guitar.java**, and create a class for mandolins. These both extend **Instrument** to get the common instrument properties, and then define their own constructors with the right type of spec class:



Create an abstract class for instrument specifications

With the instruments taken care of, we can move on to the spec classes. We need to create another abstract class, **InstrumentSpec**, since so many instruments have common specifications:



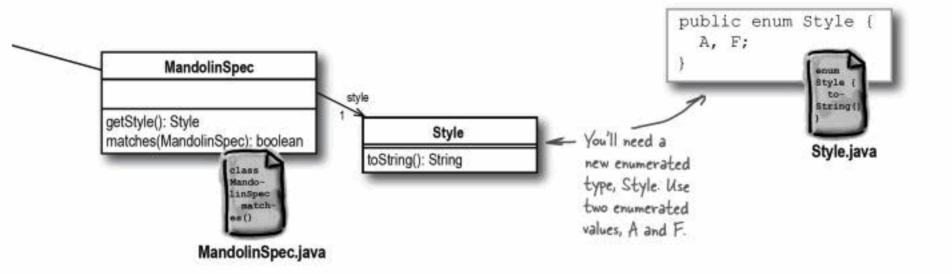
Let's code GuitarSpec...

With InstrumentSpec coded up, it's pretty simple to write the GuitarSpec class: Just as Guitar extended Instrument, Guitar Spec extends InstrumentSpec. public class GuitarSpec extends InstrumentSpec { Only a guitar has a numStrings property; it's not in the Instrument superclass. private int numStrings; public GuitarSpec (Builder builder, String model, Type type, int numStrings, Wood backWood, Wood topWood) { super (builder, model, type, backWood, topWood); this.numStrings = numStrings; This constructor just adds the guitar-specific properties public int getNumStrings() { to what's already stored in return numStrings; the base InstrumentSpec class. // Override the superclass matches() < public boolean matches(InstrumentSpec otherSpec) { matches() uses the superclass's if (!super.matches(otherSpec)) matches(), and then performs return false; additional checks to make if (!(otherSpec instanceof GuitarSpec)) sure the spec is the right return false; type, and matches the guitar-GuitarSpec spec = (GuitarSpec) otherSpec; if (numStrings != spec.numStrings) specific properties. return false; return true; InstrumentSpec model: String getBuilder(): Builder getModel(): String getType(): Type getBackWood(): Wood getTopWood(): Wood GuitarSpec gets a lot of its behavior matches(InstrumentSpec): boolean from InstrumentSpec now, so the code for GuitarSpec has slimmed down a lot from Chapter 1. GuitarSpec numStrings: int getNumStrings(): int Suitar matches(GuitarSpec): boolean GuitarSpec.java

...and MandolinSpec, too

After seeing **GuitarSpec**, **MandolinSpec** is pretty simple. It's very similar, with the addition of a member variable to reference the mandolin's style (like "A" or "F" style), and a slightly different **matches()** method:

```
public class MandolinSpec extends InstrumentSpec {
                                    Only mandolins have a Style, so this is not
                                    pushed up into the InstrumentSpec base class.
  private Style style;
  public MandolinSpec (Builder builder, String model, Type type,
                         Style style, Wood backWood, Wood topWood) {
    super(builder, model, type, backWood, topWood);
    this.style = style;
  public Style getStyle() {
    return style;
  // Override the superclass matches()
  public boolean matches (InstrumentSpec otherSpec) {
    if (!super.matches(otherSpec)) <
                                                            Just like Guitar Spec, Mandolin Spec
      return false;
                                                            uses its superclass to do basic
    if (!(otherSpec instanceof MandolinSpec))
                                                            comparison, and then casts to
      return false;
                                                           MandolinSpec and compares the
    MandolinSpec spec = (MandolinSpec)otherSpec;
                                                           mandolin-specific properties.
    if (!style.equals(spec.style))
      return false;
    return true;
}
```



Finishing up Rick's search tool

All that's left is to update the **Inventory** class to work with multiple instrument types, instead of just the **Guitar** class:

```
The inventory list now holds
                                                                 search(MandolinSpec): Mandolin [*]
                                     multiple types of instruments,
public class Inventory (
                                     not just guitars.
                                                                                            Inventory.java
  private List inventory;
                                                 By using the Instrument and
                                                 Instrument Spec classes, we can turn
  public Inventory() {
                                                 addGuitar() into a more generic method,
    inventory = new LinkedList();
                                                and create any kind of instrument
  public void addInstrument (String serial Number, double price,
                                 InstrumentSpec spec)≪
    Instrument instrument = null;
    if (spec instanceof GuitarSpec)
       instrument = new Guitar(serialNumber, price, (GuitarSpec) spec);
    } else if (spec instanceof MandolinSpec) {
       instrument = new Mandolin(serialNumber, price, (MandolinSpec)spec);
                                                                       ___ Hmmm... this isn't so great Since
    inventory.add(instrument);
                                                                          Instrument is abstract, and we
                                                                          can't instantiate it directly, we
                                                                          have to do some extra work
  public Instrument get (String serialNumber) {
                                                                          before creating an instrument
    for (Iterator i = inventory.iterator(); i.hasNext(); ) {
      Instrument instrument = (Instrument)i.next();
      if (instrument.getSerialNumber().equals(serialNumber)) {
        return instrument;
                                         Here's another spot where using
                                          an abstract base class makes our
                                          design more flexible.
    return null;
  // search(GuitarSpec) works the same as before
  public List search(MandolinSpec searchSpec) {
    List matchingMandolins = new LinkedList();
                                                                    We need another search() method
    for (Iterator i = inventory.iterator(); i.hasNext(); ) {
                                                                    to handle mandolins.
      Mandolin mandolin = (Mandolin)i.next();
      if (mandolin.getSpec().matches(searchSpec))
        matchingMandolins.add(mandolin);
    return matchingMandolins;
  }
                                                  At this point, you're ready to try out
                                                   Rick's improved app. See if you can update
                                                   FindGuitarTester on your own, and see how
```

Inventory

addInstrument(String, double, InstrumentSpec)

inventory: Instrument [*]

get(String): Instrument

things are working with these design changes.

search(GuitarSpec): Guitar [*]

Dumb Questions

Guitar and Mandolin only have a constructor. That seems sort of silly. Do we really need a subclass for each type of instrument just for that?

A: We do, at least for now. Otherwise, how could you tell a mandolin from a guitar? There's no other way to figure out what type of instrument you're working with than by checking the type of the class. Besides, those subclasses allow us to have constructors that ensure that the right type of spec is passed in. So you can't create a Guitar, and pass a MandolinSpec into its constructor.

Q: But with Instrument as an abstract class, the addinstrument() method in Inventory.java becomes a real pain!

A: You're talking about

addInstrument() on page 212,

aren't you? Yes, with Instrument as
an abstract class, you do have some extra
code to deal with. But it's still a fairly small
price to pay to ensure that you can't create
an Instrument, which really doesn't
exist in the real world.

These are little indicators that we may have — a design problem. When things just don't seem to make sense in your application, you may want to investigate a little further... which is exactly what we're about to do.

Isn't there some middle ground, though? I mean, even if there's no such thing as an "instrument" that isn't a guitar or mandolin or whatever, it still seems like we must have a design problem somewhere. Right?

A: Well, you may be onto something. It does seem like parts of our code would benefit from a concrete Instrument class, while other parts wouldn't. Sometimes this means you have to make a decision one way or the other, and just accept the trade-off. But maybe there's more going on here that we're not thinking about...

Q: Why do we have two different versions of search()? Can't we combine those into a single method that takes an InstrumentSpec?

Since InstrumentSpec is an abstract class, like Instrument, Rick's clients will have to give either a GuitarSpec or a MandolinSpec to the search () method in Inventory. And since a spec will match only other specs of the same instrument type, there's never a case where both mandolins and guitars would be returned in the list of matching instruments. So even if you consolidated the two search () methods into one, you wouldn't get any functionality benefit—and even worse, it might look like the method would return both mandolins and guitars (since the return type of search () would be Instrument [*]), even though it never actually would. Wow, this is really starting to look pretty good! Using those abstract classes helped us avoid any duplicate code, and we've got instrument properties encapsulated away into our spec classes.



You've made some MAJOR improvements to Rick's app

You've done a lot more than just add support for mandolins to Rick's application. By abstracting common properties and behavior into the Instrument and InstrumentSpec classes, you've made the classes in Rick's app more independent. That's a significant improvement in his design.

I don't know... it seems like we've still
got a few problems, like the almostempty Guitar and Mandolin classes,
and addInstrument() with all that nasty
instrument-specific code. Are we just
supposed to ignore those?

Great software isn't built in a day

Along with some major design improvements, we've uncovered a few problems with the search tool. That's OK... you're almost always going to find a few new problems when you make big changes to your design.

So now our job is to take Rick's betterdesigned application, and see if we can improve it even further... to take it from good software to GREAT software.



3 steps to great software (revisited)

Is Rick's search tool great software?

Remember the three things we talked about that you can do to write great software? Let's review them to see how well we've done on the latest version of Rick's search tool.

	nciples, like encapsulation, to e easy to extend?	o avoid duplicate

3. How easy is it to reuse Rick's application? Do changes to one part of the app force you to make lots of changes in other parts of the app? Is his software loosely coupled?

Great software every time? I can hardly imagine what that would be like!

Be sure to answer these questions, and then turn the page to see what we wrote down.





Is Rick's search tool great software?

Remember the three things we talked about that you can do to write great software? Let's review them to see how well we've done on the latest version of Rick's search tool.

- Does the new search tool do what it's supposed to do?
 Absolutely. It finds guitars and mandolins, although not at the same time. So maybe it just mostly does what it's supposed to do. Better ask Rick to be sure...
- 2. Have you used solid OO principles, like encapsulation, to avoid duplicate code and make your software easy to extend?

We used encapsulation when we came up with the InstrumentSpec classes, and inheritance when we developed an Instrument and InstrumentSpec abstract superclass. But it still takes a lot of work to add new instrument types...

3. How easy is it to reuse Rick's application? Do changes to one part of the app force you to make lots of changes in other parts of the app? Is his software loosely coupled?

It's sort of hard to use just parts of Rick's application. Everything's pretty tightly connected, and InstrumentSpec is actually part of Instrument (remember when we talked about aggregation?).

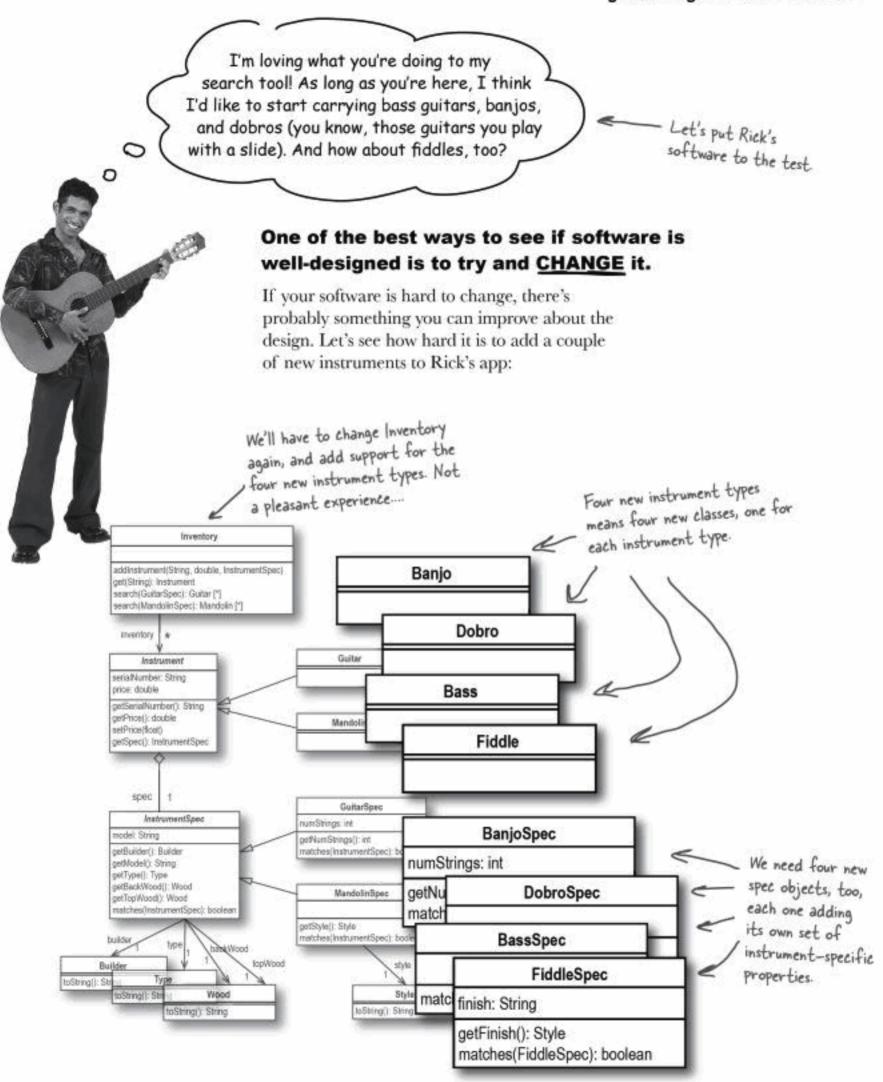
Looks like there's still some work to do... but I'll bet this will be amazing by the time you're done.

0



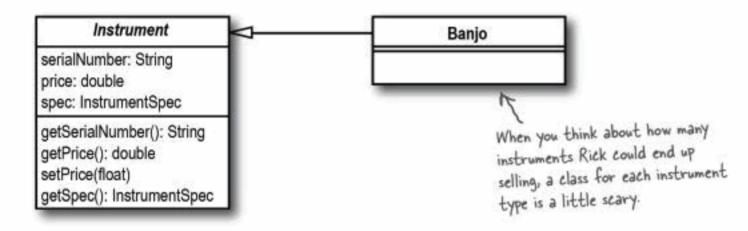
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It's OK if you got some different answers and had different ideas than we did on these questions... just make sure you thought things through, and that you understand why we answered how we did.

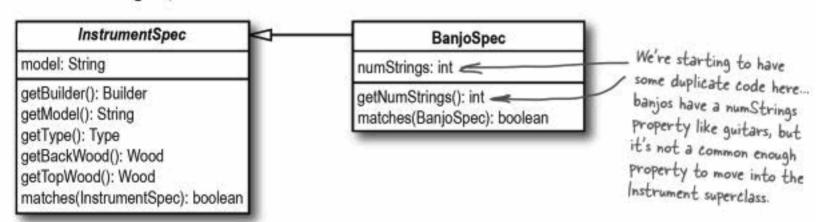


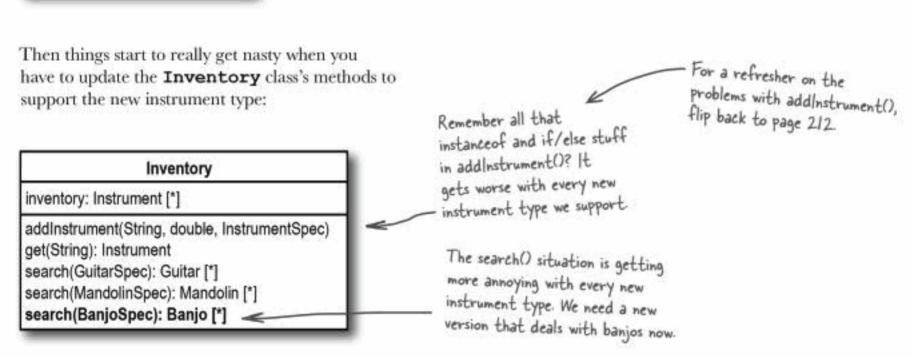
Uh oh... adding new instruments is not easy!

If ease of change is how we determine if our software is well-designed, then we've got some real issues here. Every time we need to add a new instrument, we have to add another subclass of **Instrument**:



Then, we need a new subclass of InstrumentSpec, too:





So what are we supposed to do now?

It looks like we've definitely still got some work to do to turn
Rick's application into great software that's truly easy to change
and extend. But that doesn't mean the work you've done isn't
important... lots of times, you've got to improve your design
to find some problems that weren't so apparent earlier

on. Now that we've applied some of our OO principles to Rick's search tool, we've been able to locate some issues that we're going to have to resolve if we don't want to spend

the next few years writing new **Banjo** and **Fiddle** classes (and who really wants to do that?).

Before you're ready to really tackle the next phase of Rick's app, though, there are a few things you need to know about. So, without further ado, let's take a quick break from Rick's software, and tune in to...

DD CATASTROPHE! Objectville's Favorite Quiz Show

BB CATASTROPHE!

Objectville's Favorite Quiz Show

Risk Avoidance	Famous Designers	Code Constructs	Maintenance and Reuse	Software Neuroses
\$100	\$100	\$100	\$100	\$100
\$200	Objectville's favo an array of OO	come to OO CATASTR prite quiz show. We've answers tonight, I hop to ask the right quest	got quite De you've	\$200
\$30	\$300	\$300	\$300	\$300
	\$400	\$400	\$400	\$400

We've got some great OO categories today, so let's get started. Remember, I'll read off an answer, and it's your job to come up with the question that matches the answer. Good luck!



Dumb Answers

A: It might not seem like it, but we are working on Rick's search tool, in a manner of speaking. We're going to need some pretty advanced OO techniques to make his application flexible and reusable, and we wanted to give you a chance to get a handle on these principles before you had to start applying them to a pretty complicated problem.

Q: Why are we playing a game show? Shouldn't we be fixing Rick's search tool?

A: The questions that match up with the answers in this chapter aren't easy, but you should be able to reason them all out. Take your time; it's important that you come up with these questions on your own if at all possible, and only then turn the page to get a little more information on each question and the OO principle it involves. Besides, we think you're getting to be a pretty kick-ass developer, so we have lots of confidence in you.

Q: If these are new OO principles, how am I supposed to figure out what the questions are? That's asking a lot, isn't it?

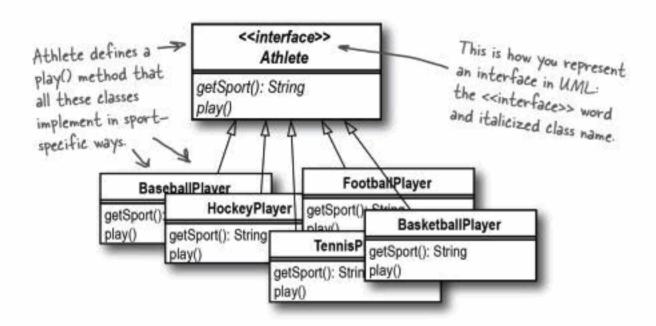
DO CATASTROPHE

Objectville's Favorite Quiz Show

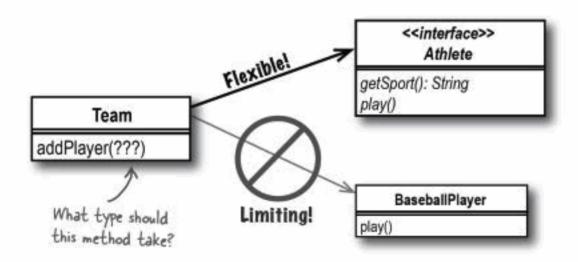
Risk Avoidance	Famous Designers	Code Constructs	Maintenance and Reuse	Software Neuroses
\$100	\$100	\$100	\$100	\$100
\$200	\$200		3200	\$200
\$300	\$300		e construct ha	
\$400	\$400	that appl and also focus o	of defining be ies to multiple being the pref of classes that those types.	types, ferred
"What is			Writhe the	te what you think question is for the er above.



Suppose you've got an application that has an interface, and then lots of subclasses that inherit common behavior from that interface:



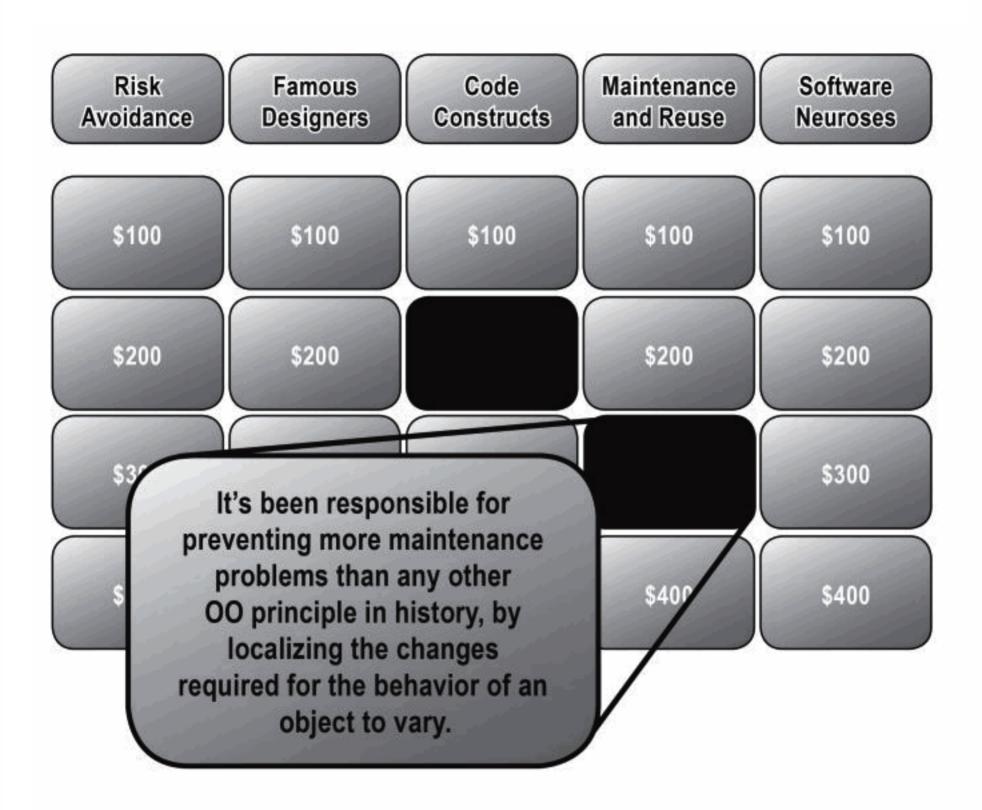
Anytime you're writing code that interacts with these classes, you have two choices. You can write code that interacts directly with a subclass, like FootballPlayer, or you can write code that interacts with the interface, Athlete. When you run into a choice like this, you should always favor coding to the interface, not the implementation.



Why is this so important? Because it adds *flexibility* to your app. Instead of your code being able to work with only one specific subclass—like <code>BaseballPlayer</code>—you're able to work with the more generic <code>Athlete</code>. That means that your code will work with any subclass of <code>Athlete</code>, like <code>HockeyPlayer</code> or <code>TennisPlayer</code>, and even subclasses that haven't even been designed yet (anyone for <code>CricketPlayer</code>?).

Coding to an interface, rather than to an implementation, makes your software easier to extend.

By coding to an interface, your code will work with all of the interface's subclasses—even ones that haven't been created yet.

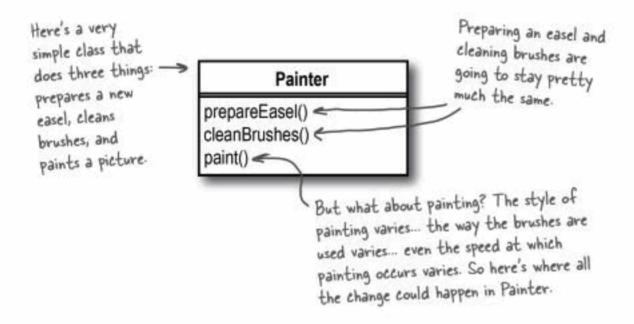


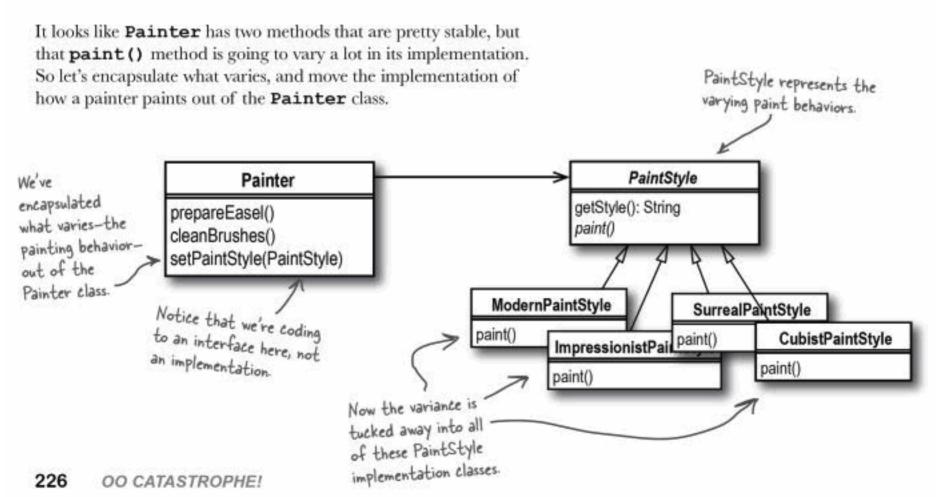
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TTIIAL	19	

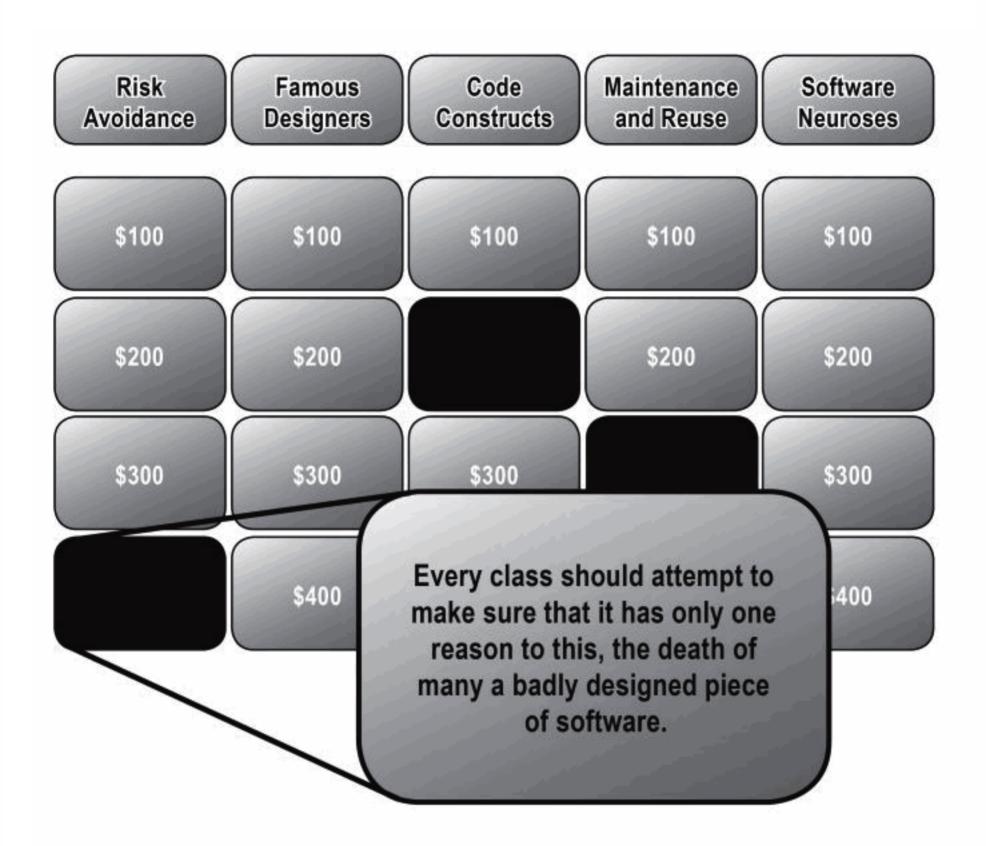
"What is ENCAPSULATION?"

We've talked a fair bit about encapsulation already, in terms of preventing duplicate code. But there's more to encapsulation than just avoiding lots of copy-and-paste. Encapsulation also helps you protect your classes from unnecessary changes.

Anytime you have behavior in an application that you think is likely to change, you want to move that behavior away from parts of your application that probably won't change very frequently. In other words, you should always try to encapsulate what varies.





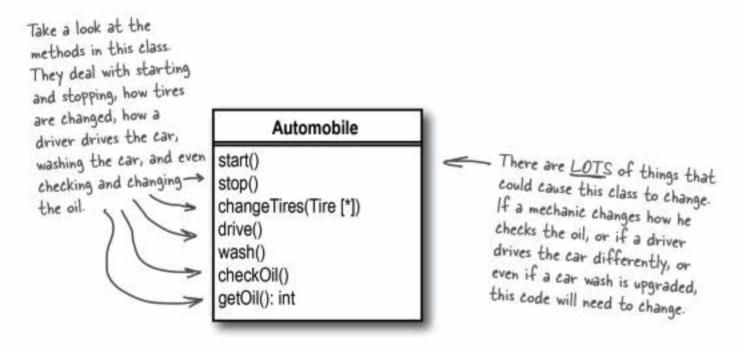


"What is	7"
TT HALIS	

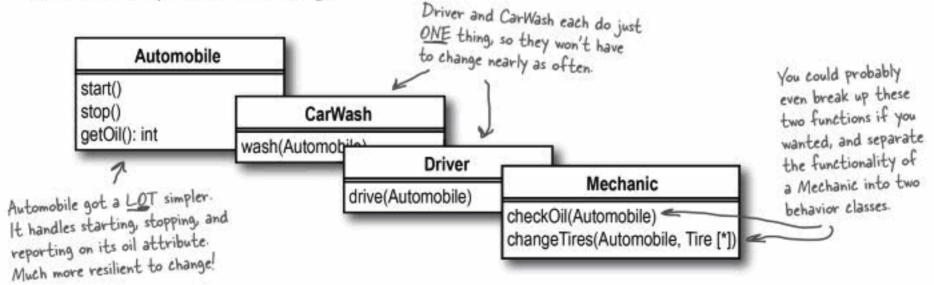
"What is CHANGE?"

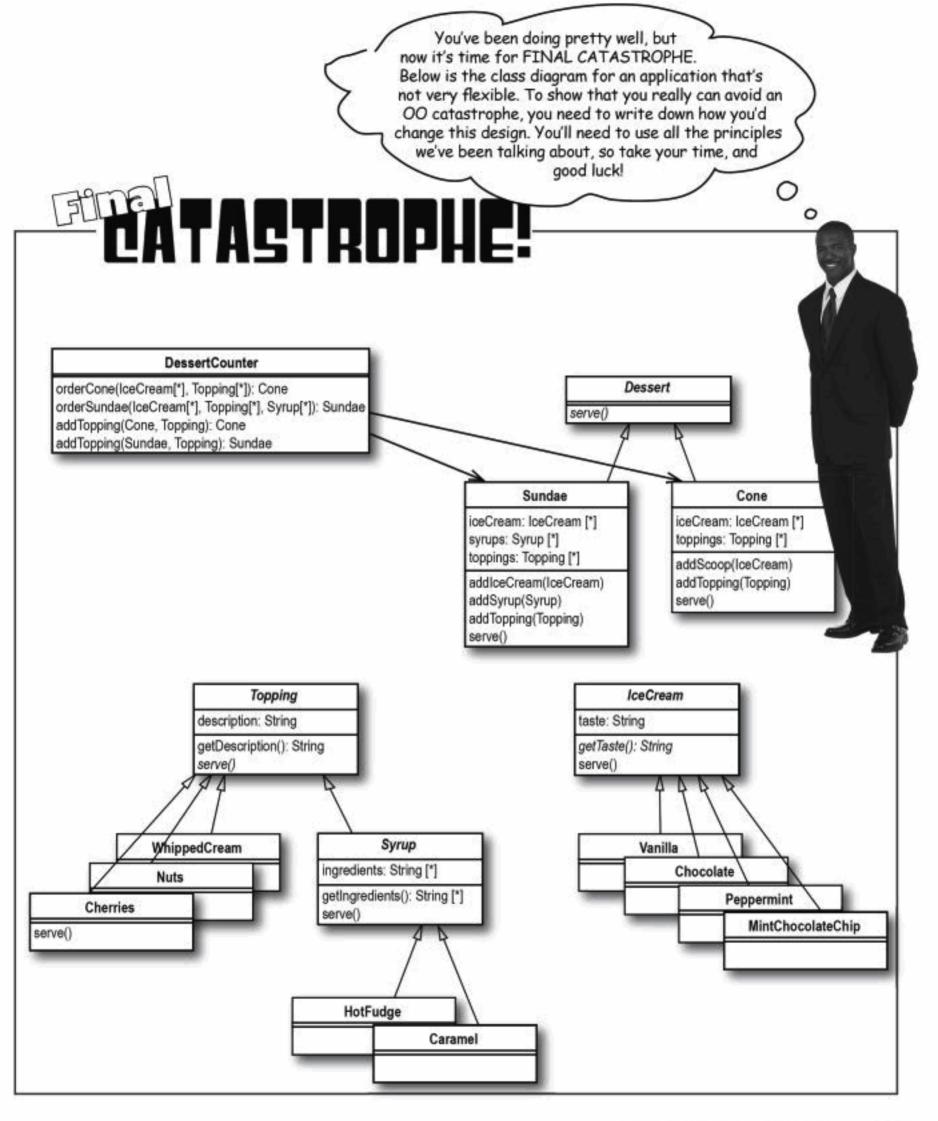
You already know that the one constant in software is CHANGE. Software that isn't well-designed falls apart at the first sign of change, but great software can change easily.

The easiest way to make your software resilient to change is to make sure **each class has only one reason to change**. In other words, you're minimizing the chances that a class is going to have to change by reducing the number of things in that class that can **cause** it to change.



When you see a class that has more than one reason to change, it is probably *trying to do too many things*. See if you can break up the functionality into multiple classes, where *each individual class does only one thing*—and therefore has only **one** reason to change.





FATASTROPHE!

Answers

Dessert

serve()

DessertCounter is coding to implementations of the Dessert interface. We can reduce these two order methods to one: orderDessert(), and then return the interface, Dessert

DessertCounter

orderCone(IceCream[*], Topping[*]): Cone orderSundae(IceCream[*], Topping[*], Syrup[*]): Sundae addTopping(Cone, Topping): Cone addTopping(Sundae, Topping): Sundae

DessertCounter has more than one reason to change: if the ordering process changes, or if how the Cone and Sundae class adds toppings changes. Adding a topping should be done to the Dessert classes directly, not here.

Syrup is an implementation of Topping... we really don't need a method specifically to add a Topping. That's coding to an implementation.

Sundae iceCream: IceCream [*] syrups: Syrup [*] toppings: Topping [*] addIceCream(IceCream) addSyrup(Syrup) addTopping(Topping) serve()

Cone

iceCream: IceCream [*] toppings: Topping [*]

addScoop(IceCream) addTopping(Topping)

serve()

There are a LOT of serve() implementations floating around. We should try and encapsulate what varies, and put all the serving code in one place. That way, if the serving process changes, we don't need to change ALL these classes.

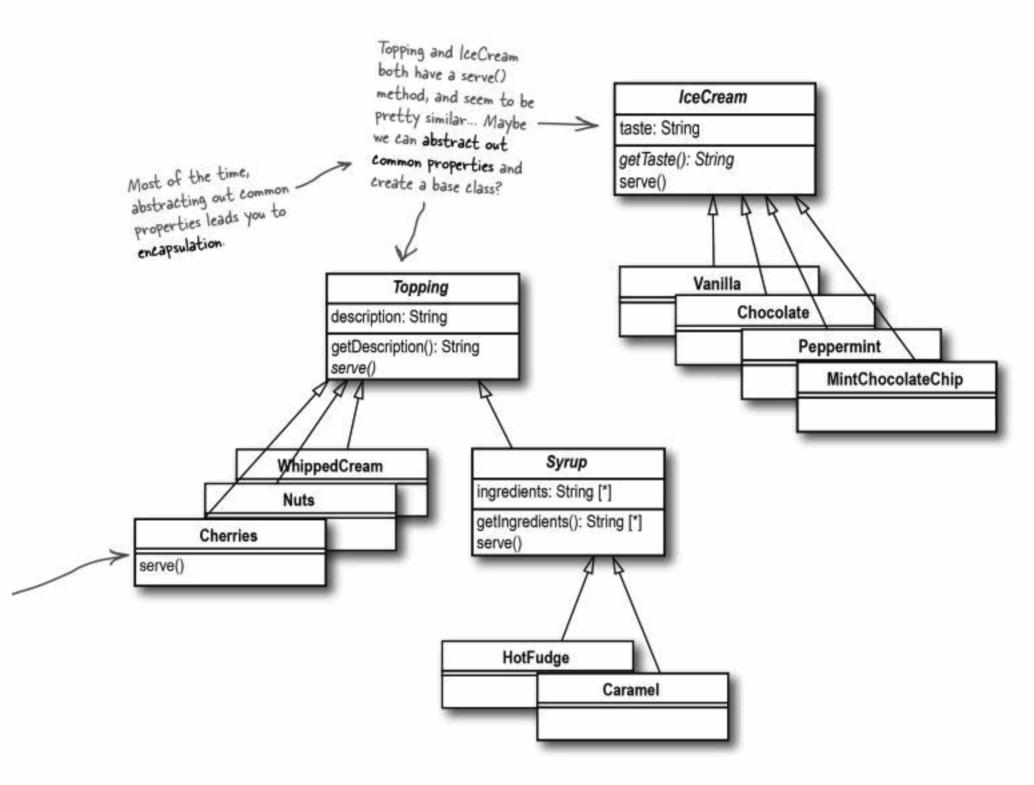
Dumb Answers

A: You've seen several times already that when you see a potential for duplicate code, you should look to encapsulate. In this case, it's reasonable to assume that serving a Sundae probably isn't that different from serving a Cone.

So you could create a new class, called **DessertService**, and put the **serve()** method in that class. Then, all of your **Dessert**, **IceCream**, and **Topping** classes could simply refer to **DessertService**. **serve()**. If **serve()** changes, you've got to update code in only one place: **DessertService**.

So you're encapsulating what might vary—the code in the serve() method—and you're making sure that each class has only a single reason to change. That's a double win!

Q: How did you know to encapsulate the serve() methods out of all those different classes? I missed that.



It's been great having you as a contestant, and we'd love to have you back next week, but we just received an urgent call from a "Rick"? Something about getting back to work on his search tool?



0

You're ready to tackle Rick's inflexible code now

With a few new OO tools and techniques under your belt, you're definitely ready to go back to Rick's software, and make it a lot more flexible. By the time you're done, you'll have used everything you've just learned on **OO Catastrophe**, and made it easy to change Rick's application, too.

00 Principles

Encapsulate what varies.

Code to an interface rather than to an implementation.

Each class in your application should have only one reason to change.

These three principles are HUGE! Take note of them, as we'll be using them a lot in the upcoming chapters.

5 (part 2) good design = flexible software

Give Your Software a 30-minute Workout

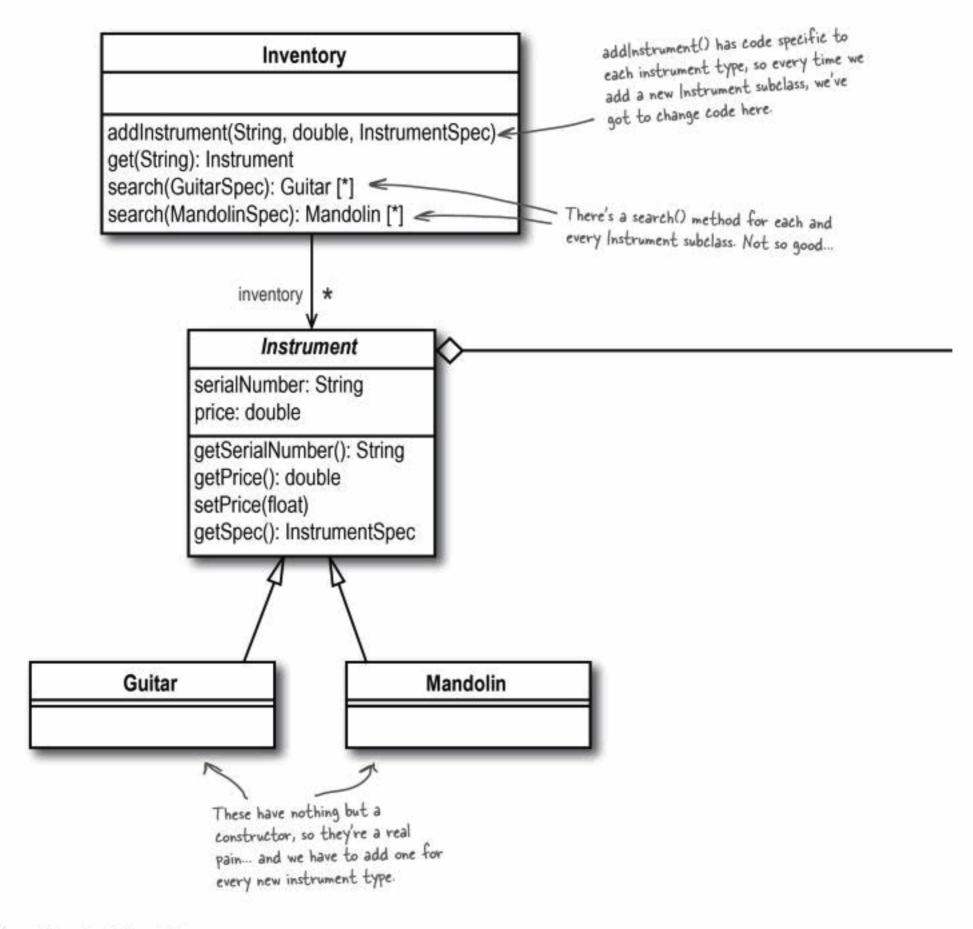


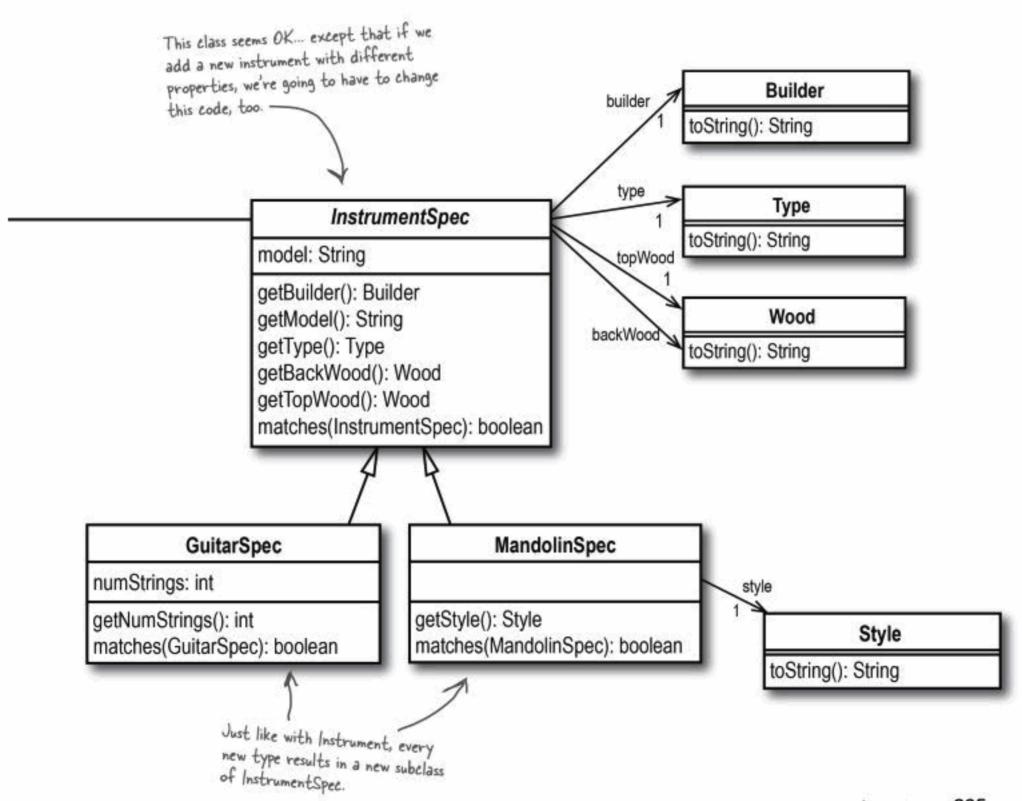
Ever wished you were just a bit more flexible?

When you run into problems making changes to your application, it probably means that your software needs to be more flexible and resilient. To help stretch your application out, you're going to do some analysis, a whole lot of design, and learn how OO principles can really loosen up your application. And for the grand finale, you'll see how higher cohesion can really help your coupling. Sound interesting? Turn the page, and let's get back to fixing that inflexible application.

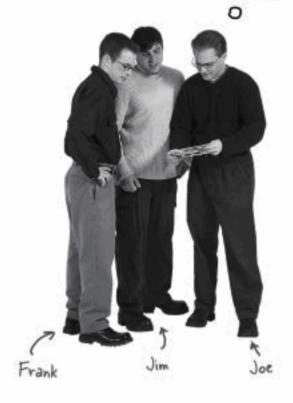
Back to Rick's search tool

Loaded up with some new OO principles, we're ready to tackle making Rick's application well-designed and flexible. Here's where we left off, and some of the problems we've discovered:





Guys, I've been looking over this class diagram for Rick's application, and there's just got to be a better way to deal with this search() method thing.



Frank: Yeah, it's a pain, but I don't see any way to get around it. We have to let Rick's clients search for each different type of instrument somehow.

Jim: I still don't see why we can't have just one search()
method that takes in an InstrumentSpec. Wouldn't that cut
down on all those different versions of search()?

Joe: Well, it would, but we still don't have any way to return multiple types of instruments. If the client provides a GuitarSpec, it's never going to match a BanjoSpec or MandolinSpec. So the list returned from search() will always have only the type of instrument that the client's spec is for.

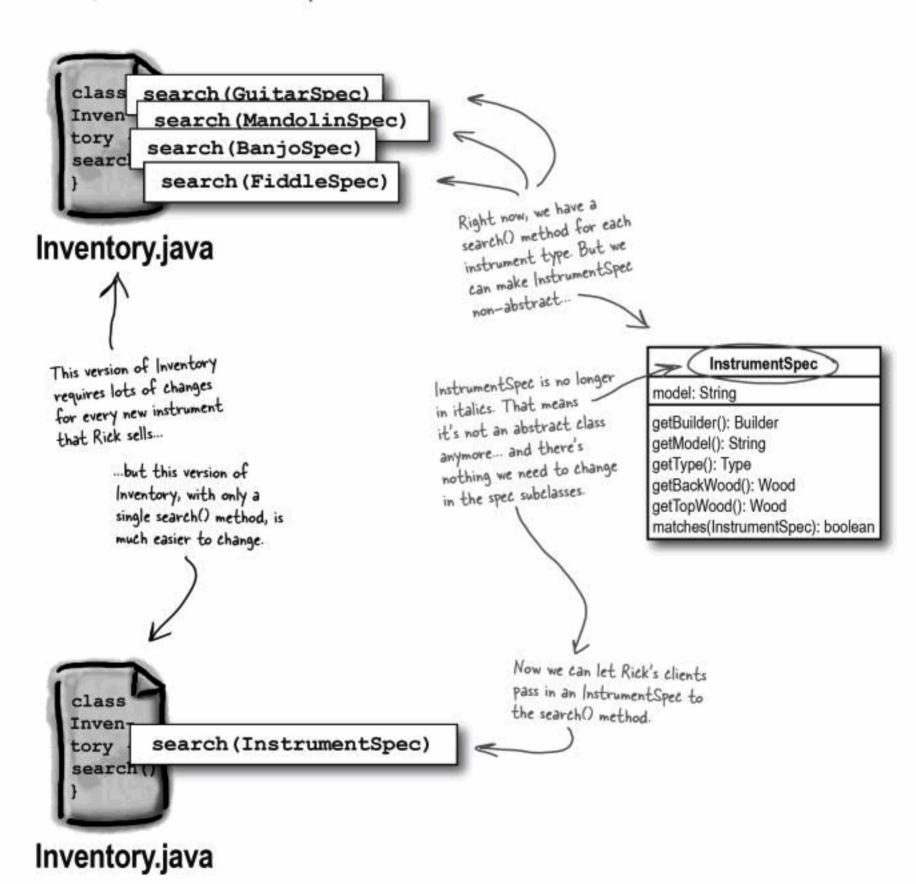
Jim: Because we can't instantiate InstrumentSpec, right? It's an abstract class, so we have to create a MandolinSpec, or a BanjoSpec, or whatever.

Frank: So maybe that's the problem... besides, shouldn't we be coding to an interface like InstrumentSpec, not an implementation like GuitarSpec or BanjoSpec?

Joe: Hmmm. I hadn't thought about that, but you're right; we really should be focusing on the interface, and not all those implementation classes.

A closer look at the search() method

It seems pretty clear that there's a problem with the way we're handling searches for Rick's clients. We could make **InstrumentSpec** a concrete class, but would that solve all our problems?



The benefits of our analysis

Let's take what we've figured out about turning InstrumentSpec into a concrete class, and see if it makes the design of Inventory any better.

```
Here's the big change
public class Inventory {
                                                        that this page highlights.
                                                                                               Inventory.java
  private List inventory;
                                                                                   We still have some
  public Inventory() {
                                                                                   issues here... this
     inventory = new LinkedList();
                                                                                    method gets
                                                                                    bigger and more
                                                                                    complicated every
  public void addInstrument(String serialNumber, double price,
                                                                                    time we add a new
                                   InstrumentSpec spec) (
                                                                                    type of instrument...
     Instrument instrument = null;
     if (spec instanceof GuitarSpec) {
       instrument = new <u>Guitar(serialNumber, price, (GuitarSpec)spec);</u>
     } else if (spec instanceof MandolinSpec) {
       instrument = new Mandolin(serialNumber, price, (MandolinSpec)spec);
                                                                        ...and we're coding to the implementation
     inventory.add(instrument);
                                                                        classes, not the Instrument base class.
  public Instrument get (String serial Number) {
    for (Iterator i = inventory.iterator(); i.hasNext(); ) (
      Instrument instrument = (Instrument)i.next();
      if (instrument.getSerialNumber().equals(serialNumber)) (
         return instrument;
                                                        search() is looking much better!
                                                        Only one version, and it takes in an Instrument Spec now.
    return null;
  public List search(InstrumentSpec searchSpec)
    List matchingInstruments = new LinkedList();
    for (Iterator i = inventory.iterator(); i.hasNext(); ) {
      Instrument instrument = (Instrument)i.next(); <</pre>
                                                            We're coding to the Instrument base type now,
      if (instrument.getSpec().matches(searchSpec))
                                                            not the implementation classes like Guitar and
         matchingInstruments.add(instrument);
                                                            Mandolin. This is a much better design.
    return matchingInstruments;
                             On top of better design, now search()
                             can return all instruments that match,
                             even if that list contains different
                             types of instruments, like two guitars
                             and one mandolin.
```

Inventory

addInstrument(String, double, InstrumentSpec)

search(InstrumentSpec): Instrument [*]

inventory: Instrument [*]

get(String): Instrument

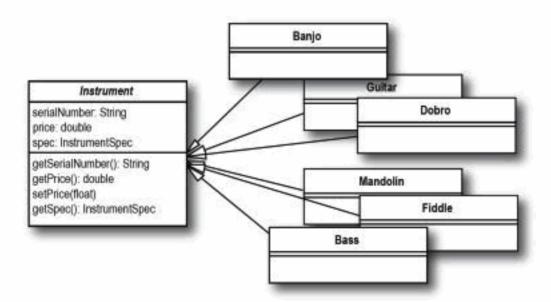
One of these things is not like the other... or is it?



The search() method isn't the only thing that makes adding new instruments to Rick's application difficult. You also have to add a new subclass of Instrument for each new instrument type. But why? Let's do a little more analysis.

Vhat things are common to all instruments?	
Vhat things are different between instruments?	

If you have any ideas for how you might change Rick's application so that you don't need all the instrument-specific subclasses, mark those changes on the class diagram below. Feel free to add or remove classes and properties; it's up to you to decide how you can improve Rick's design.



One of these things is not like the other... Sharpen your pencil or is it?

The search() method isn't the only thing that makes adding new instruments to Rick's application difficult. You also have to add a new subclass of Instrument for each new instrument type. But why? Let's do a little more analysis.

Why is there a need for an Instrument class in Rick's application?

Most instruments have at least a few common properties, like serial number and price. Instrument stores the common properties, and then each specific instrument type can extend from Instrument.

You didn't need to write down exactly what we did, but you should be thinking along the same lines here

What things are common to all instruments?

The serial number, the price, and some set of specifications

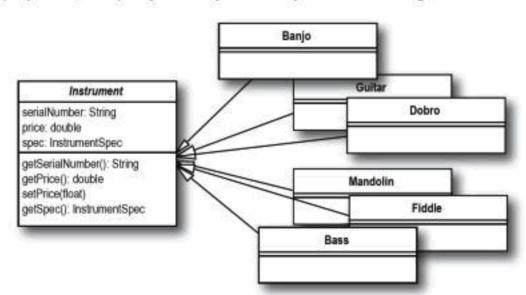
leven though the details of those specs may be different

for different instrument types).

What things are different between instruments?

The specifications: each type of instrument has a different set of properties that it can contain. And since each instrument has a different InstrumentSpec, each has a different constructor.

If you have any ideas for how you might change Rick's application so that you don't need all the instrument-specific subclasses, mark those changes on the class diagram below. Feel free to add or remove classes and properties; it's up to you how you can improve Rick's design.

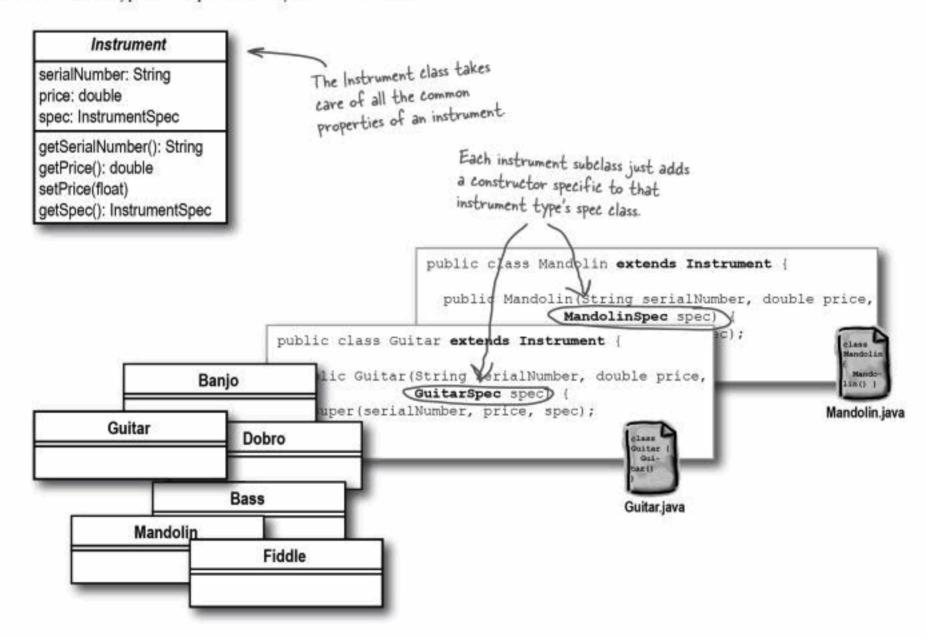


Did you come up with any ideas for changing Rick's application?

A closer look at the instrument classes

Even though **search()** is looking better, there are still some real problems with all the instrument subclasses, and the **addInstrument()** method in **Inventory**.

Remember, we originally made **Instrument** abstract because each instrument type was represented by its own subclass:



But classes are really about behavior!

But the reason you usually create a subclass is because the **behavior** of the subclass is different than the superclass. In Rick's application, is the behavior of a **Guitar** different than that of an **Instrument**? Does it *function* differently in his application than a **Mandolin** or **Banjo**?

Guitar and Mandolin and the other instruments don't have different behavior. But they have different properties... so we have to have subclasses for each instrument, right?

This is a good 00 principle, but it sure is causing headaches with all the subclasses. We'll come back to this one in a moment. All the instruments—at least from Rick's perspective—behave the same. So that leaves only two reasons to have subclasses for each instrument type:

- Because the **Instrument** class represents a concept, and not an actual object, it really should be abstract. So we have to have subclasses for each instrument type.
- Each different type of instrument has different properties, and uses a different subclass of InstrumentSpec, so we need ← an instrument-specific constructor for each type of instrument.

These seem like pretty good reasons (well, at least the first one does), but we're ending up with lots of extra classes that don't do much... and that makes our software inflexible and difficult to change. So what do we do? If we were writing a system that represented how these instruments played, we might need subclasses to handle behavior like pluck(), strum(), or frail().

This looks like another case where we're coding to an implementation instead of an interface. So this isn't a good reason to keep Instrument abstract.

Since Rick's app already does what it needs to do (Step I), we're ready to try and make his software more flexible. Remember the second step in writing great software, from back in Chapter 1:

Apply basic 00 principles to add flexibility.

How can we take this step and apply it to the problems we're finding in Rick's app?

Object-Offerite	ed Principles to the rescue!
don't know what t	a problem with Rick's app, but we're not sure what it is. When you to do to solve a design problem, just run through the OO principles e if any of them might help improve your software's design.
the box for a prin-	e, check the box if you think it could help us out. Then, if you checked ciple, it's up to you to write down how you could use that principle to earch tool design.
] Inheritance	
Polymorphism	
1 Abstraction	<u></u>
Encapsulation	

243



Object-Oriented Principles to the rescue!

There's definitely a problem with Rick's app, but we're not sure what it is. When you don't know what to do to solve a design problem, just run through the OO principles you know, and see if any of them might help improve your software's design.

☑ Inheritance	We're using inheritance already with the Instrument and InstrumentSpec
	classes, and their subclasses. But it does seem like the instrument-specific
	subclasses don't actually do anything but inherit from Instrument they just
	have slightly different constructors.
Polymorphism	We use polymorphism in the search() method to treat all instruments as
	instances of Instrument, instead of worrying about whether they're a Guitar
	or a Mandolin. So searching is a lot easier but it would be nice to be able to
	use this in addinstrument(), too, and cut down on some repetitive code.
200	

Abstraction

InstrumentSpec abstracts the details about each instruments specifications

away from the Instrument class itself, so that we can add new instrument

properties without affecting the basic Instrument class.

Encapsulation

We're using encapsulation a lot, but maybe we can use it even more...

remember, encapsulate what varies! Since the properties in each instrument
type are what varies, can we somehow encapsulate those properties away
from Instrument and InstrumentSpec completely?

Guys, we've been using inheritance, polymorphism, and abstraction in this design. But I'm beginning to think the key is encapsulation. Remember what we learned about separating what changes from what stays the same?

Joe: Yeah, you're talking about encapsulating what varies, right?

Frank: Exactly! And we know that the properties for each instrument are what varies in the application.

Jim: I thought we'd been over this; that's why we have all those subclasses of Instrument, like Guitar and Mandolin. So we can represent the differences between each instrument.

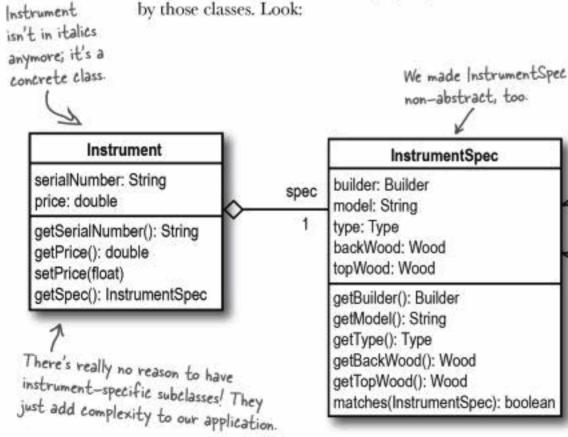
Frank: But that really didn't help... and besides, the *behavior* of each instrument doesn't vary, so do we really need subclasses for each one?

Joe: So you're saying we would make Instrument a concrete class, instead of being abstract, right? And then we can get rid of all those instrument-specific subclasses.

Jim: But... I'm totally confused. What about the properties that vary across each instrument?

Frank: What about them? The Instrument class has a reference to an InstrumentSpec, and all the property differences can be handled by those classes. Look:

We actually already have the properties encapsulated away from the rest of the application! We just weren't taking advantage of our good design decision.



numStrings: int getNumStrings(): int matches(GuitarSpec): boolean

MandolinSpec

getStyle(): Style matches(MandolinSpec): boolean

Death of a design (decision)

One of the hardest things you will ever do is to let go of mistakes you made in your own designs. In Rick's search tool, it doesn't make sense to have separate Instrument subclasses for each type of instrument. But it took us almost 30 pages (and 2 parts of Chapter 5) to figure that out. Why?

Because it seemed to make sense at the time, and it's HARD to change something you thought was already working!

Keep looking over your designs when you run into problems. A decision you made earlier may be what's

causing you headaches now.

It's easy to rip apart someone else's code, but you've got to learn to look at your own code, and identify problems. This is also where peer review, having fellow programmers look at your code, can really be a lifesaver. Don't worry if you have to make changes; a betterdesigned application will save you tons of time in the long run.

Design is <u>iterative</u>... and you have to be willing to <u>change your own designs</u>, as well as those that you inherit from other programmers.



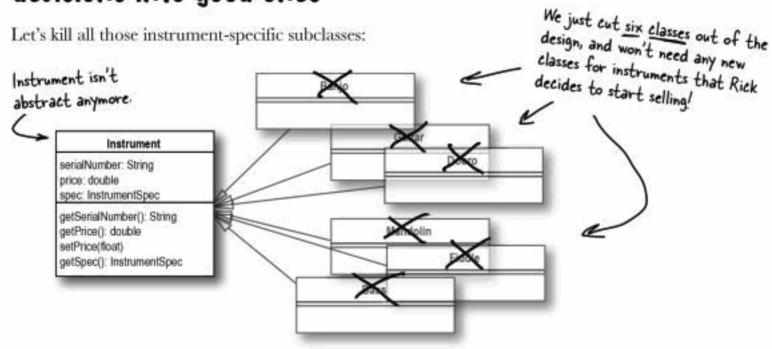
Pride kills good design

Never be afraid to examine your own design decisions, and improve on them, even if it means backtracking.

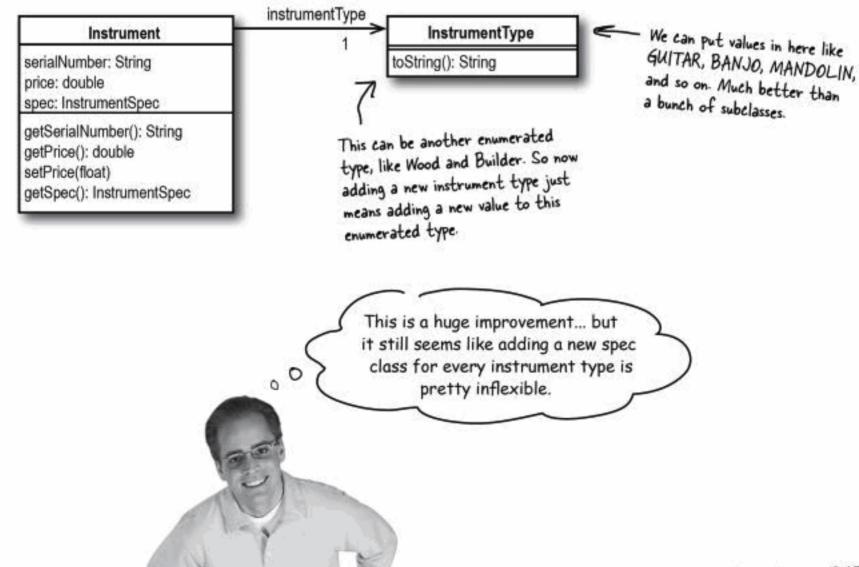


Let's kill our bad design decision to create instrument-specific subclasses once and for all, and get on with writing great software again.

Let's turn some bad design decisions into good ones



We also probably need a new property in each instrument to let us know what type of instrument it is:



One more cubicle conversation (and some help from Jill)

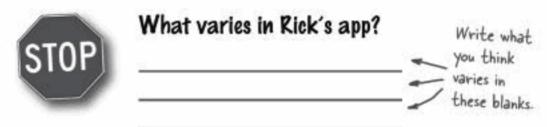
I hate to butt in, but I've been thinking about something you said earlier, Joe: Encapsulate what varies.



Jill's been listening in on the chapter, and has some ideas on how to improve Rick's app.

Joe: But we just did that... we made Instrument concrete, and got rid of all the instrument-specific subclasses.

Jill: Actually, I think that's really only the first step. What really varies in Rick's software?



Frank: We've gone through this already: the properties for each instrument are what vary.

Jill: So can we encapsulate them somehow?

Joe: We already have: we used the InstrumentSpec class for that.

Frank: Wait a second, Joe. We used InstrumentSpec because those properties were used by both clients and instruments. So that was more about duplicate code...

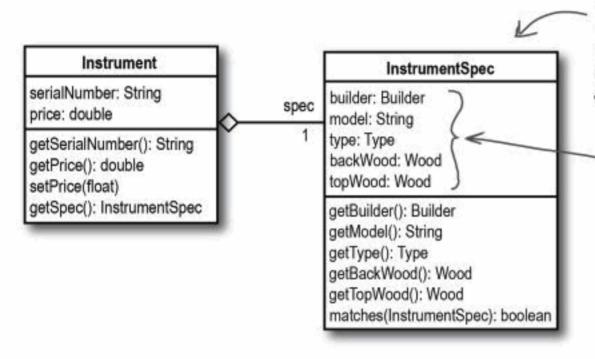
Jill: Yes! That's my point... the proeprties inside InstrumentSpec vary, too. So maybe we need to add another layer of encapsulation.

Joe: So since the properties of each instrument vary, we should pull those out of InstrumentSpec? It's almost like double-encapsulation or something.

Jill: Sort of... we encapsulate the specifications common across client requests and instruments from the Instrument class, and then we encapsulate the properties that vary from the InstrumentSpec class.

"Double encapsulation" in Rick's software

Let's look at the layer of encapsulation we already have, and then see how we can add a little more encapsulation to get those properties that vary out of the InstrumentSpec class. This really isn't an OOAFD term, so don't be surprised if your professor looks at you funny if you use it in class.



We realized in Chapter I that clients and instruments both needed to use these properties, so we created the InstrumentSpec class to abstract them away from the Instrument class.

The problem is that these properties vary across instruments, and so we're having to add a subclass for each type of instrument

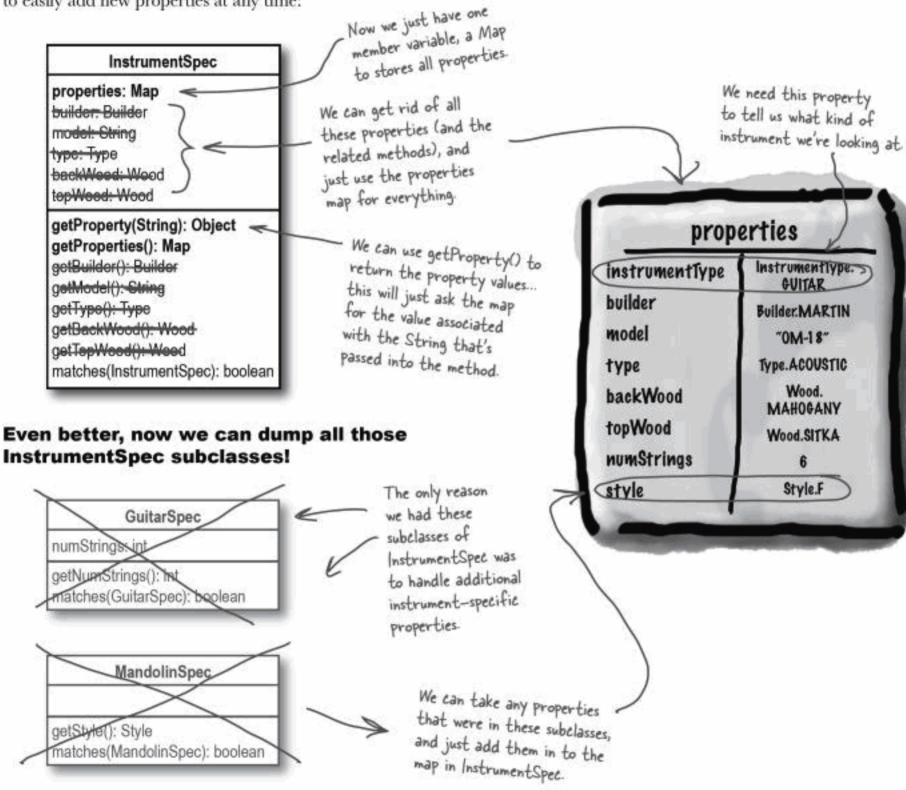
Since some of these properties vary, we want to move them out of the **InstrumentSpec** class. We need a way to refer to properties and their values, but not have those properties hardcoded into the **InstrumentSpec** class. Any ideas for how we could do that?

What type(s) do you think you could use to represent properties and access their values, but not have to change your InstrumentSpec class to support new properties?

By encapsulating what varies, you make your application more flexible, and easier to change.

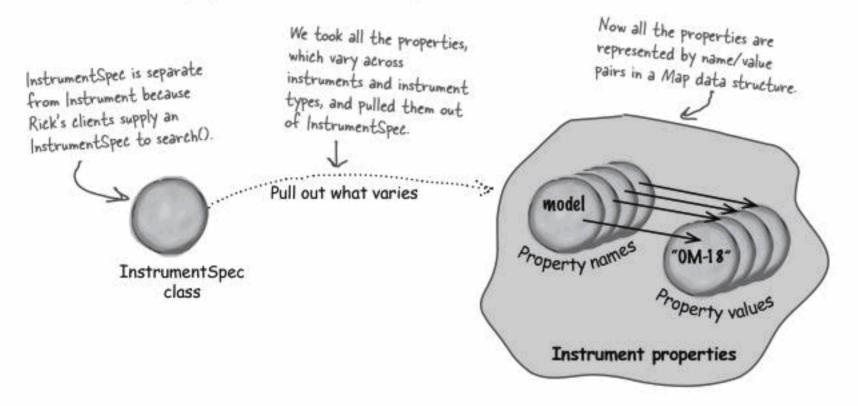
Getting dynamic with instrument properties

What did you come up with on the last page to store properties? We decided that using a **Map** would be a great way to handle various types of properties, and still be able to easily add new properties at any time:



What we did: a closer look

Anytime you see something that varies, you should look for a way to encapsulate. In the case of **InstrumentSpec**, we realized that the properties of an instrument vary.

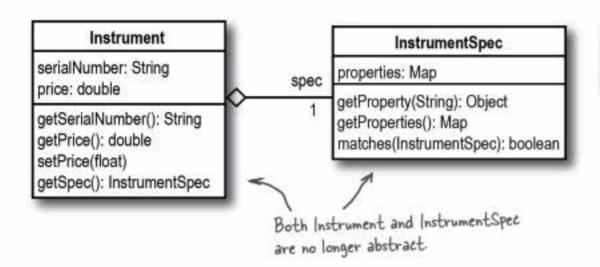


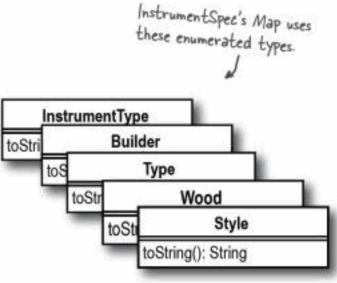
When you have a set of properties that vary across your objects, use a collection, like a Map, to store those properties dynamically.

You'll remove lots of methods from your classes, and avoid having to change your code when new properties are added to your app.

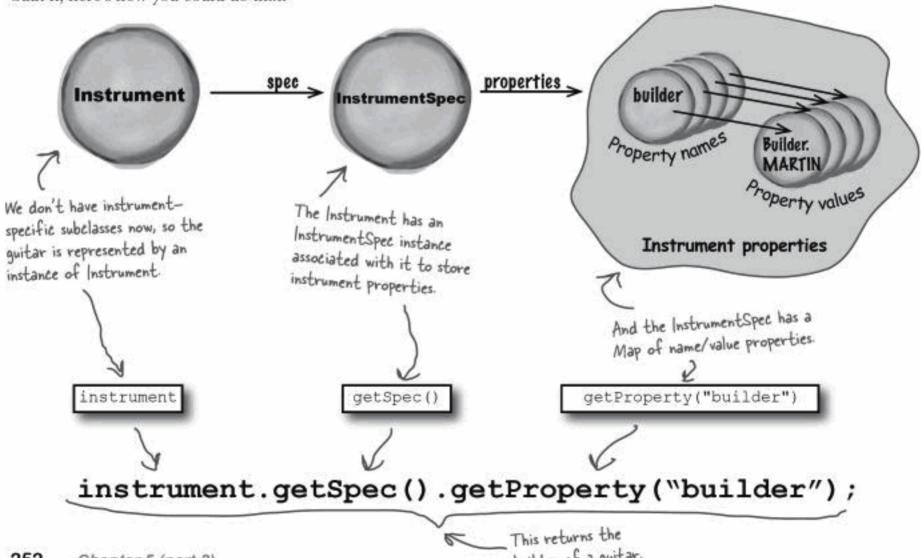
Using the new Instrument and InstrumentSpec classes

Let's take one last look at how our new Instrument and InstrumentSpec classes work in practice. Here's where we are with the design right now:





If you were accessing a guitar, and wanted to know who built it, here's how you could do that:





Code Magnets

Using a Map for storing properties seems like a good idea, but let's see how things look once we actually code up a new version of InstrumentSpec. Your job is to finish off the code below using the magnets at the bottom of the page.

```
import java.util.____;
import java.util. ;
import java.util. ;
public class InstrumentSpec (
 private properties;
 public InstrumentSpec(_____) {
   if (properties == ____) {
     this.properties = new ____();
   } else {
     this.properties = new ____( );
  }
 public getProperty(String _____) {
   return properties.get( );
 public _____ getProperties() {
   return ____;
 public boolean matches(______ otherSpec) {
   for (_____ i = otherSpec. ().keySet(). ();
       i.____(); ) {
     String ____ = (String)i. ();
     if (!properties.get(_____).equals(
         otherSpec.getProperty(_____))) {
      return ;
   return ____;
1
                                            getProperties
            Map propertyName hasNext
                                                        nstrumentSpec
                                                 Map properties
             propertyName propertyName
                            false
                                  opertyName properties
            HashMap
                         null next
   InstrumentSpec propertyName
                               getProperties
                                                               253
                                                   you are here >
```



Code Magnets Solutions

Using a Map for storing properties seems like a good idea, but let's see how things look once we actually code up a new version of InstrumentSpec. Your job was to finish off the code below:

```
Iterator
import java.util
                    HashMap
import java.util.
import java.util.
public class InstrumentSpec {
  private
            Map properties;
                                                            You could actually use any
                                     properties
  public InstrumentSpec
                                                            implementation of the Map
    if (properties ==
                           null
                                                            interface you wanted here.
                                  HashMap
       this.properties
     } else {
       this.properties = new
                                 HashMap
                                          ( properties
                                           propertyName
          object
  public
                    getProperty(String
     return properties.get propertyName
  public
           Map
                  getProperties() {
                properties
     return
  public boolean matches ( InstrumentSpec
                                               therSpec) {
                                        getProperties ().keySet().iterator
     for (
                         = otherSpec.
                                              next
                               = (String)i
                               propertyName
             otherSpec.getProperty(
                                       propertyName
                   false
         return
                                Be sure you got these two right;
                                                                      getProperties
                                otherwise, matches() will always
     return
                                return the wrong result.
}
                                                                                   List
                                                                  InstrumentSpec
```

Dumb Questions

Q: So now both Instrument and InstrumentSpec are concrete classes?

A: Right. Instrument isn't just a concept anymore; it represents actual instruments in Rick's inventory. And InstrumentSpec is what clients use to pass in their specs when they're searching, and what Instrument uses to store properties for an instrument.

Q: So I can get rid of my Guitar and Mandolin subclasses?

A: Yup. As well as Banjo, Dobro, and any other instrument-specific subclasses of Instrument you may have created.

Q: And that's because we use the Instrument class directly now, right?

A: You got it! Remember, you typically subclass because behavior changes. In the Instrument subclasses, no behavior was changing; in fact, all we did for each instrument subclass was create a new constructor. That added a ton of classes, reduced the flexibility of our app, and really didn't give us any helpful functionality.

Guitar and Mandolin, but I'm confused about why we don't need the different subclasses of InstrumentSpec anymore.

A: It's OK; that's one of the trickiest parts of the design of Rick's application.

Remember, one of the key principles in any OO design is to encapsulate what varies. In Rick's app, the properties of each instrument varied. So we pulled those properties out of InstrumentSpec, and put them into a Map. Now, when you add another instrument with a new property, you can just add the new property as a name/value pair in the properties Map.

Q: And with less classes to deal with, our software is more flexible?

A: In this case, that's true. There are certainly times where adding classes will make your design more flexible, though. Remember, adding an InstrumentSpec class helped separate instruments from their properties, and that was good; but in this chapter, we've been removing classes, and that's made it easier to add new instruments to Rick's software.

Q: I never would have figured out that we didn't need subclasses for instruments or their specs. How am I supposed to ever get good at this?

A: The best way to get good at software design is to write software! In Rick's application, we had to go down some wrong paths—like adding Guitar and Mandolin classes—to figure out what the right thing to do was.

Most good designs come about through bad designs; almost nobody gets it all right the first time. So just do what makes sense, and then start applying your OO principles and patterns to see if you can make improvements to what you've got.

Most <u>good</u> <u>designs</u> come from analysis of <u>bad</u> <u>designs.</u>

Never be afraid to make mistakes and then change things around.

Finishing up Rick's app: the InstrumentType enum

We've almost got ourselves a great piece of software. Let's follow through on our new design ideas, starting with a new enumerated type for each instrument type:

So far, these are the types of instruments that Rick sells.

```
public enum InstrumentType {
 GUITAR, BANJO, DOBRO, FIDDLE, BASS, MANDOLIN;
                                                          InstrumentType
                                                      String(): String
 public String toString() {
    switch(this) {
                                                  Type (
      case GUITAR: return "Guitar";
      case BANJO: return "Banjo";
      case DOBRO: return "Dobro";
                                              InstrumentType.java
      case FIDDLE: return "Fiddle";
      case BASS: return "Bass";
      case MANDOLIN: return "Mandolin";
                                                        toString() just
      default: return "Unspecified";
                                                        makes it easier to
                                                        Print things out
```

Let's update Inventory, too

With the changes to Instrument and InstrumentSpec, our Inventory class starts to get much simpler:

Inventory

inventory: Instrument [*]

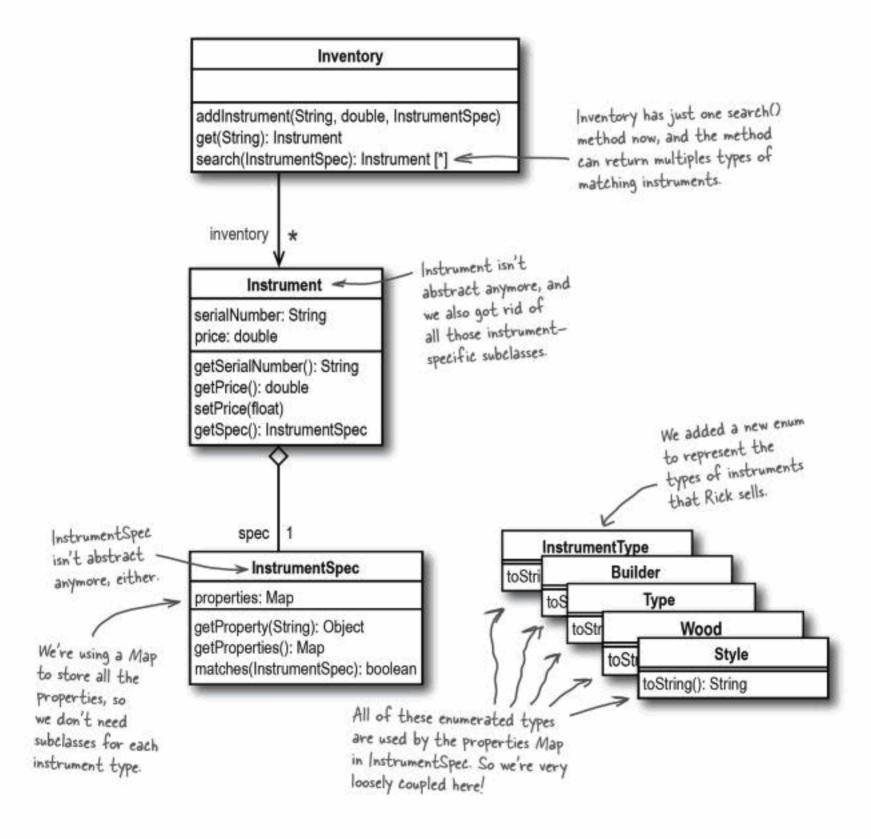
addInstrument(String, double, InstrumentSpec) get(String): Instrument

```
search(InstrumentSpec): Instrument [*]
public class Inventory (
                                                                                   Adding an
 public void addInstrument(String serialNumber, double price,
                                                                                   instrument
                                                                                   just got a
                               InstrumentSpec spec) {
   Instrument instrument = null;
                                                                                    lot easier.
   if (spec instanceof GuitarSpec) (
      instrument = new Guitar(serialNumber, price, (GuitarSpec)spec);
    } else if (spec instanceof MandolinSpec) {
      instrument = new Mandolin(serialNumber, price, (MandolinSpec)spec);
    Instrument instrument = new Instrument(serialNumber, price, spec);
    inventory.add(instrument);
                                                          Now we're able to instantiate
                                                          Instrument directly, since it's
                                                           no longer abstract
  // etc
```

harpen your pencil	Let's see what we've really done.
	We've made a ton of changes to Rick's software, all in the name of "more flexibility." Let's see how things look now. Flip back to the class diagram of Rick's app on page 234, and recall what things looked like when we started. Then, below, draw a class diagram for how Rick's application looks now.
	Answers on the next pag

Behold: Rick's flexible application

We've made a ton of changes to Rick's application... and it's easy to forget what we've been working towards. Look at the class diagram below, though, and see how much simpler Rick's application is now:



But does the application actually work?

Rick's software looks a lot better than it did way back at the beginning of this chapter—and it sure looks better than when we added all those subclasses for banjos and mandolins. But we've still got to make sure his search tool actually works! So let's update our test class, and check out how searches work with the new version of Rick's software:



```
public class FindInstrument {
                                                      Now clients fill out an InstrumentSpec. Since
  public static void main(String[] args) {
                                                      this test client didn't specify an instrument
    // Set up Rick's inventory
                                                      type, the search could bring back guitars,
    Inventory inventory = new Inventory();
                                                      mandolins, or anything else that Rick sells.
    initializeInventory(inventory);
    Map properties = new HashMap();
    properties.put("builder", Builder.GIBSON);
                                                                                   We have to work a
    properties.put("backWood", Wood.MAPLE);
                                                                                   little more directly
    InstrumentSpec clientSpec = new InstrumentSpec(properties);
                                                                                   with the Map that
                                                                                   InstrumentSpec uses,
    List matchingInstruments = inventory.search(clientSpec);
                                                                                   but it's easy now to
    if (!matchingInstruments.isEmpty()) {
      System.out.println("You might like these instruments:");
                                                                                   just loop through each
      for (Iterator i = matchingInstruments.iterator(); i.hasNext(); )
                                                                                    instrument's properties
         Instrument instrument = (Instrument)i.next();
                                                                                    and print them out.
         InstrumentSpec spec = instrument.getSpec();
         System.out.println("We have a " + spec.getProperty("instrumentType")
           " with the following properties:");
         for (Iterator j = spec.getProperties().keySet().iterator();
              j.hasNext(); ) {
           String propertyName = (String)j.next();
           if (propertyName.equals("instrumentType"))
             continue;
           System.out.println("
                                      " + propertyName +
             spec.getProperty(propertyName));
                                                                            We want to skip over the
         }
                                                                            instrument Type property,
         System.out.println(" You can have this " +
                                                                            since we've already handled
           spec.getProperty("instrumentType") + " for $" +
                                                                           that before we start looping.
           instrument.getPrice() + "\n---");
    } else {
      System.out.println("Sorry, we have nothing for you.");
  // initializeInventory() method here
                                                  We also need to add some instruments to Rick's
                                                   inventory so we can search for more than
                                                   guitars... we'll do that on the next page.
```

To see if the new version of Rick's software works, we need to run a search on more than just guitars. Your job is to write code for the initializeInventory() method in FindInstrument.java, and add several guitars, mandolins, and banjos to Rick's inventory. Below, we've listed the instruments Rick currently has, and even written code to add the first guitar to help you get started.



Guitars

Collings CJ 6-string acoustic, Indian Rosewood back and sides, Spruce top, Serial #11277, for \$3999.95

> Martin D-18 6-string acoustic, Mahogany back and sides, Adirondack top, Serial #122784, for \$5495.95

Fender stratocastor 6-string electric,

Alder back and sides and top, Serial #V95693, for \$1499.95

Fender stratocastor 6-string electric, Alder back and sides and top, Serial #V9512, for \$1549.95

Gibson SG'61 Reissue 6-string electric, Mahogany back, sides, and top, Serial #82765501, for \$1890.95

Banjos do not have a top wood.

Gibson Les Paul 6-string electric, Maple back, sides, and top, Serial #70108276, for \$2295.95

there's the beginning of initialize Inventory(), where the first guitar shown above is added to Rick's inventory.

<u> Mandolins</u>

Gibson F5-G acoustic mandolin, Maple back, sides, and top, Serial #9019920, for \$5495.99

> Remember, the numStrings attribute doesn't apply to mandolins

Banjos

Gibson RB-3 5-string acoustic banjo, Maple back and sides, Serial #8900231, for \$2945.95

Banjos do not have a top wood.

private static void initializeInventory(Inventory inventory)
Map properties = new HashMap();
properties.put("instrumentType", InstrumentType.GUITAR);
properties.put("builder", Builder.COLLINGS);
properties.put("model", "CJ");
properties.put("type", Type.ACOUSTIC);
properties.put("numStrings", 6);
properties.put("topWood", Wood.INDIAN_ROSEWOOD);
properties.put("backWood", Wood.SITKA);
inventory.addInstrument("11277", 3999.95,
 new InstrumentSpec(properties));
// your code goes here

You should write code here to add the other instruments shown above.

FindInstrument.java

1

Answers on page 262

Test driving Rick's well-designed software

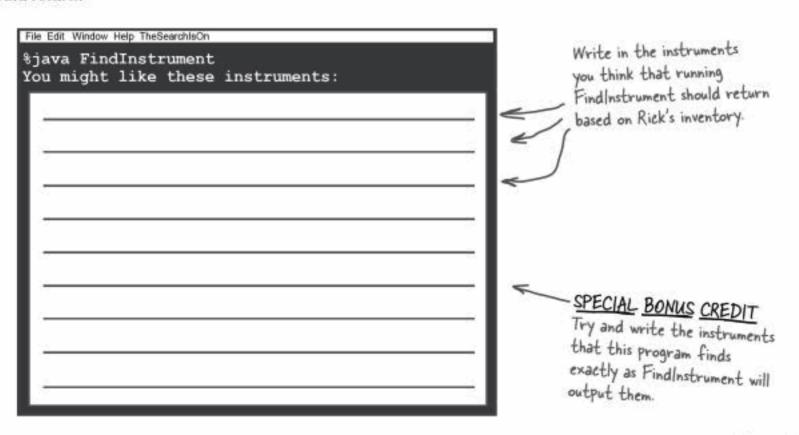
Be sure you've added all the instruments shown on the last page to your **initializeInventory()** method in **FindInstrument.java**, and then compile all your classes. Now you're ready to take Rick's software for a test drive...

...well, almost. First, you need to figure out
what a search based on the current version of
FindInstrument should return. Here's the set of
preferences that Rick's current client has supplied:

Map properties = new HashMap();
properties.put("builder", Builder.GIBSON);
properties.put("backWood", Wood.MAPLE);
InstrumentSpec clientSpec =
 new InstrumentSpec(properties);

Based on those specs, look over the instruments shown on the last page, and write in which guitars, mandolins, and banjos you think Rick's search tool should return: Rick's client didn't specify an instrument type, but he wants something from Gibson with a maple back.

FindInstrument.java



Inventory Roundup Solutions

To see if the new version of Rick's software works, we need to run a search on more than just guitars. Your job was to write code for the initializeInventory() method in FindInstrument.java, and add several guitars, mandolins, and banjos to Rick's inventory.

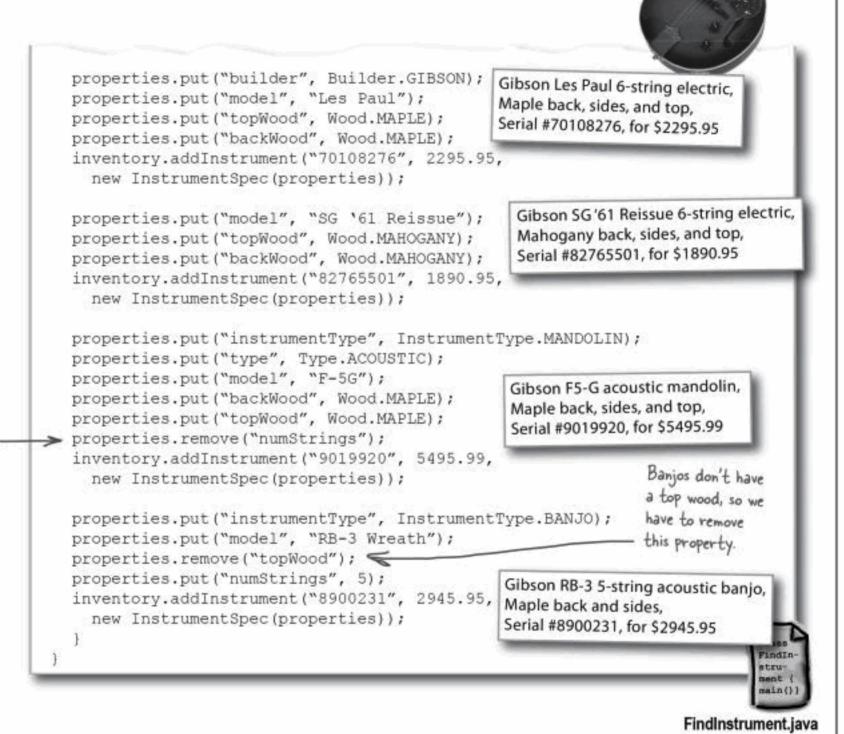
```
Map properties = new HashMap();
This is a
              properties.put("model", "CJ");
bit of a
shortcut:
              properties.put("numStrings", 6);
we're
just using
the same
Map over
 and over.
              properties.put("model", "D-18");
              properties.put("builder", Builder.FENDER);
              properties.put("model", "Stratocastor");
              properties.put("type", Type.ELECTRIC);
              properties.put("topWood", Wood.ALDER);
              properties.put("backWood", Wood.ALDER);
              inventory.addInstrument("V95693", 1499.95,
                new InstrumentSpec(properties));
              inventory.addInstrument("V9512", 1549.95,
                new InstrumentSpec (properties));
```

```
private static void initializeInventory(Inventory inventory) {
  properties.put("instrumentType", InstrumentType.GUITAR);
  properties.put("builder", Builder.COLLING".
                                                Collings CJ 6-string acoustic,
                                                Indian Rosewood back and sides, Spruce
  properties.put("type", Type.ACOUSTIC);
                                               top, Serial #11277, for $3999.95
  properties.put("topWood", Wood.INDIAN ROSEWOOD);
  properties.put("backWood", Wood.SITKA);
  inventory.addInstrument("11277", 3999.95,
    new InstrumentSpec(properties));
                                                 Martin D-18 6-string acoustic,
  properties.put("builder", Builder.MARTIN);
                                                 Mahogany back and sides, Adirondack top,
                                                 Serial #122784, for $5495.95
  properties.put("topWood", Wood.MAHOGANY);
  properties.put("backWood", Wood.ADIRONDACK);
  inventory.addInstrument("122784", 5495.95,
    new InstrumentSpec(properties));
                                                  Fender stratocastor 6-string electric,
```

Alder back and sides and top, Serial #V95693, for \$1499.95 Fender stratocastor 6-string electric,

Alder back and sides and top, Serial #V9512, for \$1549.95

The specs for these two Strats are the same; only the properties in Instrument are different



Don't

forget to

numStrings

remove

for the

mandolin

if you're

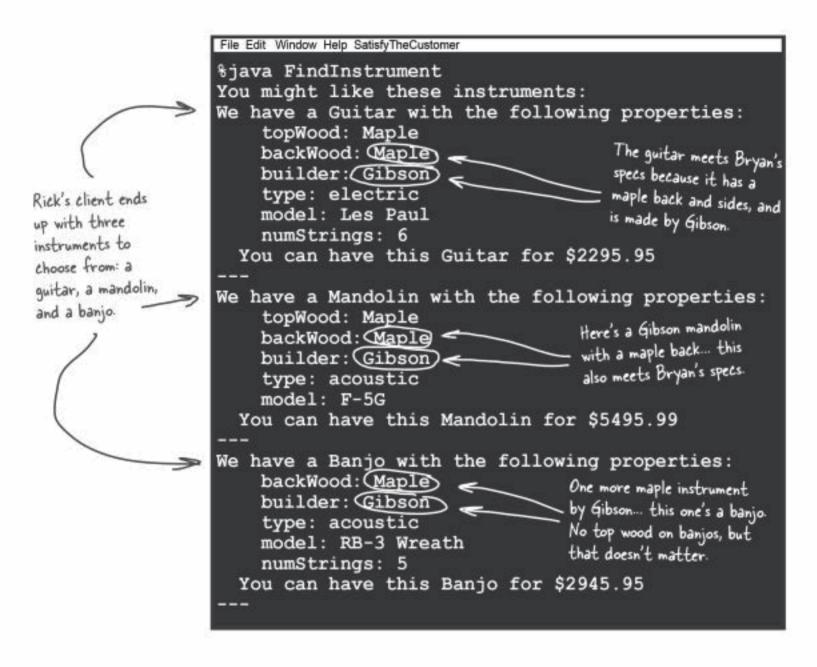
the same

properties

reusing

map.

Rick's got working software, his client has three choices:



Dumb Questions

Q: My output isn't the same as yours. What did I do wrong?

A: If your version of Rick's tool returned different guitars, or output the same guitars but with different properties, then you should be sure you have the same instruments in your inventory as we do. Check the exercise on page 260, and the answers on page 261-262, and make sure the instruments you have in Rick's inventory match ours.

Q: Is this really a good test since we only have one banjo and one mandolin?

A: That's a great question, and you're right, it would be better to have a few more mandolins and banjos to really make sure Rick's search tool picks only matching mandolins and banjos. Go ahead and add a few non-matching banjos or mandolins, and try testing out Rick's search tool with the additional instruments.

That's great that you've got your software working right, but don't start patting yourself on the back for a great design just yet. Me and my buddies at the bureau of change are here to see just how cohesive your software really is.

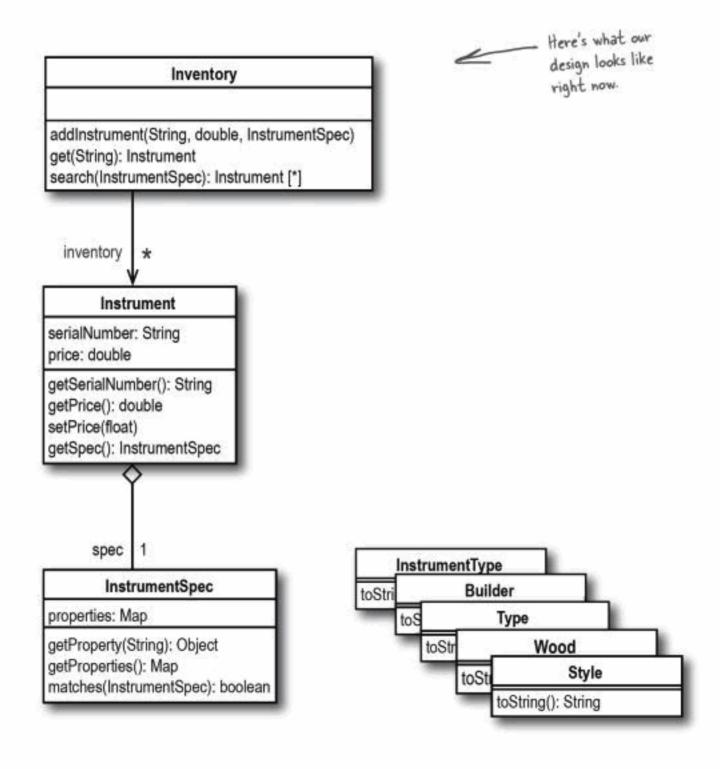


- * How easy is it to <u>change</u> Rick's software?
- Is Rick's software really well-designed?
- * And what the heck does cohesive mean?

The Great Bass-of-Change Challenge

How easy is it to change Rick's search tool?

Let's add support for dobros and fiddles back into Rick's application. We tried to do that earlier, back in the first part of Chapter 5, and it turned into a total mess. Things should be much easier this time, right? Below is the class diagram for the current version of Rick's software.



bureau de change

9	How many classes did you have to add to support Rick's new instrument types?
8	How many classes did you have to change to support Rick's new instrument types?
6	Suppose that Rick decided that he wanted to start keeping up with what year an instrument was made in. How many classes would you need to change to support keeping up with this new information?
4	Rick also wants to add a new property, neckWood, that tracks what wood is used in the neck of an instrument How many classes would you need to change to support this property?

Seeing how easy it is to change your software is one of the best ways to figure out if you really have well-designed software.

→ Answers on page 268

The Great Base-of-Change Challenge

How easy is it to change Rick's search tool?

Let's add support for dobros and fiddles back into Rick's application. We tried to do that earlier, and it turned into a total mess. Things should be much easier this time, right?

Let's apply the ease-of-change test to our software:

How many classes did you have to add to support Rick's new instrument types?

None! We got rid of all the instrument-specific subclasses of Instrument and InstrumentSpec.

A How many classes did you have to change to support Rick's new instrument types?

One: we need to add any new instrument types to the InstrumentType enumerated type.

Suppose that Rick decided that he wanted to start keeping up with what year an instrument was made in. How many classes would you need to change to support keeping up with this new information?

None! You can just store the year that an instrument was made in the properties Map in InstrumentSpec.

A Rick also wants to add a new property, neckWood, that tracks what wood is used in the neck of an instrument. How many classes would you need to change to support this property?

One in the worst case, and maybe none! neckWood
is just another property we can store in the
InstrumentSpec map... but we might need to add new
wood enumerated values to the Wood enum.

Sweet! Our software is easy to change... ...but what about that "cohesive" thing?

A cohesive class does

The more cohesive your classes are, the higher the cohesion of your software.

one thing - really well and

does not try to

Look through the methods of your classes—do they all relate to the name of your class? If you have a method that looks out of place, it might belong on another class.

do

or be

something else. ~

Cohesive classes are focused on specific tasks. Our Inventory class worries about just Rick's inventory, not what woods can be used in a guitar, or how to compare two instrument specs.

Instrument doesn't try to handle searches, or keep up with what woods are available. It is focused on describing an instrument—and nothing else-

Scholar's Corner

cohesion. Cohesion measures the degree of connectivity among the elements of a single module, class, or object. The higher the cohesion of your software is, the more well-defined and related the responsibilities of each individual class in your application. Each class has a very specific set of closely related actions it performs.



Cohesion, and one reason for a class to change

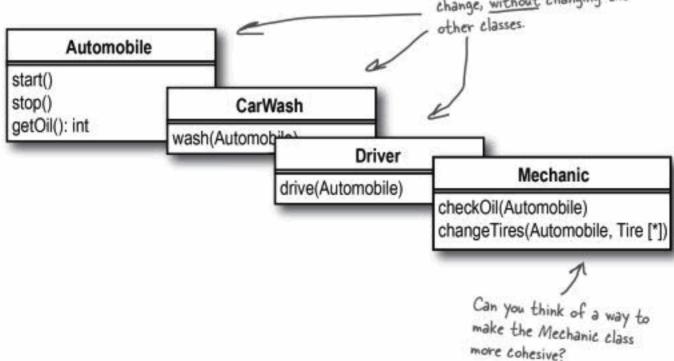
You may not realize it, but we've already talked about cohesion in this book. Remember this?

Every class should attempt to make sure that it has only one reason to this, the death of many a badly designed piece of software.

This was one of the answers from OO CATASTROPHE! Do you remember what the question was?

Cohesion is really just a measure of how closely related the functionality of the classes in an application are. If one class is made up of functionality that's all related, then it has only one reason to change... which is what we already talked about in **OO CATASTROPHE!**

Here are the classes we talked about when we made sure each class had only a single reason to change: The function of each of these classes is well-defined. Each one is a highly cohesive class, and that makes it easy to change, without changing the other classes.



Dumb Questions

Q: So cohesion is just a fancy word for how easy it is to change my application?

A: Not exactly. Cohesion focuses on how you've constructed each individual class, object, and package of your software. If each class does just a few things that are all grouped together, then it's probably a highly cohesive piece of software. But if you have one class doing all sorts of things that aren't that closely related, you've probably got low cohesion.

Q: So highly cohesive software is loosely coupled, right?

A: Exactly! In almost every situation, the more cohesive your software is, the looser the coupling between classes. In Rick's application, the Inventory class really worries just about managing inventory—and not about how instruments are compared or what properties are stored in an instrument spec. That means that Inventory is a highly cohesive class. That also means it's loosely coupled with the rest of the application—changes to Instrument, for example, don't have a lot of effect on the Inventory class.

Q: But all that means the software will be easier to change, doesn't it?

A: Most of the time, yes. But remember the version of Rick's application that we started with in this chapter? It only supported guitars, and we didn't even have Instrument or InstrumentSpec classes. That was pretty cohesive software—Guitar was very loosely coupled with Inventory. However, it took a lot of work and redesign to support mandolins.

When you fundamentally change what an application does—like going from selling only one type of instrument to multiple types—you may have to make lots of changes to a design that's already cohesive and loosely coupled. So cohesion isn't always a test of how easy it is to change software; but in cases where you're not dramatically changing how software works, highly cohesive software is usually easy to change.

Q: And high cohesion is better than low cohesion?

A: Right. Good OO design is when each class and module in your software does one basic thing, and that one thing really well. As soon as one class starts doing two or three different things, you're probably moving away from cohesion, and good OO design.

Q: Wouldn't software that's cohesive be easier to reuse, as well as change?

A: You got it. High cohesion and loose coupling adds up to software that can easily be extended, or even broken up and reused, because all the objects in the software aren't interdependent.

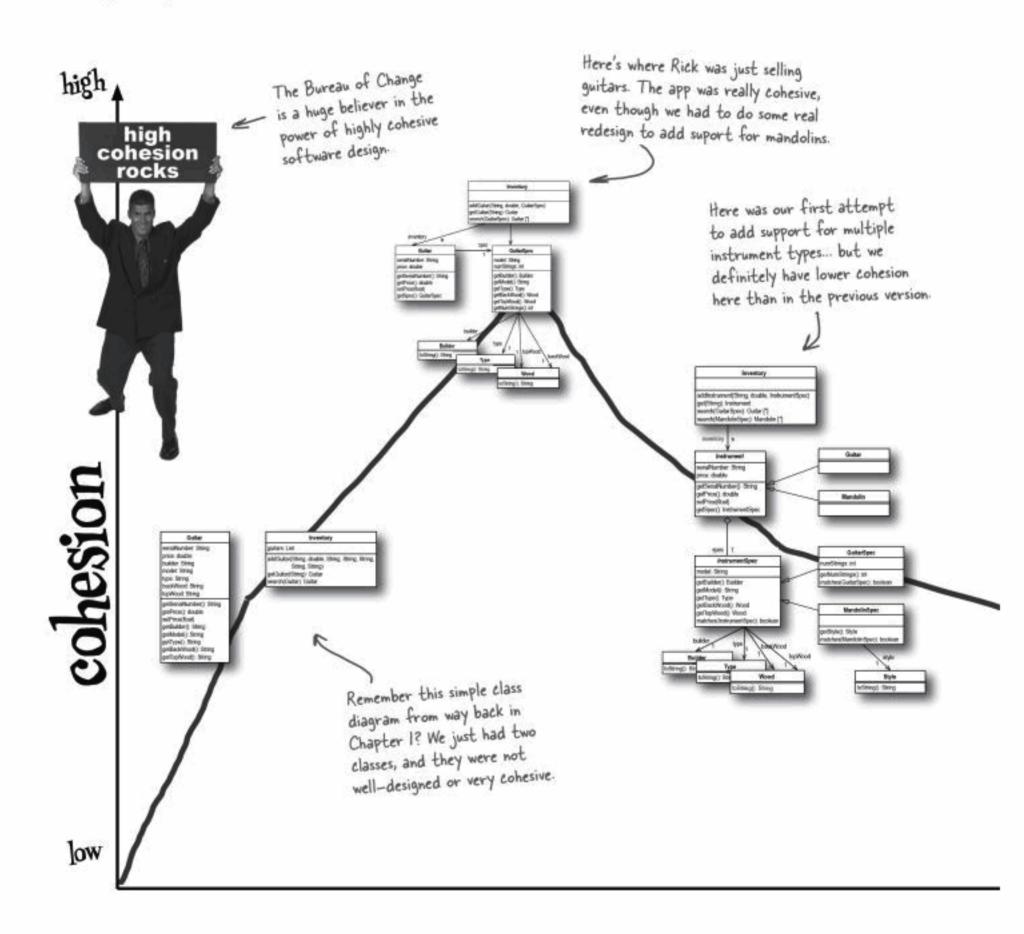
Think about it this way: the higher the cohesion in your application, the better defined each object's job is. And the better defined an object (and its job) is, the easier it is to pull that object out of one context, and have the object do the same job in another context. The object is happy to just keep on doing its very specific job, no matter where it's being used.

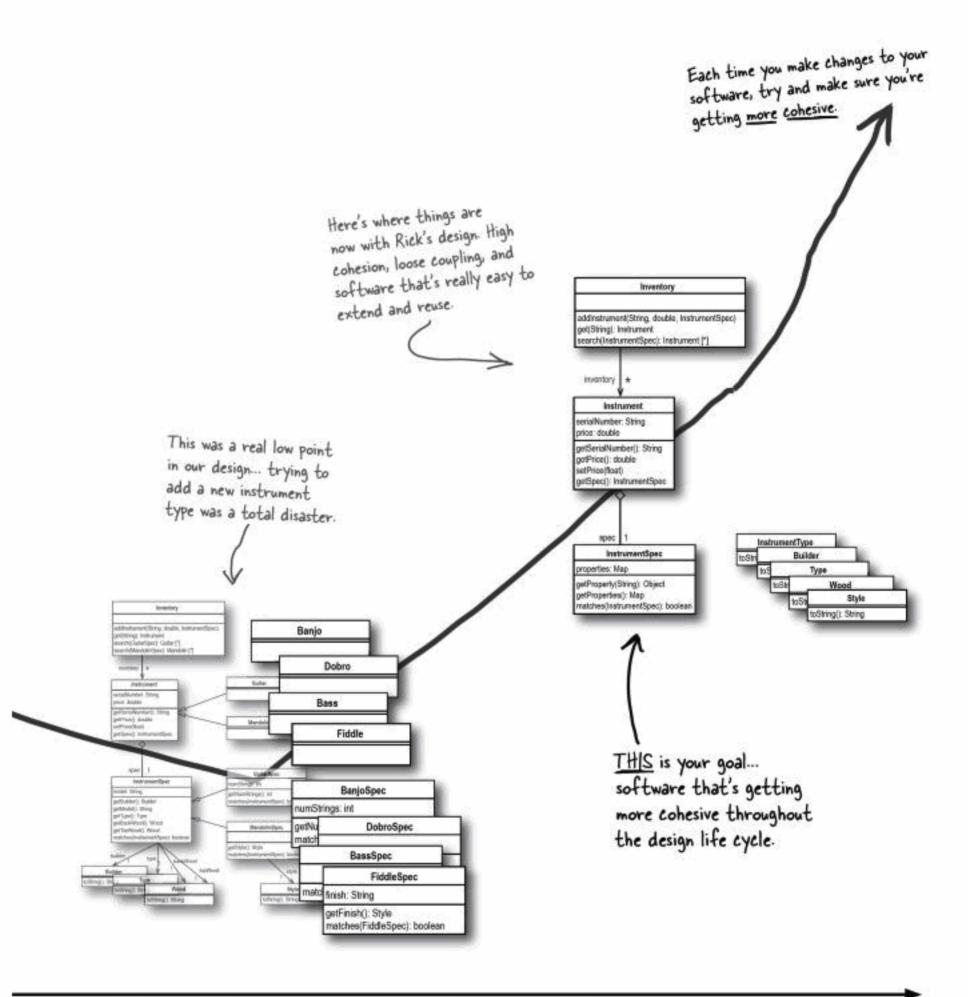
And we've been making Rick's application more cohesive throughout his chapter, haven't we?

A: For the most part, yes. But let's look a little bit closer at that question...

Rick's software, in review

So have our changes to Rick's software resulted in high cohesion? Are our objects loosely coupled? And can we make changes easily? Let's take a look:





This sounds great and all, but how do you know when you're done? I mean, is there some sort of scale of cohesion, and when I get to a "10" or whatever, it means that I'm finished?



Great software is usually about being good enough.

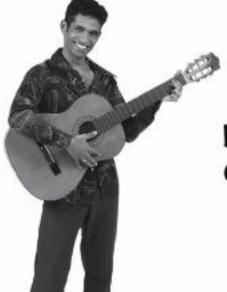
It's hard to know when to stop designing software. Sure, you can make sure that your software does what it's supposed to do, and then start working on increasing the flexibility and cohesion of your code. But then what?

Sometimes you just have to stop designing because you run out of time... or money... and sometimes you just have to recognize you've done a good enough job to move on.

If your software works, the customer is happy, and you've done your best to make sure things are designed well, then it just might be time to move on to the next project. Spending hours trying to write "perfect software" is a waste of time; spending lots of time writing great software and then moving on, is sure to win you more work, big promotions, and loads of cash and accolades.

Knowing when to say "It's good enough!"

I love it! I can finally sell any kind of instrument I want, and help my clients find just what they're looking for.



Make sure the customer is happy Before you ever leave a project, you always want to make sure your software does what it's supposed to do:

Really nice design here. High cohesion, the classes are loosely coupled... I'll bet the next time Rick needs something changed, we won't have too much trouble at all.

Once you've got functionality down, move on to making good design decisions, using solid 00 principles to add flexibility.

Make sure your design is flexible

If you've done <u>both</u> of these things, it may just be time to <u>move</u> <u>on</u>... to the next project, the next application, even the next chapter!



Tools for your OOA&D Toolbox

Wow, you've really come a long way since we started working with Rick way back in Chapter 1. You've learned a ton about design, so let's do a quick review of what you've added to your toolbox.

We did a ton of design in this chapter, so take a second to review everything we've learned.

Requirements

Good requirements ensure you works like your customers exp

Make sure your requirements by developing use cases for yo

Use your use cases to find ou things your customers forgot

Your use cases will reveal any or missing requirements that have

Your requirements will always grow) over time.

Analysis and Design

Well-designed software is easy to change and extend.

Use basic 00 principles like encapsulation and inheritance to make your software more flexible.

If a design isn't flexible, then CHANGE IT! Never settle on bad design, even if it's your bad design that has to change.

Make sure each of your classes is cohesive: each of your classes should focus on doing ONE THING really well.

Always strive for higher cohesion as you move through your software's design life cycle.

The goal of good design is highly cohesive, loosely coupled software.

00 Principles

Encapsulate what varies.

Code to an interface rather than to an implementation.

Each class in your application should have only one reason to change.

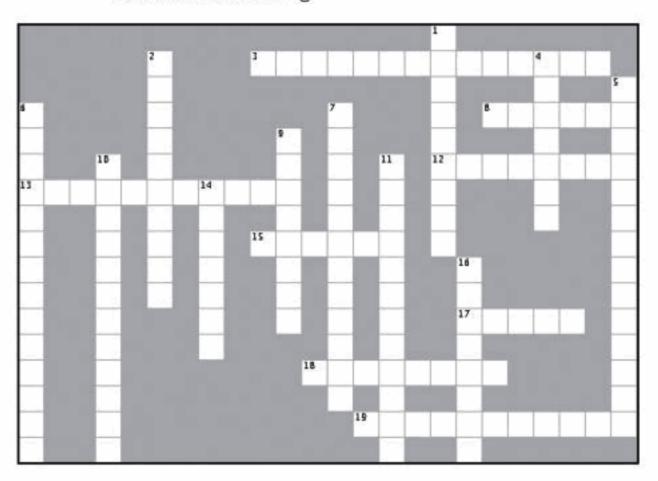
Classes are about behavior and functionality.

Between OO CATASTROPHE! and this chapter, we've added quite a few new OO principles to our toolbox.



OOA&D Cross

This one is a particularly tough puzzle: almost all the answers are more than one word, and they're spread across **both** parts of Chapter 5. Good luck, and keep that left brain working.



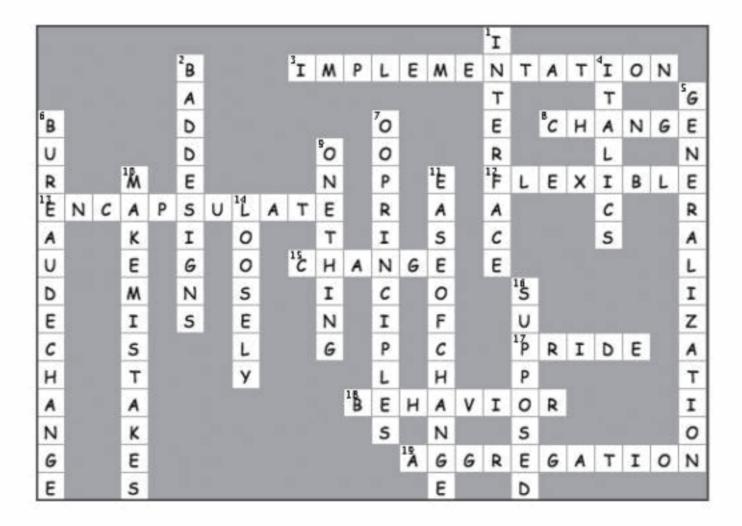
Across

- 3. Never code to this if you can help it.
- Great software is easy to _____
- 12. Software that's easy to change is
- 13. Do this to what varies.
- 15. Never be afraid to do this to your designs.
- 17. This will kill good design.
- 18. Classes are about this.
- 19. When one thing is made up of another.

Down

- 1. Always code to this if possible.
- Most good designs come from analysis of these.
- Abstract classes are written this way in UML class diagrams.
- When a class inherits behavior from another class.
- This was the type of group ensuring your software was highly cohesive.
- Apply these to add flexibility to your software.
- 9. Cohesive classes do this really well.
- Don't be afraid to do this; it will help you find better solutions.
- We used this test to see if Rick's application was cohesive.
- Highly cohesive software is also almost always _____ coupled.
- Great software must always do what it is _____ to do.





6 solving really big problems

"My Name is Art Vandelay... I am an Architect"



It's time to build something REALLY BIG. Are you ready?

You've got a ton of tools in your OOA&D toolbox, but how do you use those tools when you have to build something really big? Well, you may not realize it, but you've got everything you need to handle big problems. We'll learn about some new tools, like domain analysis and use case diagrams, but even these new tools are based on things you already know about—like listening to the customer and understanding what you're going to build before you start writing code. Get ready... it's time to start playing the architect.

Look, all this stuff about writing great software sounds terrific, but real applications have a lot more than five or ten classes. How am I supposed to turn big applications into great software?

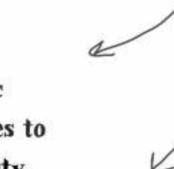
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You solve <u>big problems</u> the same way you solve small problems.

We've been working with fairly simple applications so far... Rick's guitar shop had less than fifteen classes in its worst state, and Doug's dog door never had more than five. But everything you've learned so far applies to working with big applications, too.

1. Make sure your software does what the customer wants it to do.

Remember these steps to writing great software? They all apply to working with huge, 1000+ class applications just as much as when you're working with just a couple of classes.



3. Strive for a maintainable, reusable design.

2. Apply basic 00 principles to add flexibility.

It's all in how you <u>look</u> at the big problem

Think about how you work on big problems, in big software applications. You usually look at the big picture, but then start working on just one part of the application's functionality.

The best way to look at a big problem is to see it as lots of individual pieces of functionality.

You can treat each of those pieces as an <u>individual problem</u> to solve, and apply the things you already know.

Once you get one part of an application working like you want it to, then you can move on to another piece of functionality within the app. At each step, though, you're applying the same basic principles we've been talking about for the last 250 pages or so.

This BIG PROBLEM Small is really just a Problem collection of Small functionalities, Problem where each piece of functionality is really Small a smaller problem on Problem Small its own. Problem Big Problem

You can solve a big problem by breaking it into lots of functional pieces, and then working on each of those pieces individually.

The things you already know...

You've already learned a lot of things that will help you solve big software problems... you just may not have realized it. Let's take a quick look at some of the things we already know about how to write great (big) software:

> By encapsulating what varies, you make your application more flexible, and easier to change.

Using encapsulation helps with big problems, too. The more you encapsulate things, the easier it will be for you to break a large app up into different pieces of functionality.

Coding to an interface, rather than to an implementation, makes your software easier

1 to extend.

This is even more important in big apps. By coding to an interface, you reduce dependencies between different parts of your application... and "loosely coupled" is always a good thing, remember?

The best way
to get good
requirements is =
to understand
what a system is
supposed to do.

- If you know what each small piece of your app's functionality should do, then it's easy to combine those parts into a big app that does what it's supposed to do.

282

Chapter 6

Analysis helps you ensure

your system works in a

real-world

context.

This sure doesn't change with bigger problems. In fact, the higher the cohesion of your app, the more independent each piece of functionality is, and the easier it is to work on those pieces one at a time.

Great software

is easy to change and extend, and does what the customer wants it to do.

Analysis is even more important with large software... and in most cases, you start by analyzing individual pieces of functionality, and then analyzing the interaction of those pieces.

Got a big problem? Take a few of these little principles, and call me in the morning. I bet you'll have things under control in no time.

So let's solve a BIG problem!

Enough about what you already know; let's see how we can apply these things to a brand new, really big piece of software. Turn the page to learn a bit about Gary, his new game company, and a large software project.



Here's the big problem we're going to be working on for the next few chapters.



Gary's Games Vision Statement



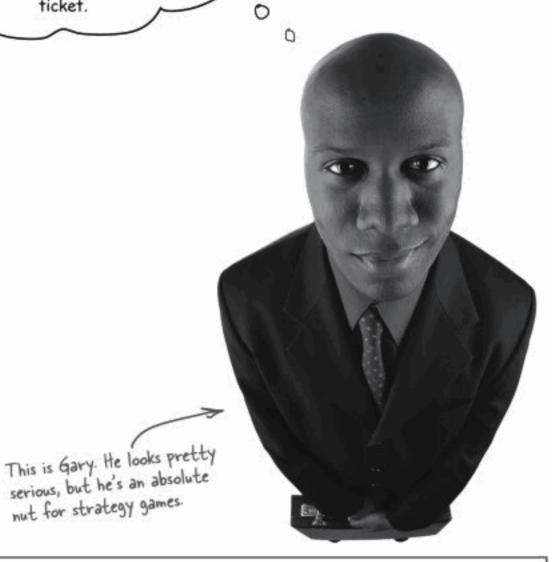
Gary's Games provides frameworks that game designers can use to create turn-based strategy games. Unlike arcade-style shoot-'em-up games and games that rely on audio and video features to engage the player, our games will focus on the technical details of strategy and tactics. Our framework provides the bookkeeping details to make building a particular game easy, while removing the burden of coding repetitive tasks from the game design.

The game system framework (GSF) will provide the core of all of Gary's Games. It will be delivered as a library of classes with a well-defined API that should be usable by all board game development project teams within the company. The framework will provide standard capabilities for:

- Defining and representing a board configuration
- Defining troops and configuring armies or other fighting units
- Moving units on the board
- Determining legal moves
- Conducting battles
- Providing unit information

The GSF will simplify the task of developing a turn-based strategic board game so that the users of the GSF can devote their time to implementing the actual games.

I'm not interested in one of those fancy, flashy Star Wars rip-off games... I want something with strategy, that makes you think! A cool turn-based war game, that's the ticket.



Sharpen your pencil —

What should we do first?

Below are several things that you might start out doing to get going on Gary's Games. Check the boxes next to the things you think we should start with.

Talk to Gary.

- Gather requirements.
- Start a class diagram.

- Talk to people who might use the framework.
- Write use cases.
- Start a package diagram.

Hey, this is an easy one.
We start out by writing out the requirements and use cases, like we did with Doug's Dog Doors.

Requirements and use cases

are a good place to start...

Starting out working on a system by building a requirements list and writing use cases is a great idea. You can figure out what a system is supposed to do, and just go down your list adding functionality bit by bit... solving lots of small problems to solve one really big problem.

But I'm not sure we really have enough information to figure out the requirements or use cases yet... all we've got is that fancy vision statement. But that really doesn't tell us much about what the system we're building is supposed to do.



One of the programmers on your team.

...but what do we <u>really</u> know about the system so far?

That vision statement seemed to have a lot of information about what Gary wants, but it leaves a lot open to interpretation.

What kind of board did Gary have in mind? And who's the customer, really? Game players or game designers? And will all the games be historically based, or do we have to support things like lasers and spaceships? It sounds like there's a lot more we need to know before we can write a very good set of requirements.



We need a lot more information

All we've got to go on with Gary's system so far is a vision statement... and that didn't tell us very much at all. So now we've got to figure out what the system is supposed to do. So how do we do that?

What is the system like?

One way you can find out more about a system is to figure out what the system is <u>like</u>. In other words, are there some things that you <u>do know about</u> that the system functions or behaves like?





This is called variability... what things are different?





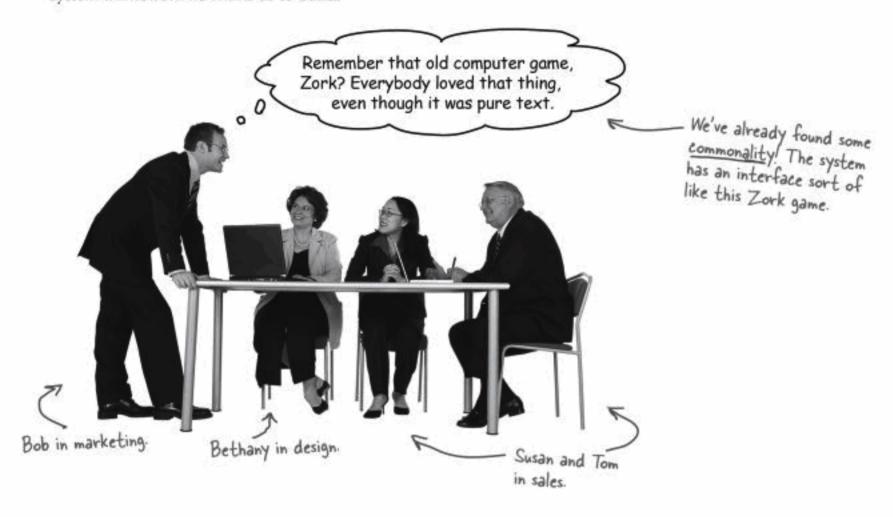
What is the system not like?

Another great way to find out what a system should do is to figure out what it's <u>not</u> like. This helps you determine what you <u>don't need</u> to worry about in your system.

So let's listen in on one of Gary's meetings, and see what we can find out...

Customer Conversation

We need to listen in a little more on what Gary and his team are planning before we can get started on the game system framework he wants us to build.



Tom: Yeah, Gary loves text-based games. And people are getting a little tired of all the fancy graphics in games like Star Wars episode 206 (or whatever the heck they're up to these days).

Here's some variability. The system is not a graphic-rich game.

Flexbility is going to be key to support all these variations.

Bethany: And we need all sorts of different time periods. We could have a Civil War version, with battles at Antietam and Vicksburg, and a World War I version over in Europe... players will love all the historical stuff, I'll bet.

Susan: Nice idea, Beth! I'll bet we can let game designers create add-on packs, too, so you could buy a World War II: Allies game, and then buy an add-on for other forces that the core game didn't include.

Bob: That's a cool marketing point, too... if our system supports different time periods, unit types, uniforms, and offensives, we're going to be able to sell this to almost anyone developing games.

Bethany: Do you think we need to worry about battles that aren't historical? I mean, we could sell our system to the folks that make the fancy starship games, and let them create sci-fi battles, right?

OK, now we're

about actual

game system.

features of the

starting to get some ideas

Tom: Hmmm... I'll bet Gary would go for that, if they're still creating turn-based games. Why not clean up on that market as well as the history buffs?

Bob: Do you think we could market this as a system to create everything from online Risk to a modern-day Stratego? Those were both killer strategy board games back in the day... I'd love to sell our system to people that make those sorts of games.

A little more commonality... so we're really aiming at turnbased wargames.

Strategy

have some

commonality

of game to pay

attention to.

games again ...

we definitely

Bethany: So let's talk details. We know we've got to sell this to lots of game designers, so we need it to be really flexible. I'm thinking we start with a nice square board, and fill it up with square tiles.

Tom: We can let the game designers pick how many tiles on the board, right? They can choose a height and width, or something like that?

Bethany: Yeah. And then we should support all different types of terrains: mountains, rivers, plains, grass...

Susan: ...maybe space or craters or asteroid or something for the space games...

Bob: Even underwater tiles, like seaweed or silt or something, right?

Bethany: Those are great ideas! So we just need a basic tile that can be customized and extended, and a board that we can fill with all the different tiles.

Susan: Do we have to worry about all those movement rules and things that these games usually have?

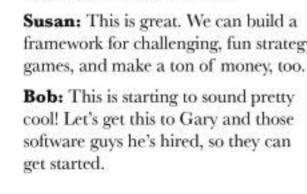
Tom: I think we have to, don't we? Don't most of these unit can only move so many tiles because he's carrying

strategy games have all sorts of complicated rules, like a too much weight, or whatever?

Bethany: I think most of the rules depend on the specific game, though. I think we should leave that up to the game designeres who use our framework. All our framework should do is keep track of whose turn it is to move, and handle basic movement stuff.

Susan: This is great. We can build a framework for challenging, fun strategy

So did you get all that? You're ready to start working on my new game system now, right?



0

Figure out the features

You've learned a lot about what Gary and his team want the game system framework to do, so let's take that information and figure out the **features** of the system.



Bethany said the game system should support different time periods. That's a feature of the game system.

Bethany: And we need all sorts of <u>different time periods</u>. We could have a Civil War version, with battles at Antietam and Vicksburg, and a World War I version over in Africa and Italy... players will love all the historical stuff, I'll bet.

Here's another feature: different types of terrain. This single feature will probably create several individual requirements.

Bethany: Yeah. And then we should support all <u>different types</u> of <u>terrains</u>: mountains, rivers, plains, grass...

Susan: ...maybe space or craters or asteroid or something for the space games...

Bob: Even underwater tiles, like seaweed or silt or something, right?

But what is a feature, anyway?

A feature is just a high-level description of something a system needs to do. You usually get features from talking to your customers (or listening in on their conversations, like we just did on the last few pages).

A lot of times, you can take one feature, and come up with several different requirements that you can use to satisfy that feature. So figuring out a system's features is a great way to start to get a handle on your requirements.

<

Starting with the features of a system is really helpful in big projects—like Gary's game system—when you don't have tons of details, and just need to get a handle on where to start.

Feature (from customer)

Requirement (for developer)

Supports different types of terrain.

Here's a single feature we got from the customer.

A tile is associated with a terrain type.

Game designers can create custom terrain types.

Each terrain has characteristics that affect movement of units.

That single feature results in multiple different requirements.

Get features from the customer, and then figure out the requirements you need to implement those features.

	We need a list of features for Gary's game system.
	You've got plenty of information from Gary and his team, and now you know how to turn that information into a set of features. Your job is to fill in the blanks below with some of the features you think Gary's game system framework should have.
_	

Sharpen your pencil _ answers

We need a list of features for Gary's game system.

You've got plenty of information from Gary and his team, and now you know how to turn that information into a set of features. Your job is to fill in the blanks below with some of the features you think Gary's game system framework should have.

Supports different types of terrain.

Supports multiple types of troops or units that are game-specific.

Each game has a board, made up of square tiles, each with a terrain type

Supports different time periods, including fictional periods like sci-fi and fantasy.

Supports add-on modules for additional campaigns or battle scenarios.

The framework keeps up with whose turn it is and coordinates basic movement.

This all seems pretty arbitrary...
some of those features look just like
requirements. What's the big difference
between calling something a feature, and
calling something a requirement?

It's OK if these aren't the exact features you got, or if you had more detailed things in this list. These are just what we came up with.



Don't get hung up on the "difference" between a feature and a requirement.

Lots of people use "feature" to mean different things, so it's not a term you should get too worked up about. For some people, a feature is a requirement; and you'll even hear some people say "feature requirement," which really can get confusing.

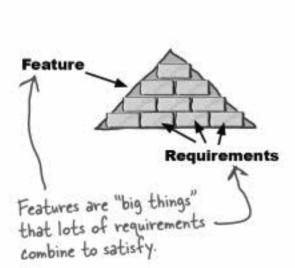
Others think of features as higher-level than requirement, which is how we've been talking about them. So it might take several requirements to satisfy one feature of a system.

The main thing is that if you're stuck on where to get started, especially with a big project, you can gather features (or requirements!) to get a handle on the high-level things you know you'll need to take care of in the system you're bulding.

Dumb Questions

So there's no difference between a feature and a requirement?

Well, this really depends on who you ask. For some people, a feature is a "big" thing that a system does, like "support different types of terrain." But to put that feature into place, there are lots of "small" things that the system must do, like "define a base terrain type" and "allow developers to extend the base terrain type" and "allow each tile to contain multiple terrain types." All of these little things are considered requirements. So a single feature is satisfied by several requirements, like this:

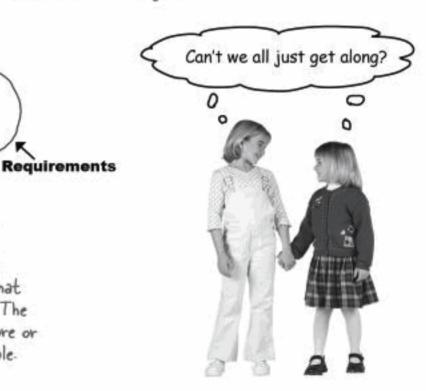


Q: You said, "some people." So there are other ways to look at features and requirements?

Right. A lot of other people don't make such a distinction between a feature and a requirement. One feature might be "supports different time periods" (which is a pretty big thing), and another might be "allow for water as a type of terrain" (which is a pretty small, specific thing). In this approach, there's not really a big difference between what a feature is and what a requirement is. So these people see things a lot more like this:

So which is right?

Both! Or neither, if you prefer. There's no "one right way" to think about features and requirements, especially if you don't want to waste lots of time arguing over definitions with your programmer buddles. You're better off thinking about both features and requirements as the things your system needs to do. If you want to consider features the "big picture" things, and requirements the "smaller, more detailed" things, that's OK ... just don't get into any barroom fights over it, alright?



In this approach, there's a lot of overlap in what a feature is, and what a requirement is. The two terms are more or less interchangeable.

OK, so we've got the feature and requirement thing figured out. Now we can write some use cases, right?



Always <u>defer</u> <u>details</u> as long as you can.

Use cases don't always help you see the big picture.

When you start to write use cases, you're really getting into a lot of detail about what the system should do. The problem is that can cause you to lose sight of the big picture. In Gary's game system, we're really not ready for a lot of detail... we're just trying to figure out what the framework actually is at this point.

So even though you could start writing use cases, that probably won't help you figure out exactly what you're trying to build, from the big-picture point of view. When you're working on a system, it's a good idea to defer details as long as you can... you won't get caught up in the little things when you should be working on the big things.

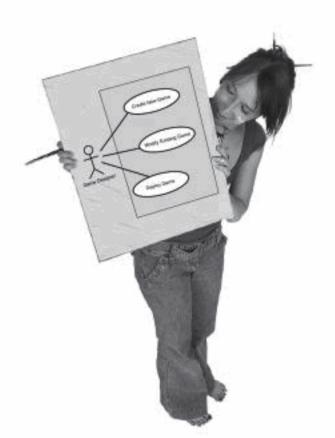


If we did write use cases for Gary's game system, who would the actors be? So what **are** we supposed to do now?
You've been telling us we need to know
what the system is supposed to do for like
200 pages now, and suddenly use cases
aren't a good idea? What gives?

You still need to know what your system is supposed to do... but you need a BIG-PICTURE view.

Even though use cases might be a little too focused on the details for where we are in designing the system right now, you still need to have a good understanding of what your system needs to do. So you need a way to focus on the big picture, and figure out what your system should do, while still avoiding getting into too much detail.



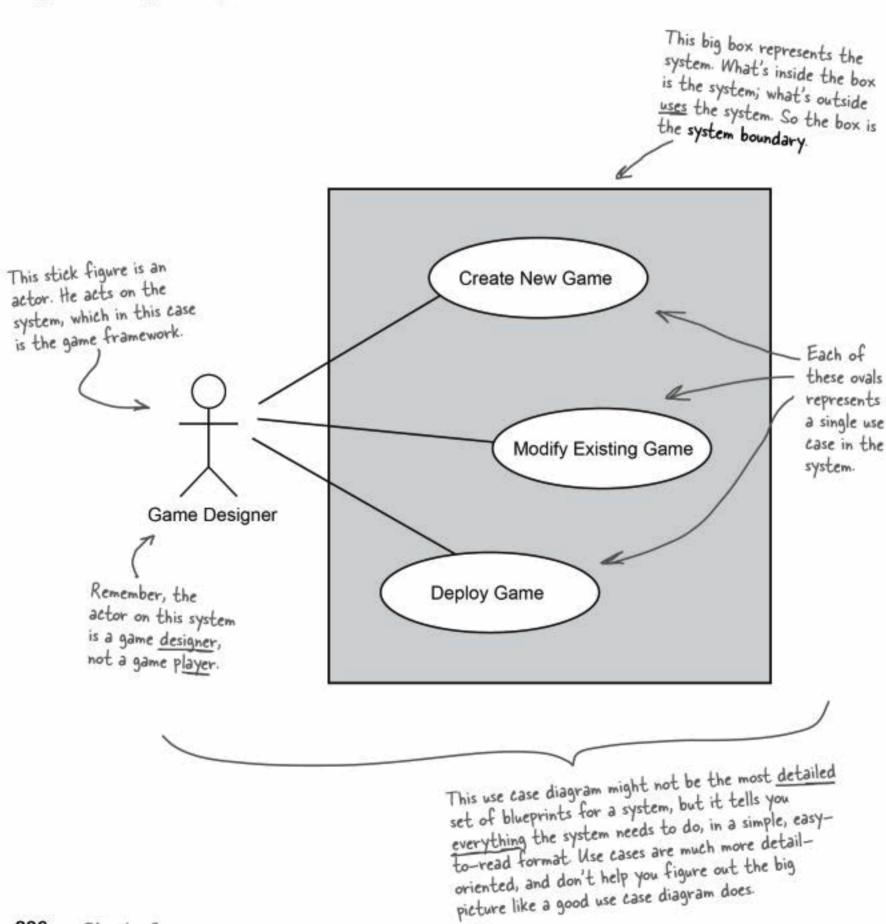


Ever hear that a picture is worth a thousand words?

Let's see if we can show what the system is supposed to do.

Use case diagrams

Sometimes you need to know what a system does, but don't want to get into all the detail that use cases require. When you're in a situation like this, a use case diagram could be just what you need:



OK, this is just plain stupid. What good does that diagram do us? Do we really need to draw a picture to figure out that game designers are going to create and modify games?

Use case diagrams are the blueprints for your system.

Remember, our focus here is on the big picture. That use case diagram may seem sort of vague, but it does help you keep your eye on the fundametal things that your system must do. Without it, you could easily get so caught up in the details of how a designer creates a new game that you completely forget that they need to actually deploy that game. With a use case diagram, you'll never forget about the big picture.



But what about all those features we worked so hard to figure out? They don't even show up on the use case diagram!

Use your feature list to make sure your use case diagram is complete.

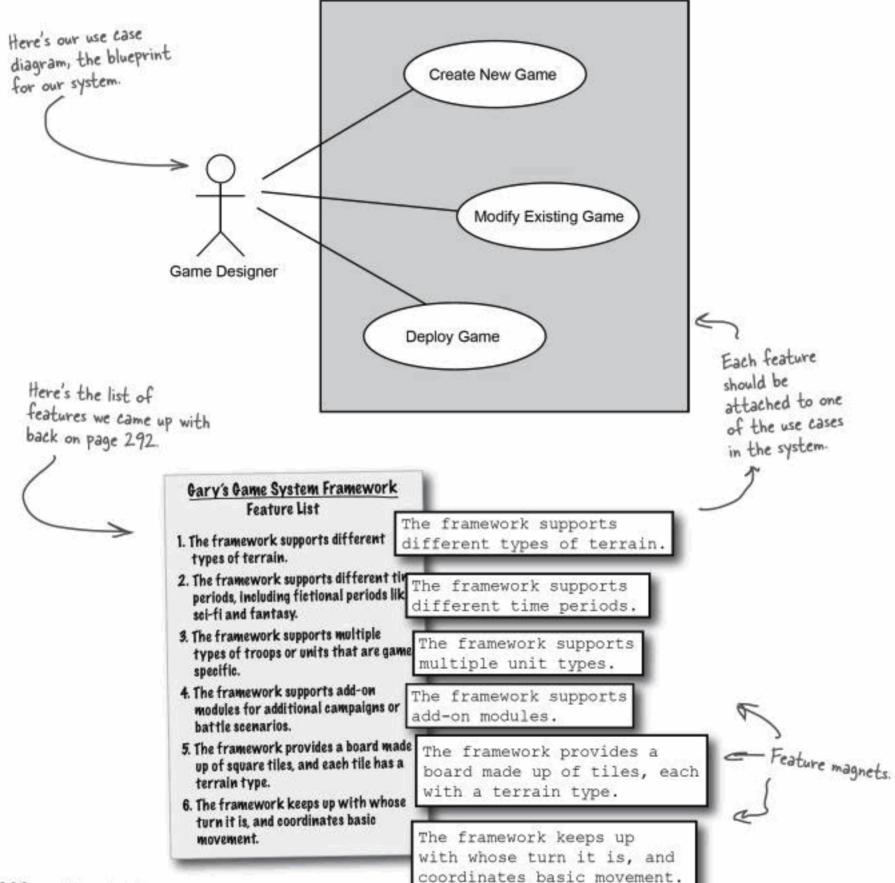
Once you have your features and a use case diagram, you can make sure you're building a system that will do everything it needs to. Take your use case diagram, and make sure that all the use cases you listed will cover all the features you got from the customer. Then you'll know that your diagram—the blueprints for your system—is complete, and you can start building the system.





Feature Magnets

It's time to match up the game framework's features to the use cases in your use case diagram. Place the magnet for each feature on the use case that will handle that feature. If your use case diagram is complete, then you should be able to attach each feature magnet to a use case on your diagram. Good luck!



Dumb Questions

Q: So an actor is a person that uses the system?

A: An actor is actually any external entity (it doesn't have to be a person) that interacts with the system. So in a cash machine, you'd obviously have a person that uses the system as an actor, but you might also have the bank as an actor, because it deposits money in the system. If it's not part of the system but acts on the system, it's an actor.

Q: What's the box around everything for? And why are the actors outside of the box?

A: The box shows the boundaries of the system. So you have to code up everything inside the box, but you don't have to worry about the stuff outside the box. The actors—the game designers using your framework—are outside of the box because they use your system; they're not part of it.

Q: And each circle is a use case?

A: Right. That's part of why use case diagrams are great for getting a handle on the big picture: they can show you multiple use cases, and how all those use cases work together to do really big tasks. It also helps you avoid getting into details about a particular requirement too early (like now, when you should be worrying about the overall system design).

Q: I've seen use case diagrams with lines marked with <<include>> and <<extend>>. What's that about?

A: UML and use case diagrams do define ways to specify what kind of relationships exist between use cases. So you could say that one use case includes another, or that one use case extends another. That's what the <<include>> and <<extend>> keywords mean.

However, it's easy to spend a lot of time arguing over whether a use case extends this use case, or includes that one. And suddenly, you're spending your time on how a tile can support mountains or units need to carry a backpack, instead of focusing on the bigger picture. You can use <<include>> and <<extend>>, but it's really not that big of a deal, and those keywords should never distract from the overall design process.

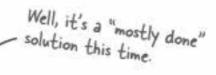
Q: So use case diagrams are more about a general picture of the system than including lots of little details?

A: Now you've got it! If you're worrying too much about what to call a use case, or whether you should use a particular relationship between use cases, you've lost sight of the big picture. Use your use case diagrams to get a clear 10,000-foot view of your system, nothing more.

Thanks for all the info, but can we get back to that Feature Magnets exercise?

I'm stuck trying to match one of the features to a use case...



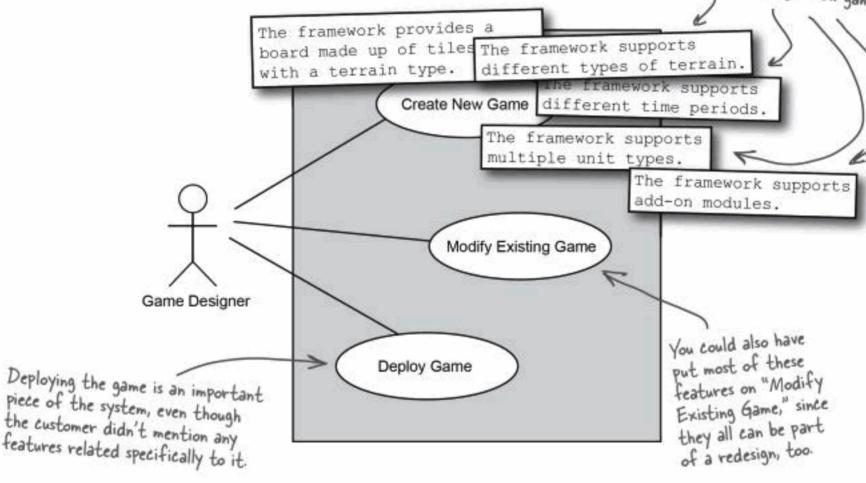




Feature Magnets Solutions

It's time to match up the game framework's features to the use cases in your use case diagram. Were you able to find a use case for each feature in the game framework?

Almost all of the features have to do with a game designer creating a new game.



But there's one feature still left... what up with that?

There's probably one feature you had some trouble placing on the use case diagram. Think about this feature carefully: it's really not something the game designer directly interacts with or worries about, because the functionality is already taken care of.

So how is this feature related to the system? And what actors are involved? And are we missing some use cases in our diagram?

What do you think?

The framework keeps up with whose turn it is, and coordinates basic movement.

We know this is a feature, but why doesn't it have a place in our blueprints?

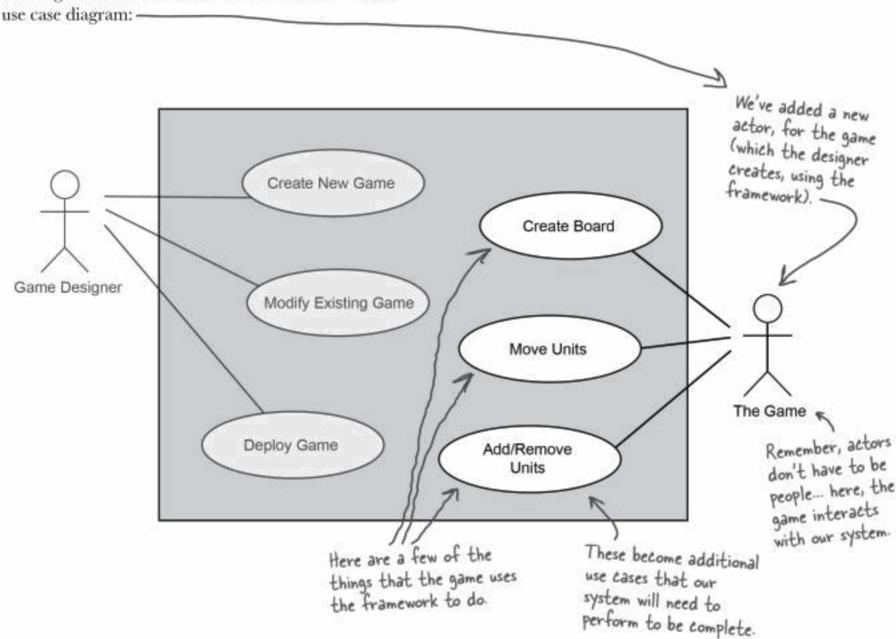
The Little Actor

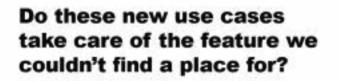
A small Socratic exercise in the style of The Little Lisper

What system are you designing?	A game framework, duh!
So what is the point of the framework?	To let game designers build games.
So the game designer is an actor on the system?	Yes. I've got that in my use case diagram.
And what does the game designer do with the framework?	Design games. I thought we established that!
Is the game the same as the framework?	Well, no, I suppose not.
Why not?	The game is complete, and you can actually play it. All the framework provides is a foundation for the game to be built on.
So the framework is a set of tools for the game designer?	No, it's more than that. I mean, the feature I'm stuck on is something the framework handles for each individual game. So it's more than just tools for the designer.
Interesting. So the framework is part of the game, then?	Well, I guess so. But it's like a lower level, like it just provides some basic services to the game. The game sort of sits on top of the framework.
So the game actually uses the framework?	Yes, exactly.
Then the game actually uses the system you're building?	Right, that's just what I said. Oh, wait then
if the game uses the system, what is it?	An actor! The game is an actor!

Actors are people, too (well, not always)

It turns out that in addition to the game designer, the game itself is an actor on the framework you're building. Let's see how we can add a new actor to our

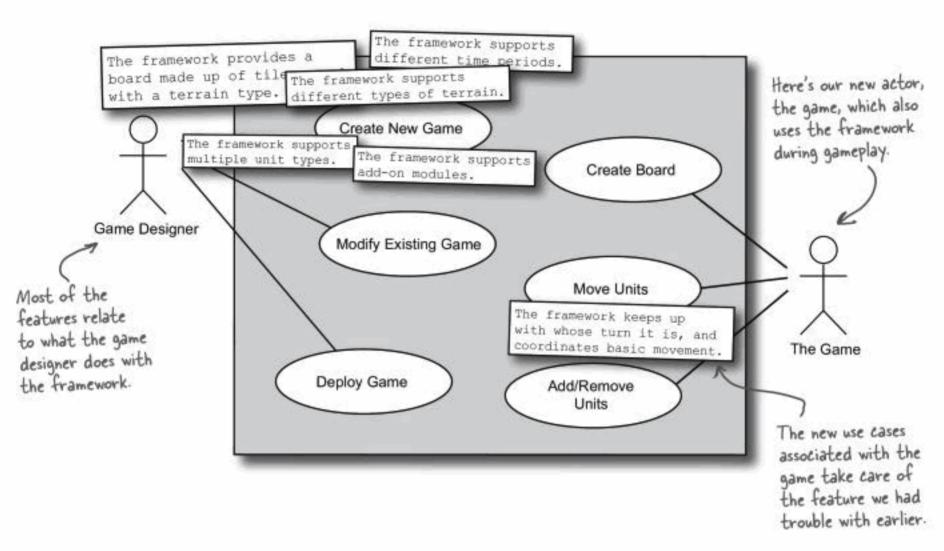


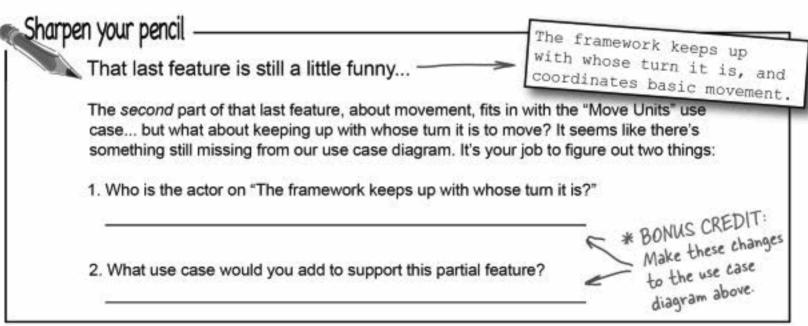


The framework keeps up with whose turn it is, and coordinates basic movement.

Use case diagram... check! Features covered... check!

With a new actor in place, we can finally take our use case diagrams and our features, and match them all up.







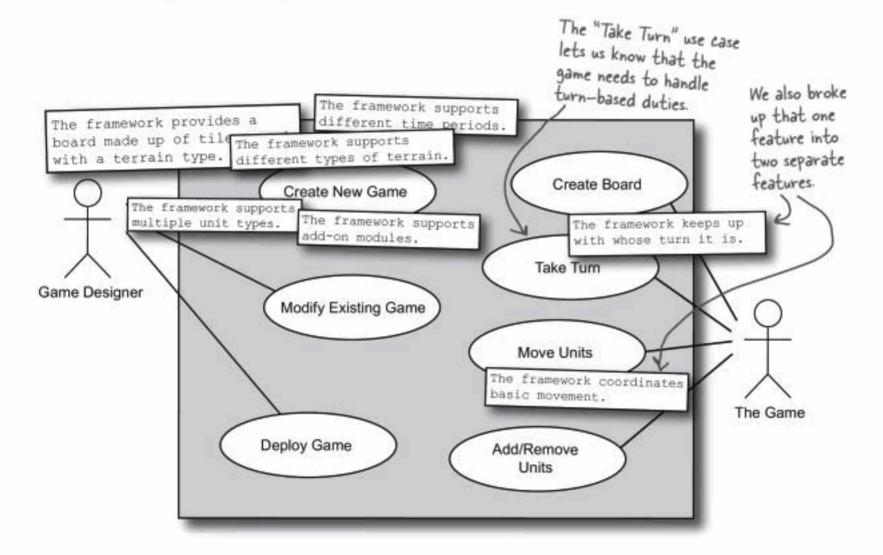
The second part of that last feature, about movement, fits in with the "Move Units" use case... but what about keeping up with whose turn it is to move? It seems like there's something still missing on our use case diagram. It's your job to figure out two things:

- 1. Who is the actor on "The framework keeps up with whose turn it is?"

 The game is still the actor... it's using the framework to

 handle managing whose turn it is.
- 2. What use case would you add to support this partial feature?

 We need a use case for "Take Turn" where the framework
 handles basic turn duties, and lets the custom game handle
 the specifics of that process.



So what exactly have we done?

You've got a list of features that Gary's game system framework needs to support, and that tells you all the major pieces of the system you need to build. This is a lot like the requirements list you built way back in Chapter 2 for Todd and Gina's dog door... except it focuses on the big picture.

Use a feature or requirement list to capture the <u>BIG THINGS</u> that your system needs to do.

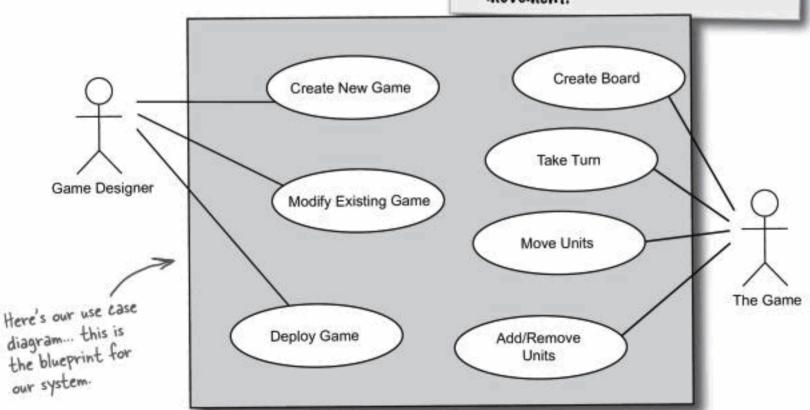
Once you've got your features and requirements mapped out, you need to get a basic idea of how the system is going to be put together. Use cases are often too detailed at this stage, so a use case diagram can help you see what a system is like at 10,000 feet... kind of like a blueprint for your application.

Draw a use case diagram to show what your system <u>IS</u> without getting into unnecessary detail.

Here's our feature list... the system has to do these things.

Gary's Game System Framework Feature List

- 1. The framework supports different types of terrain.
- The framework supports different time periods, including fictional periods like sci-fi and fantasy.
- 3. The framework supports multiple types of troops or units that are gamespecific.
- The framework supports add-on modules for additional campaigns or battle scenarios.
- 5. The framework provides a board made up of square tiles, and each tile has a terrain type.
- 6. The framework keeps up with whose turn it is.
- 7. The framework coordinates basic movement.



Cubicle Conversation

Isn't it about time we started actually talking about code? I mean, I get that we need a feature list, and use case diagrams, and all that, but at some point we have to actually build something, you know?



Domain analysis lets you check your designs, and still speak the customer's language. Frank: I don't know, Jim. I think we have been talking about code.

Jim: How do you figure that? I mean, what line of code is "framework supports different types of terrain" really going to turn into?

Frank: You're talking about those features we figured out, right? Well, that's not just one line of code, but it certainly is a big chunk of code, right?

Jim: Sure... but when do we get to talk about what classes we need to write, and the packages we put those classes into?

Frank: We're getting to that, definitely. But the customer really doesn't understand what most of that stuff means... we'd never be sure we were building the right thing if we started talking about classes and variables.

Jim: What about class diagrams? We could use those to show what we're going to code, couldn't we?

Frank: Well, we could... but do you think the customer would understand that much better? That's really what domain analysis is all about. We can talk to the customer about their system, in terms that they understand. For Gary, that means talking about units, and terrain, and tiles, instead of classes, objects, and methods.

Let's do a little domain analysis!

Let's put all these things we've figured out about the game system together, in a way that Gary, our customer, will actually understand. This is a process called **domain analysis**, and just means that we're describing a problem using terms the customer will understand.

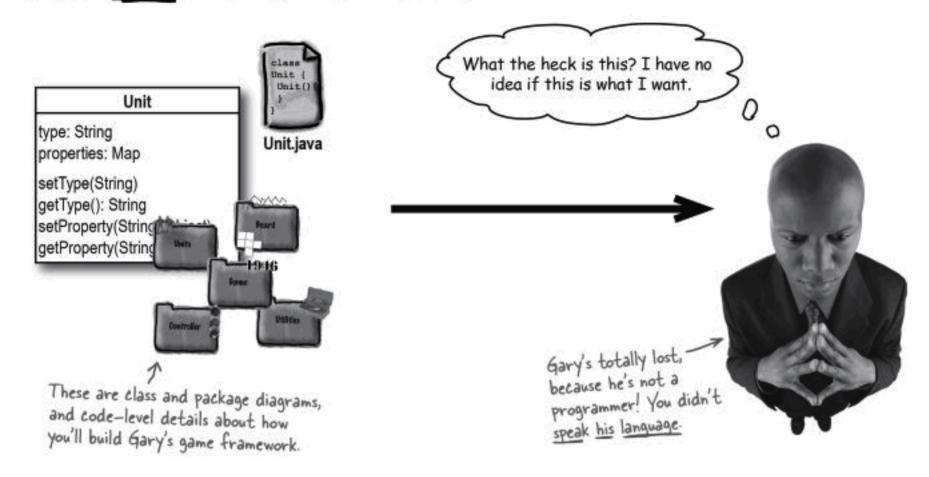
The domain here is game systems. These features are Gary's Game System Framework using terms that the Feature List customer understands. 1. The framework supports different types of terrain. 2. The framework supports different time periods, including fictional periods like sci-fi and fantasy. The framework supports multiple types of troops or units that are game-4. The framework supports add-on modules for additional campaigns or battle scenarios. 5. The framework provides a board made This whole feature list is up of square tiles, and each tile has a terrain type. a form of analysis, just 6. The framework keeps up with whose like we've been doing in turn it is. earlier chapters. 7. The framework coordinates basic movement.

Scholar's Corner

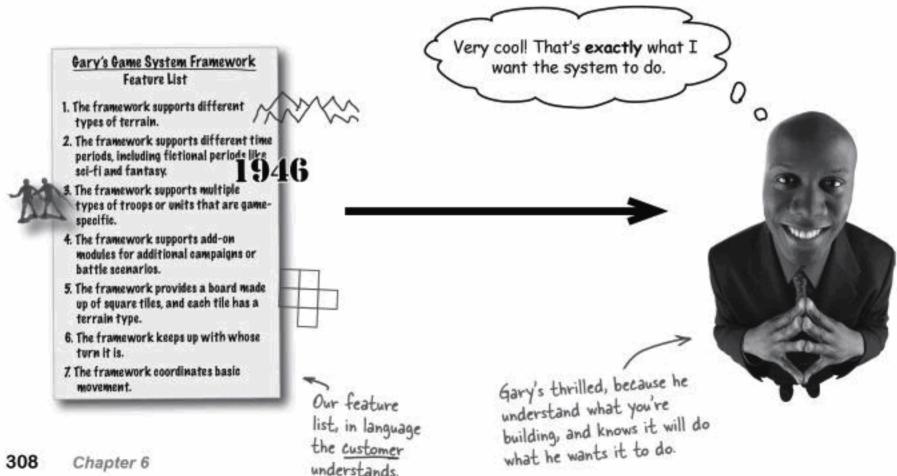
domain analysis. The process of identifying, collecting, organizing, and representing the relevant information of a domain, based upon the study of existing systems and their development histories, knowledge captured from domain experts, underlying theory, and emerging technology within a domain.



What most people give the customer...

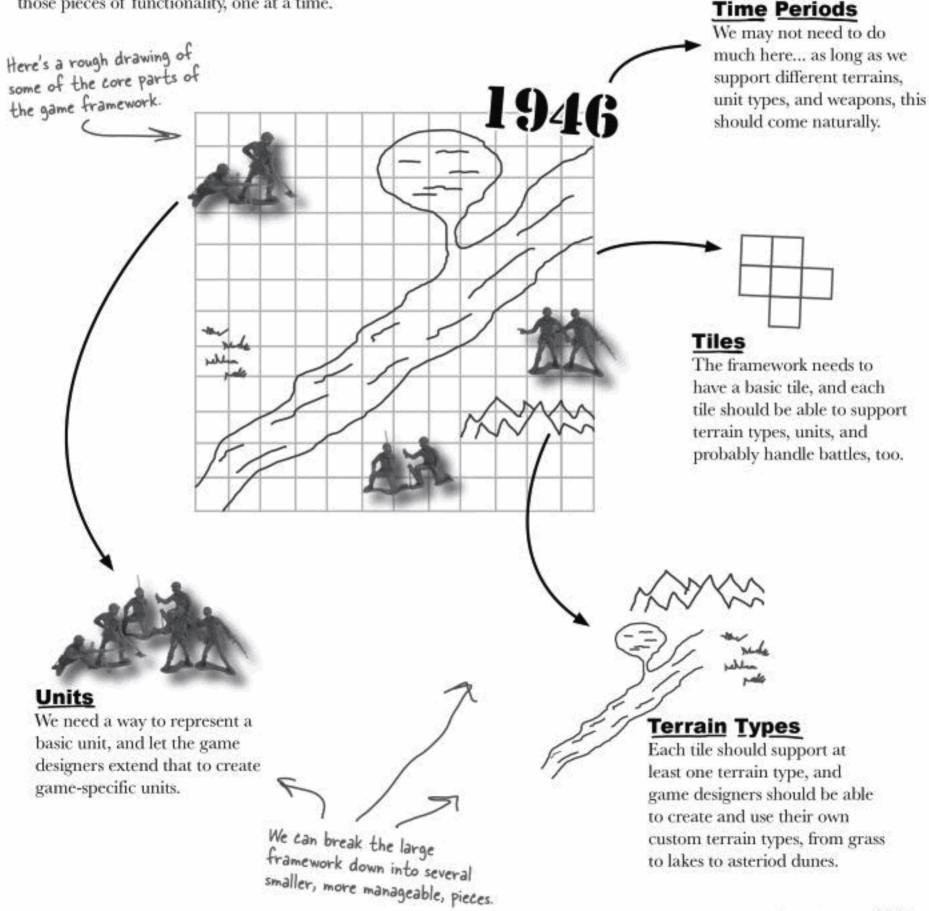


What we're giving the customer...



Now divide and conquer

With the customer onboard, and a nice completed set of blueprints, you're ready to start breaking up your big problem into different pieces of functionality—and then you can use what you've learned already to tackle each of those pieces of functionality, one at a time.



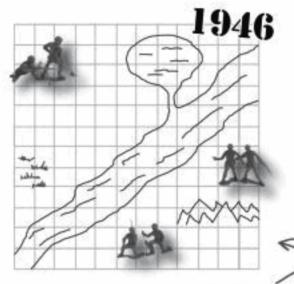
The Big Break-Up

It's time to break up our big problem—Gary's game framework—into lots of smaller pieces of functionality. You've already seen how we can divide the game and its features into some basic groups of functionality, so you're already well on your way.

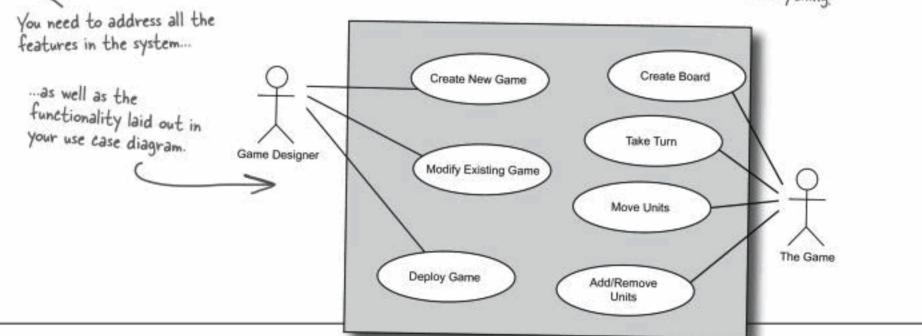
Below are the features and diagrams we've been using throughout this chapter to show what Gary's system needs to do. You need to look at these, and figure out what modules you want to use to handle all this functionality, and how you want to split the features and requirements up. Make sure your modules cover everything you think the game framework will need to do!

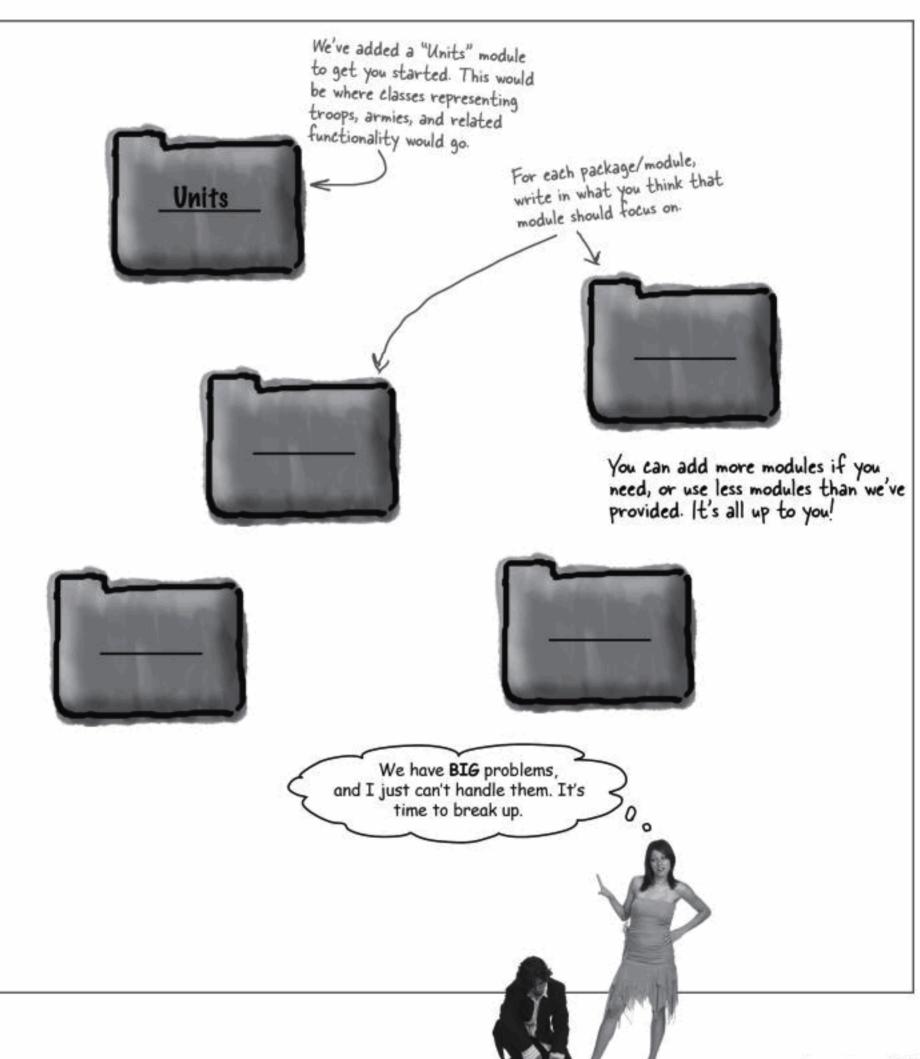
Gary's Game System Framework Feature List

- The framework supports different types of terrain.
- The framework supports different time periods, including fictional periods like sci-fi and fantasy.
- The framework supports multiple types of troops or units that are gamespecific.
- The framework supports add-on modules for additional campaigns or battle scenarios.
- The framework provides a board made up of square tiles, and each tile has a terrain type.
- The framework keeps up with whose turn it is.
- 7. The framework coordinates basic movement.



Here's the game board to remind you of some of the major areas to focus on... but remember, this isn't everythinal





Our Big Break-Up

Here's what we did to handle all the features of Gary's system, and to break the big problem up into several smaller, more manageable pieces of functionality.



This takes care of troops, armies, and all the units used in a game.



We're using a Game module to store basic classes that can be extended by designers. These relate to the time period of the game, basic properties of the game, and anything else that sets up the basic structure of each game.



there's where we can handle the turns of each player, basic movement, and anything else related to keeping a game actually going. This module is sort of the "traffic cop" for the games that designers create.

The board module handles the board itself, tiles, terrain, and other classes related to creating the actual board used in each game.

We chose to NOT have a module just for terrain, or tiles, since there would only be one or two classes in those modules. Instead, we tied that all into the Board module.

Board



It's always a good idea to have a Utilities module, to store tools and helper classes that are shared across modules.

There's no single RIGHT answer to this exercise!

It's OK if your answers don't match up with ours exactly. There are lots of ways to design a system, and this is just the one we chose. What you do need to worry about is that you've covered all the features and use cases with your design, and that it makes sense... you don't want a module to have just one class in it, or one that will have one or two hundred.

Dude, this game is gonna SUCK!

You don't even have a graphics package...
even if it's not all fancy, I've gotta at
least be able to see the freaking board
and units.

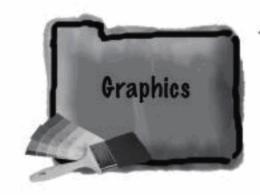
To the second se

Tony may know a lot about what makes for a killer game, but he's not your customer!

Pon't forget who your customer <u>really</u> is

It might seem like Tony has a good point... until you remember who the customer for Gary's game system framework really is. Your job is to write a framework for game designers, not to create actual games. Every game's user interface will be different, so it's up to the game designer to take care of graphics, not you.

Domain analysis helps you avoid building parts of a system that aren't your job to build.



This is something that the game designer would create... it's not your responsibility.



Take a close look at the modules and groupings in the game system framework. Do you recognize a commonly used design pattern?

Here's a hint for you Head First Design Patterns readers.



You know, once the game designer adds in a Graphics module, this looks an awful lot like the Model-View-Controller pattern.

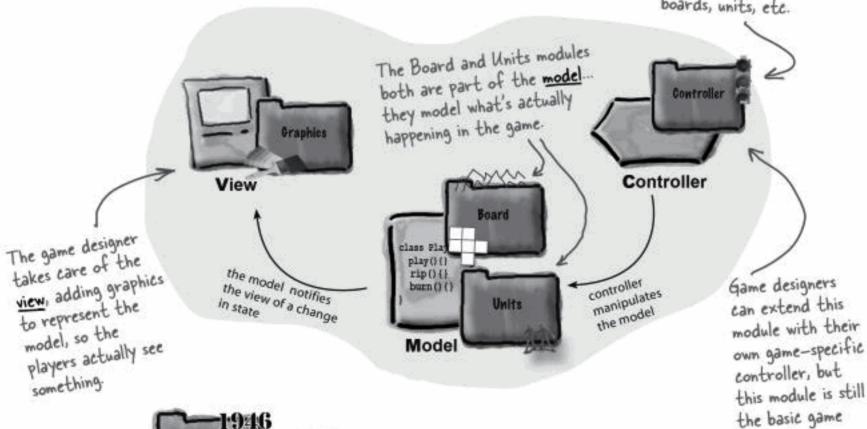


Most people refer to this as the MVC pattern.

It's the Model-View-Controller Pattern!

there's the game
controller that we're
going to write. It
handles basic turns
and figuring out what
needs to happen with
boards, units, etc.

controller.



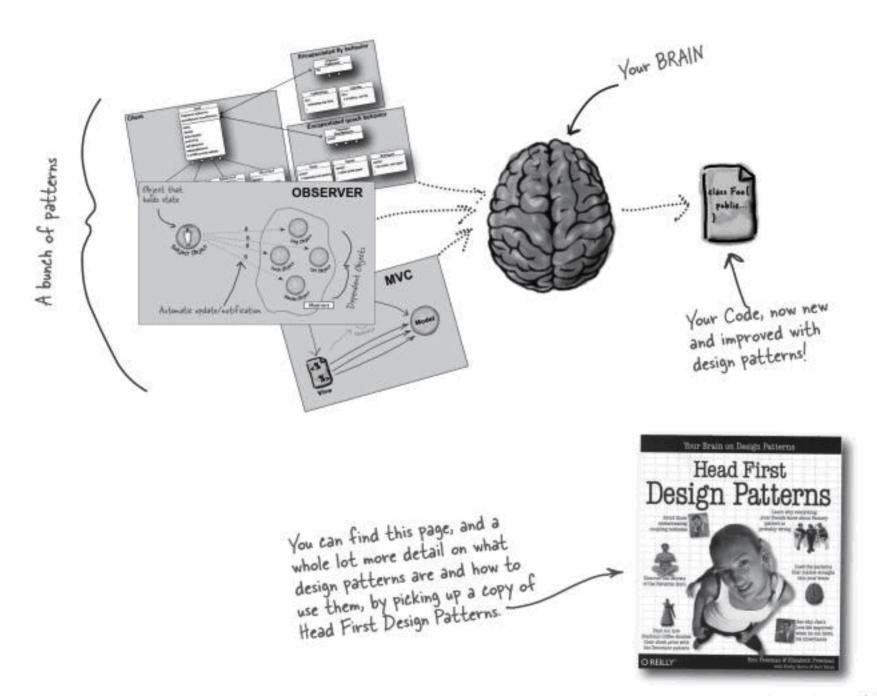
Utilities

These really don't fit into the MVC pattern, but they're still part of the system.

What's a design pattern? And how do I use one?

We've all used off-the-shelf libraries and frameworks. We take them, write some code against their APIs, compile them into our programs, and benefit from a lot of code someone else has written. Think about the Java APIs and all the functionality they give you: network, GUI, IO, etc. Libraries and frameworks go a long way towards a development model where we can just pick and choose components and plug them right in. But... they don't help us structure our own applications in ways that are easier to understand, more maintainable and flexible. That's where Design Patterns come in.

Design patterns don't go directly into your code, they first go into your BRAIN. A design pattern is just a way to design the solution for a particular type of problem. Once you've loaded your brain with a good working knowledge of patterns, you can then start to apply them to your new designs, and rework your old code when you find it's degrading into an inflexible mess of jungle spaghetti code.



I haven't read Head First Design Patterns, and I'm still a bit fuzzy on exactly what a design pattern even is. What should I do?



Keep going! Design patterns are one of the last steps of design.

It's OK if you're not familiar with design patterns. Design patterns help you take those last steps of design—once you've used OO principles like encapsulation and delegation to make your software flexible, a well-chosen design pattern can add just that extra bit of flexibility to your design, and save you some time, too.

But it's no big deal if you're not familiar with design patterns. You can still work through this book, and get a handle on really solid design. Then, we'd recommend you pick up Head First Design Patterns, and see how other people have been handling some classic design problems, and learn from them.

Feeling a little bit lost?

We've done a lot of things in this chapter, and some of them don't even seem to be related...

- → Gathering features
- → Domain analysis
- → Breaking Gary's system into modules
- → Figuring out Gary's system uses the MVC pattern.

But how does any of this really help us solve <u>BIG</u> problems?

Remember, the whole point of all this was to get a handle on how to deal with really large applications like Gary's game system framework—that involve a lot more than some basic design and programming.

But here's the big secret: you've already done everything you need to handle Gary's BIG problem.

> OK, I must have missed that. Can you let me in on what I missed?



The power of OOA&D (and a little common sense)

Gary's Games

Compa Games provides Extrements that game designers can use to crose num-based strategy games. Unlike attrade-style shoot-ent-up games and games that rely on studio and video features to engage that player, one games will factus on the technical details of sentegy and tactics. Our financiarity provides the brookleeping details to make building a particular game case, while removing the burden of redding aspectages tasks from the game design.

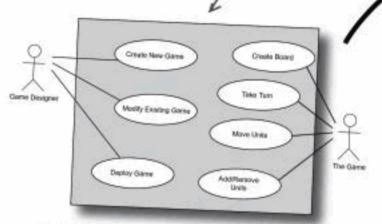
The game communications (GSF) will provide the core of old of Gary's Games. It will be delivered as a library of classes with a well-defined API that should be undie by all beard game development project traine within the company. The transversk will provide standard manufacture for

- + defining and representing a bound configuration
- defining troops and configuring armics or other fighting units
- * moving units on the board
- determining legal moves
- · conducting luttles
- prociding unit information

The GSF will samples the task of developing a num-based strategic board game so that the users of the GSF can devois their first to implementing the actual games.

We started out with this rather vague, far-reaching vision statement Now that's a BIG problem.

Once we knew what we were building, we created a use case diagram to help us understand the big picture.

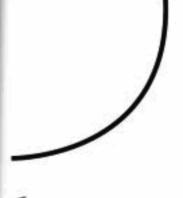


We listened to the customer.

Gary's Game System Framework Feature List

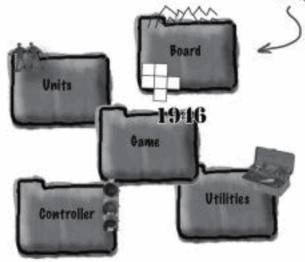
- 1. The framework supports different types of terrain.
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- 3. The framework supports multiple types of troops or units that are gamespecific.
- 4. The framework supports add-on modules for additional campaigns or battle scenarios.
- 5. The framework provides a board made up of square tiles, and each tile has a terrain type.
- 6. The framework keeps up with whose
- 7. The framework coordinates basic movement.

We made sure we understood the system. We drew up blueprints for the system we're building.



Using domain analysis, we made sure we understand what Gary wanted his system to do.

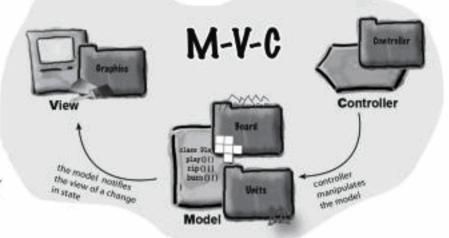
With a blueprint and feature list in hand, we were able to break up Gary's big app into lots of smaller pieces of individual functionality.



We broke the big problem up into smaller pieces of functionality. We even took a design pattern that we already understand, and applied it to our system.

Look! You already know how to solve these smaller problems, using everything you've already learned about analysis and design...

> ...and you can even figure out how to apply the MVC pattern from Head First Design Patterns.



We apply design patterns to help us solve the smaller problems.



Congratulations!

You've turned a BIG PROBLEM into a bunch of smaller problems that you already know how to solve.

Tools for your OOA&D Toolbox

You've taken on a huge problem, and you're still standing! Review some of the things you've learned about handling big problems, and then you're ready for the return of the OOA&D crossword puzzle.

Requi Analysi

Good require works like a Make sure

Well-designed and extend.

by developi Use your u Use basic OO and inheritar more flexible

Your use ca or missing thave.

things your

Your requir

If a design is
IT! Never se
it's your bad
Make sure ei
each of your

Always strive move throug lifecycle.

ONE THING

Solving Big Problems

Listen to the customer, and figure out what they want you to build.

Put together a feature list, in language the customer understands.

Make sure your features are what the customer actually wants.

Create blueprints of the system using use case diagrams (and use cases).

Break the big system up into lots of smaller sections.

Apply design patterns to the smaller sections of the system.

Use basic OOAFD principles to design an code each smaller section.

We've got a whole new category of techniques we learned about in this chapter.

00 Principles

Encapsulate what varies.

Code to an interface rather than to an implementation.

Each class in your application should have only one reason to change.

Classes are about behavior and functionality.



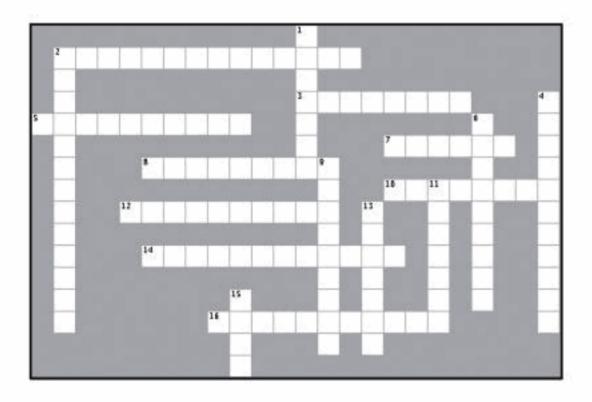
- The best way to look at a big problem is to view it as a collection of smaller problems.
- Just like in small projects, start working on big projects by gathering features and requirements.
- Features are usually "big" things that a system does, but also can be used interchangeably with the term "requirements."
- Commonality and variability give you points of comparison between a new system and things you already know about.

- Use cases are detail-oriented; use case diagrams are focused more on the big picture.
- Your use case diagram should account for all the features in your system.
- Domain analysis is representing a system in language that the customer will understand.
- An actor is anything that interacts with your system, but isn't part of the system.



OOA&D Cross

It's time for another left-brain workout. Below is a puzzle with lots of blank sqaures; to the right are some clues. You know what to do, so go for it!



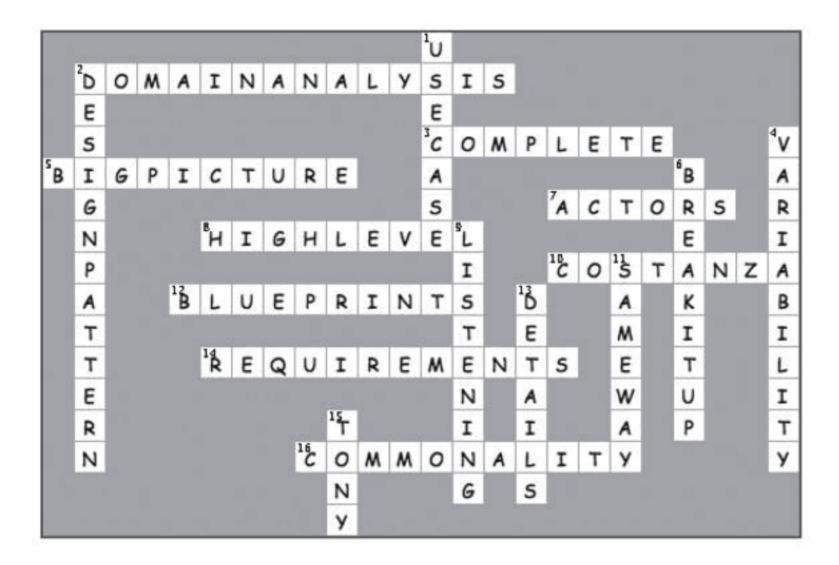
Across

- This helps you speak to the customer in their language (2 words)
- You can use your feature list to make sure your use case diagram is this.
- Use cases don't always help you see this (2 words).
- 7. These aren't always people.
- A feature is a _____ description of something a system needs to do (2 words)
- 10. Art Vandelay's "real" last name
- A use case diagram acts as this for your system.
- You can figure out these based on your features.
- This is the measure of how things are similar.

Down

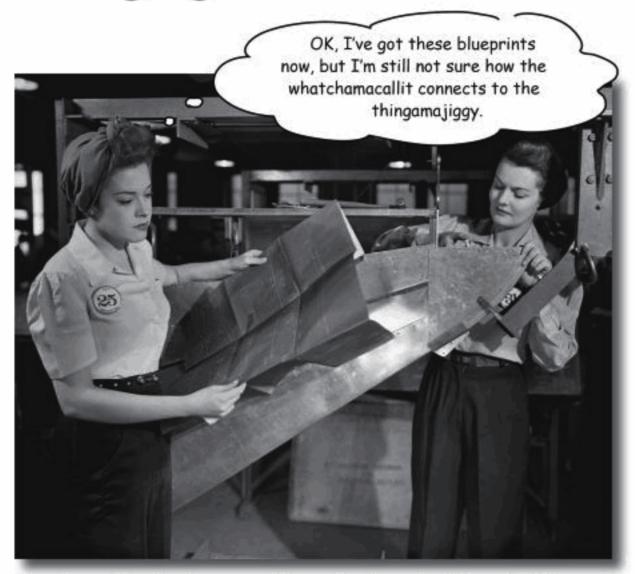
- 1. An oval in a use case diagram represents one of these
- We applied ones of these to your Gary's framework.
- 4. The measure of how things are different.
- You should solve a big problem by doing this to it (3 words)
- You can figure out a system's features by _____ to the customer.
- You solve big problems the _____ you solve small problems (2 words).
- 13. Defer these as long as possible.
- 15. He wasn't the customer.





7 architecture

Bringing Order to Chaos



You have to start somewhere, but you better pick the right somewhere! You know how to break your application up into lots of small problems, but all that means is that you have LOTS of small problems. In this chapter, we're going to help you figure out where to start, and make sure that you don't waste any time working on the wrong things. It's time to take all those little pieces laying around your workspace, and figure out how to turn them into a well-ordered, well-designed application. Along the way, you'll learn about the all-important 3 Qs of architecture, and how Risk is a lot more than just a cool war game from the '80s.

Feeling a little overwhelmed?

So you've got lots of small pieces of functionality that you know how to take care of ... but you've also got use case diagrams, feature lists, and a whole lot of other things to think about.

Gary's Game System Framework Feature List

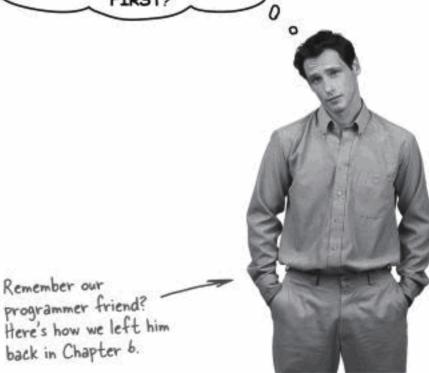
- 1. The framework supports different types of terrain.
- 2. The framework supports different time periods, including fictional periods like sci-fi and fantasy.
- 3. The framework supports multiple types of troops or units that are gamespecific.
- 4. The framework supports add-on modules for additional campaigns or battle scenarios.
- 5. The framework provides a board made up of square tiles, and each tile has a terrain type.
- 6. The framework keeps up with whose turn it is.
- 7. The framework coordinates basic movement.

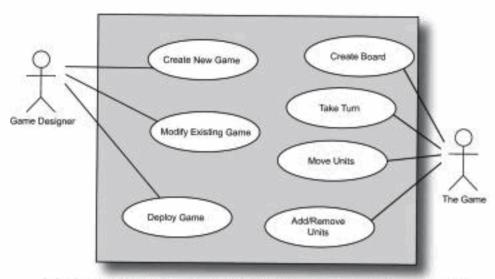
We have feature lists...



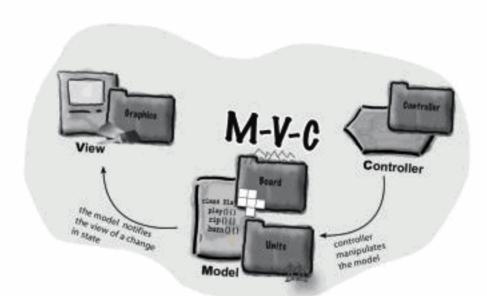
...individual modules to code...

OK, even if I do know how to handle all these individual pieces, where the heck am I supposed to start? Can you at least tell me what to do FIRST?

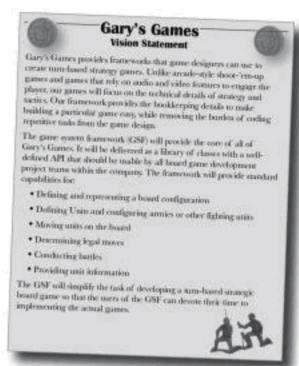




...high-level views of what we need to build...



...and even some design patterns to apply.



...the customer's vision...



Do you think it matters what you should try to do first? If you do, why? And what would **you** work on first?

We need an architecture

It's really not enough to just figure out the individual pieces of a big problem. You also need to know a little bit about how those pieces fit together, and which ones might be more important than others; that way, you'll know what you should work on *first*.

We already knew this... architecture helps us design these big systems.

Our use case

Architecture is your design structure,

and highlights the most important

parts of your app, and the

relationships

diagram was the start of this, but it's still pretty unclear how all the modules into the module into t

Now this is what we need... how do we figure out what's most important, so we can build those parts of our app first?

All this is particularly important when you're working with other programmers... you have to all understand the same architecture.

Scholar's Corner

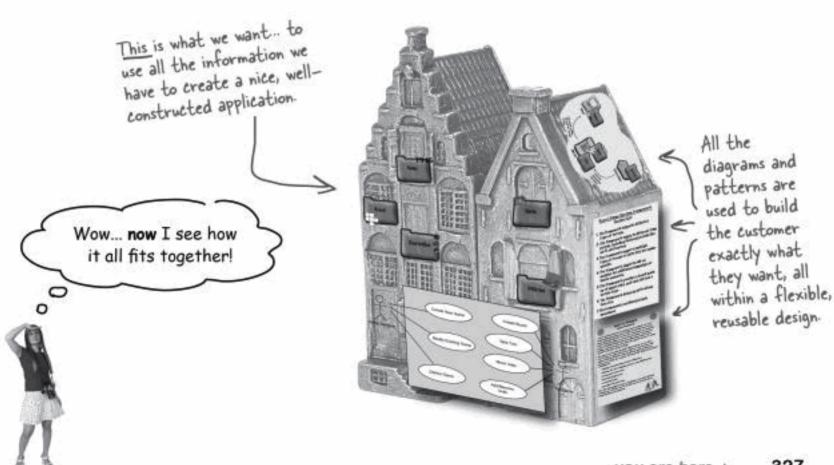
architecture. Architecture is the organizational structure of a system, including its decomposition into parts, their connectivity, interaction mechanisms, and the guiding principles and decisions that you use in the design of a system.



Architecture takes a big chaotic mess...



...and helps us turn it into a well-ordered application



You write great software the same way, whether you're working on a small project, or a huge one. You can still apply the three steps we talked about way back in Chapter 1.

Remember this page from the first chapter? These 3 steps apply to building great <u>BIG</u> software, too.

well-dissigned apparatock

We know that these three steps will help us tackle each of these individual pieces of the game system framework.



Great software in 3 easy steps

1. Make sure your software does what the customer wants it to do.

This other factories on the contamer Make some the app does what it supposed to do FRCT.

It may not some easy now, but we'll show you have GOAFD and some hast principles can change your saftware forester.

2. Apply basic
00 principles to
add flexibility.

Once your softmore morks, you can start to remove displicate code and use good OO practices

Strive for a maintainable, reusable design.

Got a good object-oriented app that does what it should? It's time to apply patterns and principles to make easy year softwire is ready to use for years to come.

You are here a

11

These three steps apply when you're working on really big applications, too. So we need to start with what the customer wants an app to do, before we get into details about the actual design of the app.



Really BIG application

Let's start with functionality

The first step is always to make sure an application does what it's supposed to do. In small projects, we used a requirements list to write down functionality; in big projects, we've been using a feature list to figure those things out:

All of these features are about functionality... they focus on what the system has to do, not on what principles or patterns you use to build the system.

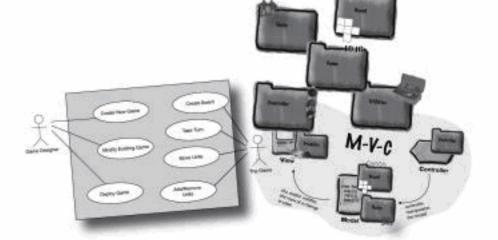
Gary's Game System Framework Feature List

- The framework supports different types of terrain.
- The framework supports different time periods, including fictional periods like sci-fi and fantasy.
- The framework supports multiple types of troops or units that are gamespecific.
- The framework supports add-on modules for additional campaigns or battle scenarios.
- 5. The framework provides a board made up of square tiles, and each tile has a terrain type.
- The framework keeps up with whose turn it is.
- 7. The framework coordinates basic movement.

We'll come back to these other diagrams and patterns later... but right now, we're focusing solely on the functionality of the system.

But which of these are the most important?

Even if we know to start by focusing on functionality, we still need to figure out which pieces are the most important. *Those* are the pieces we want to focus on first.



Sharpen your pencil

What do YOU think are the most important features?

Even though our feature list has only seven things on it, there's a lot of work in those seven features. It's your job to figure out which features you think are the most important, and then in what order you'd work on those things.

Gary's Game System Framework Feature List

- The framework supports different types of terrain.
- The framework supports different time periods, including fictional periods like sci-fi and fantasy.
- The framework supports multiple types of troops or units that are gamespecific.
- The framework supports add-on modules for additional campaigns or battle scenarios.
- The framework provides a board made up of square tiles, and each tile has a terrain type.
- 6. The framework keeps up with whose turn it is.
- 7. The framework coordinates basic movement.

You've got to handle all
of these features, but
it's up to you to figure
out the order you
should tackle them in.

Write down the 4 things you'd do first, in order, in these blanks.

1			
2			
3.			

Wait a second... if architecture is about the **relationships** between the parts of an application, why are we talking about the individual parts? Shouldn't we be talking about how the parts work together?

The things in your application that are really important are architecturally significant, and you should focus on them FIRST.

You gotta start somewhere!

It's awfully hard to talk about the relationships between parts of a system if you don't have any of the parts themselves. So say you wanted to talk about how the Board module interacted with the Units module:



To figure out how these modules interact, you'd need to have at least the basics of the two modules in place first.

So architecture isn't just about the relationships between parts of your app; it's also about figuring out which parts are the **most** important, so you can start building those parts first.



The three Qs of architecture

When you're trying to figure out if something is architecturally significant, there are three questions you can ask:

1. Is it part of the essence of the system?

Is the feature really **core** to what a system actually is? Think about it this way: can you imagine the system without that feature? If not, then you've probably found a feature that is part of the **essence** of a system.



Note from marketing: suggest replacing profanity with "heck."

If you're not sure what the description of a particular feature **really means**, it's probably pretty important that you pay attention to that feature. Anytime you're unsure about what something is, it could take lots of time, or create problems with the rest of the system. Spend time on these features early, rather than late.

3. How the "heck" do I do it?

Another place to focus your attention early on is on features that seem **really hard** to implement, or are **totally new** programming tasks for you. If you have no idea how you're going to tackle a particular problem, you better spend some time up front looking at that feature, so it doesn't create lots of problems down the road.



BE the Architect

To the right, you'll find the feature list we figured out in the last chapter. Your job is to play like you're the architect, and figure out what's architecturally significant by using the three Qs of architecture we just talked about.

Gary's Game System Framework Feature List

- The framework supports different types of terrain.
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- The framework provides a board made up of square tiles, and each tile has a terrain type.
- 6. The framework keeps up with whose turn it is.
- 7. The framework coordinates basic movement.

What's significant?	Why?
	- Write down
;	Write down which of the three Qs appli
1	(you can write more than one, if you need to

Check and see how close your answers here match up to what you wrote down on page 330.

BE the Architect Solutions

To the right, you'll find the feature list we figured out in the last chapter. Below are the things we thought were architecturally significant, and which of the three Qs we used to make our decisions.

Gary's Game System Framework Feature List

- 1. The framework supports different types of terrain.
- 2. The framework supports different time periods, including fictional periods like sci-fi and fantasy.
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What's significant?

We decided that the board was core to the game ... without a board, there really isn't a game!

Why?

We thought that troops were essential

to the game ... and we're not sure what

"game-specific" might really mean. So two Qs applied here.

Q3 (and maybe Q2)

Q1, Q2

The framework coordinates basic movement

This seems a little vague, but it's not something we're sure about how to do. Definitely worth spending some time up front

figuring out what this means, and what we need to do.

The board for the game

Game-specific units

Dumb Questions

Q: I'm a little confused about what you mean by the "essence" of the system. Can you say more about that?

A: The essence of a system is what it is at its most basic level. In other words, if you stripped away all the bells and whistles, all the "neat" things that marketing threw in, and all the cool ideas you had, what would the system really be about? That's the essence of a system.

When you're looking at a feature, ask yourself: "If this feature wasn't implemented, would the system still really be what it's supposed to be?" If the answer is no, you've found yourself an "essence feature." In Gary's system, we decided that the game wouldn't really be a game without a board and some units, and there are some more examples in the Brain Power at the bottom of the page.

Q: If you don't know what something means, isn't that a sign that you've got bad requirements?

A: No, but it is a sign that you might need to get some additional requirements, or at least some clarification. In the early stages, you can leave some details out to get a basic sense of a system. But at this stage, it's time to fill in some of those details, and that's what the second Q of architecture is all about.

If I'm working on a new system, I probably won't know how to do anything on my feature list. So won't the 3rd Q of architecture about not knowing how to do something always apply?

A: No, not at all. For instance, even if you've never written code to decide whether a player typed in the letter "q" or the letter "x," you know how to write a basic if/else statement, and it's easy to grab keyboard input from a player. So a feature like getting keyboard input isn't something you don't know how to do, even if you've never written code specifically for that task before. It's just a few new details, really.

But if you had to write a multi-threaded chat server, and you're new to threads and network programming, then that would be something that you don't know how to do. Those are the things to look out for: particularly hard tasks that you're unsure about how to handle.

O: Doesn't this all end up just being a judgment call, anyway?

A: In a lot of cases, yes. But as long as you choose to start working on the things that seem the most important to the system, you're going to get off to a good start.

What you don't want to do is see some things that look familiar—perhaps you've solved the same problem in another project—and start there. Start with the core pieces of the system, and the things that look like they might be particularly hard, and you'll be on the road to success.

The <u>essence</u> of a system is what that system is at its most <u>basic level</u>.

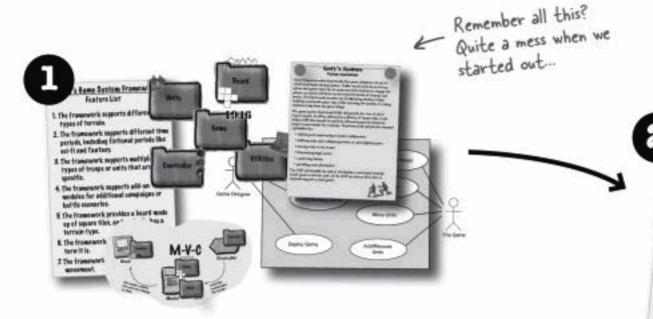


What do you think the essence of each of these systems is:

- · A weather-monitoring station?
- A home automation remote control?
- A beat-controlling, music-mixing DJ application?

We've got a lot less chaos now...

Using the three Qs of architecture, we've started to add some order to all that confusion we started out with:



But then we focused on making the system do what it is supposed to do.

Gary's Game System Framework Feature List

- The framework supports different types of terrain.
- The framework supports different time periods, including fictional periods like soi-fi and fantasy.
- 5 The framework supports multiple types of troops or units that are gamespecific.
- The framework supports add-on modules for additional campaigns or battle scenarios.
- 5. The framework provides a board made up of square tiles, and each tile has a terrain type.
- 6. The framework keeps up with whose form it is.
- Z The framework coordinates basic

8

Gary's Game System Framework KEY Features

- 1. The board for the game—essence of the system
- 2. Game-specific units—essence, and what does this mean?
- 3. Coordinating movement—what is it, and how do we do it?

Finally, we've
 narrowed that down
 to just a few key
 features to focus on.

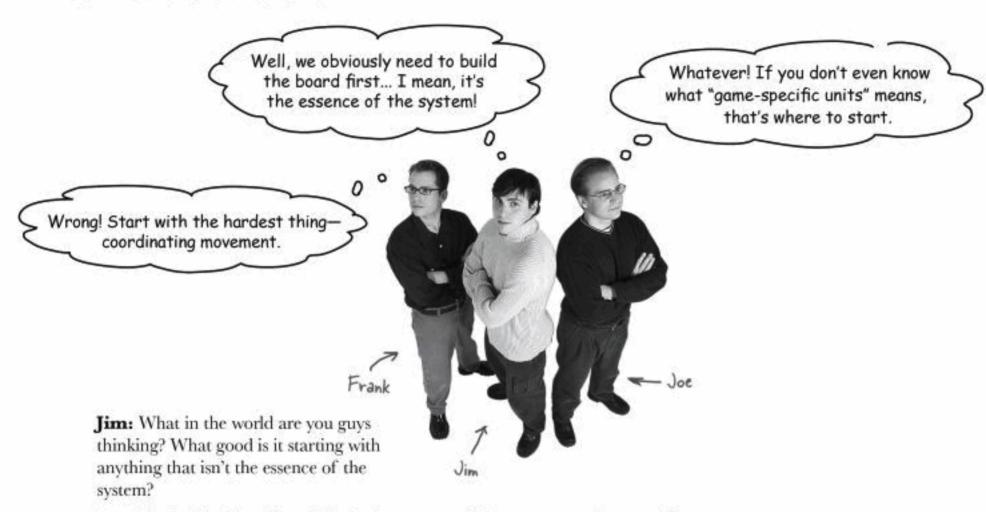
I know I love a man in uniform, but there are still choices to be made...

...but there's still plenty left to do

We've gotten Gary's system down to three key features, but the big question remains: which one should you work on first?



Argument Cubicle Conversation



Joe: That's ridiculous. Even if that's the essence of the system, you've got to figure out what game-specific units are. That could take weeks to write if it's harder than we think!

Frank: Maybe... but we *know* that coordinating movement will be tough, because we don't have a clue how to do it! How can you possibly work on anything else when you *know* the movement deal is going to be difficult?

Joe: But the game-specific units might be difficult, too! We just don't know, and that's my point. We've got to figure out the parts of the system we don't know anything about, or they could be real trouble!

Jim: You guys go on and write movement engines and deal with units. Me, I'm gonna write a board, because... well... something tells me Gary will want to see a *board* for his *board game system*. And I'm not about to leave the board for later... I'm taking it on first.

Frank: You're both nuts. While you're putting off the hard tasks, I'm gonna make sure the things that I don't have any real idea about are taken care of, right away.

So who do you think is right? Do you agree with:

☐ Jim (build the board)	Joe (build the game-specific units

☐ Frank (build the movement engine)

Check the box next to who you agree with.

Leave it to a bunch of boys to get into a big argument.
I think they're ALL right... the problem isn't which feature to start with, the problem is RISK!

Jill works with Frank, Jim, and Joe, and is used to breaking up their arguments.

The reason that these features are architecturally significant is that they all introduce **RISK** to your project. It doesn't matter which one you start with—as long as you are working towards reducing the RISKS in succeeding.

Take another look at our key features:

Gary's Game System Framework KEY Features

- 1. The board for the game—essence of the system
- 2. Game-specific units—essence, and what does this mean?
- 3. Coordinating movement—what is it, and how do we do it?

Since we don't know what this means, it could be a ton of work, and that's a RISK in meeting schedules and deadlines.

This is something we're not sure how to do, so there's a <u>RISK</u> that we won't figure it out, or it will take a really long time.

If the core features of the system aren't in place, there's a serious RISK that the customer won't like the system.

0

The point here is to <u>REDUCE RISK</u>, not to argue over which key feature you should start with first. You can start with ANY of these, as long as you're focused on building what you're supposed to be building. architecture Bringing Order to Chaos > The point here is to REDUCE RISK, not to argue over which key feature you s as long as you're focused on building what you're supposed to be building.

architecture

Well, I still think my risk is bigger than yours... Sharpen your pencil Find the risk in your own project. Think about the project you're working on in your day job right now. Now write down the first thing you started working on when you started the project: Now think about the 3 Qs of architecture that we talked about back on page 332. If you applied those to your project, write down a few features that you think would be architecturally significant: If you look at those features closely, you'll probably see that they all have a lot of RISK connected to them. They're the things that could cause you lots of problems, or delay you getting your project done. In the blanks below, write down which of those features you think you should have worked on first, and why. What risks did it create? What risks could you have reduced by working on it first?

hara t 220



For Gary's game system, let's start out by working on the board module. Your job is to write a Board interface that game designers can then use and extend to build their own games.

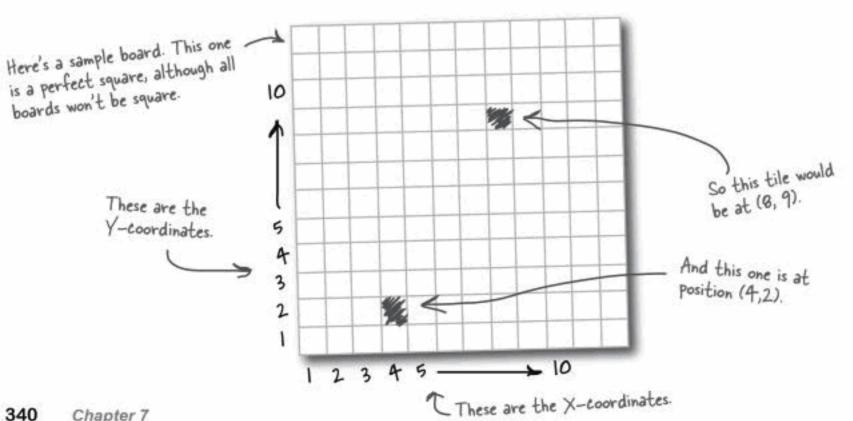
The problem:

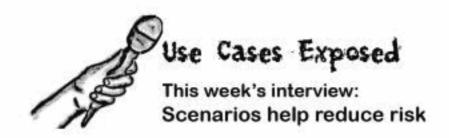
Here are some detailed requirements that we got from Gary and his design team

You need a **Board** base type that game designers can use to create new games. The board's height and width are supplied by the game designers for their games. Additionally, the board can return the tile at a given position, add units to a tile, and return all the units at a given X-Y position.

Your task:

- Create a new class called Board. java.
- Add a constructor to Board that takes in a width and height, and creates a new board with that height and width. The constructor also needs to fill the board with square tiles, one at each X-Y position.
- Write a method that will return the tile at a given position, given that tile's X- and Y-position.
- Write methods to add units to a tile based on that tile's X- and Y-position.
- Write a method to return all the units on a tile, given the X- and Y-position of the tile.





HeadFirst: Hi there, Scenario, we appreciate you taking the time to talk with us today.

Scenario: I'm really happy to be here, especially in a chapter that isn't just about use cases.

HeadFirst: Well, yes, to tell the truth, I was rather surprised when I was told we'd be interviewing you. We're really focusing on architecture here, and working on features that would reduce risk.

Scenario: Absolutely! Well, that sounds like a very good way to approach big problems.

HeadFirst: Yes, well... ahem... then why are you here?

Scenario: Oh! I'm sorry, I just assumed you knew. I'm here to help reduce risk, also.

HeadFirst: But I thought you were just a particular path through a use case. We haven't even written any use cases yet!

Scenario: That's no problem, I can still be a real help. I mean, look, let's be honest, lots of developers just don't ever really take the time to sit down and write out use cases. Good grief, it took you something like four pages in Chapter 6 to convince people to even use a use case diagram, and that's much easier to draw than it is to write a use case!

HeadFirst: Well, that's true... there is a lot of resistance to writing out use cases. But they're really helpful, I thought they saved the day with Todd and Gina's dog door.

Scenario: Oh, I agree! But in cases where developers just don't have the time, or a use case is too formal for what's needed, I can really give you a lot of the advantages of a use case, without all the paperwork.

HeadFirst: Hmmm, that is appealing. So tell me how that works.

Scenario: Well, take that board you've been writing. Suppose you wanted to reduce the risks of Gary seeing it, and thinking of something important you forgot to add to it...

HeadFirst: Ahh, yes, forgetting an important requirement is always a risk!

Scenario: Well, you could come up with a simple scenario for how the board would be used—that's where I come in—and then make sure the board works with everything in your scenario.

HeadFirst: But there's no use case... what steps do we pick in the scenario we make up?

Scenario: It doesn't have to be that formal. You might say, "The game designer creates a new board 8 squares wide by 10 squares high," and "Player 1 kills Player 2's troops at (4, 5) so the board removes Player 2's troops from that tile."

HeadFirst: Oh, so just little descriptions of how the board is used?

Scenario: You've got it! Then you run through each description, and make sure your board handles those cases. It's not quite as thorough as a use case, but I really can help you make sure you don't forget any big requirements.

HeadFirst: This is fantastic! We'll be right back with more from Scenario.

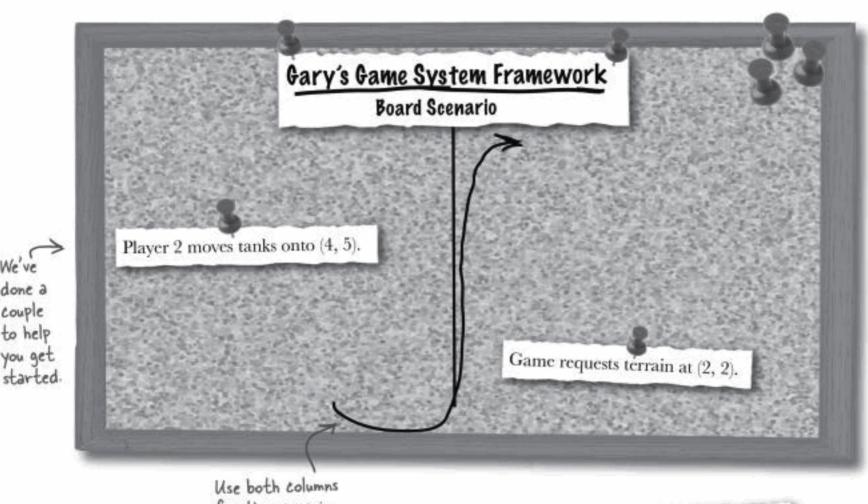
Scenario Scramble

Write a scenario for the Board interface you just coded.

Reducing risk is the name of the game in this chapter. You've coded a Board interface based on a few requirements we gave you, but it's your job to figure out if we forgot anything-before Gary sees your work and finds a mistake.

This is the risk we're trying to reduce or eliminate using a scenario.

Your job is to take the fragments of a scenario from the bottom of this page, and put them into an order that makes sense on the bulletin board. The scenario should run through a realistic portion of a game. When you're done, see if you left out anything on the Board interface, and if you did, add the missing functionality into your code. You may not need all the scenario fragments; good luck!



Pin the scenario fragments onto this piece of paper.

for the scenario.

Player 1 battles Player 2.

Player 1's units lose the battle.

Player 2 moves army onto (4, 5).

Game requests terrain at (4, 5).

came designer creates board with a height and width.

Player 1's units are removed from (4, 5).

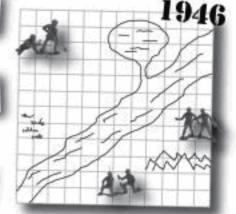
Game designer creates a new board.

Player 2's units win the battle.

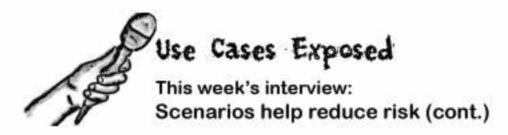
Game requests units from (4, 5).

Player 1 moves artillery onto (4, 5)

Player 1 moves subs to (2, 2). Game designer supplies height and width.



We've done a couple



HeadFirst: We're back with Scenario, again. Scenario, we're getting quite a few calls. Would you mind taking some of our listener's questions?

Scenario: Sure, I'd be happy to.

HeadFirst: Great. First, here's one we're getting a lot. This is from Impatient in Idaho: "So you're saying I don't need to write use cases, anymore, right? I can just use scenarios?"

Scenario: Oh, thanks, Impatient, I actually get that question often. I firmly believe you should still write use cases whenever possible. I'm helpful for quick problems, and to find the most common requirements, but remember, I'm only one path through a use case. If there are lots of alternate paths, you might miss some important requirements if you used just a scenario for your requirements.

HeadFirst: That's right, we've actually had Happy Path and Alternate Path on our show before.

Scenario: Well, they're really just specialized versions of me, if you want the truth. We try not to talk much about our family relationships, we all wanted to make it in this world on our own. But we're really all part of the Scenario family. And you really need all of us to be sure you've got a system completely right. But if you're just getting started, and a use case seems like it might be premature, just using me is a good way to get started.

HeadFirst: OK, here's another question, from Nervous in Nebraska: "You said you would help me reduce risk, and I hate risk. Could you tell me exactly how you can help me avoid risk?"

Scenario: Another good question. Remember, when you're figuring out requirements, whether you're using a use case, a use case diagram, or a scenario, you're trying to make sure you are building just what the customer wants. Without good requirements, the risk is letting down or upsetting the customer by building the wrong thing.

HeadFirst: So you're reducing risk in the requirements phase?

Scenario: A lot of the time, yes. That's when you're writing use cases, putting together a requirements list, and using lots of scenarios to chart out all the paths through a use case.

HeadFirst: But you also help out in big project architecture, right? That's why we're interviewing you now?

Scenario: Exactly. Sometimes, you don't have a complete requirements list and a bunch of use cases, but you still need to get some basic work done to see how a system is going to work. That's what we've been doing here: using a scenario to get the basics of a module or piece of code down, so you can get the basic building blocks of your application in place.

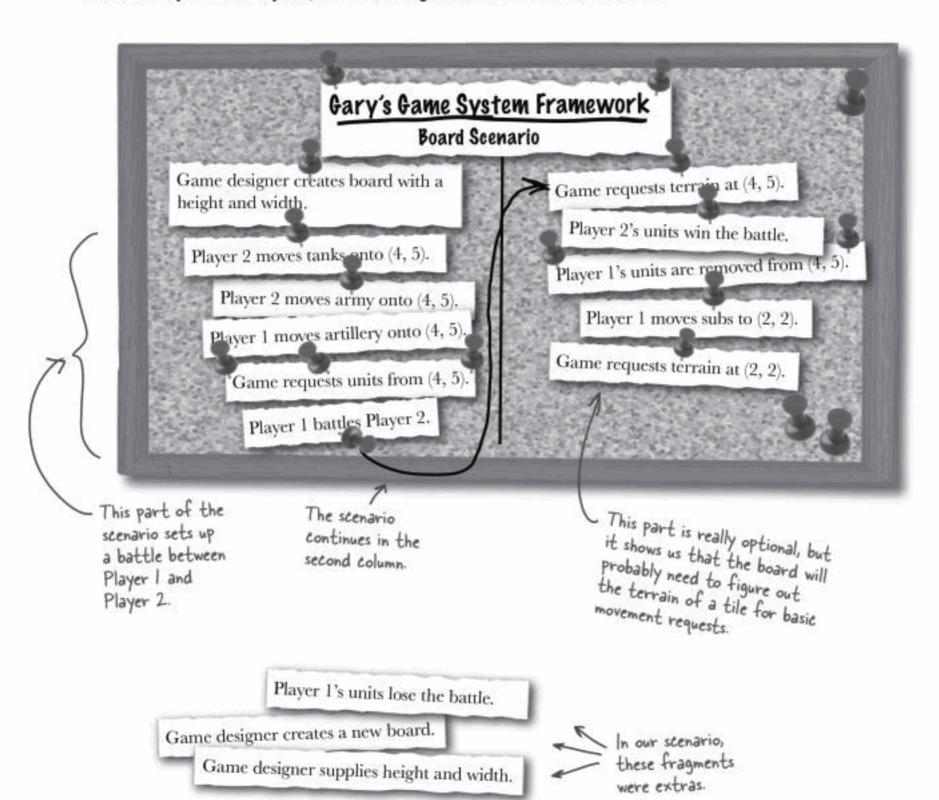
HeadFirst: So you're really a handy guy, aren't you?

Scenario: I'd like to think so. I help in gathering requirements, in being sure your use cases are complete, but also in architecture, helping you reduce risk and reduce the chaos and confusion around what a particular module or piece of code does.

Scenario Scramble Solution

Write a scenario for the Board interface you just coded.

Below is the scenario we came up with. Yours might be a bit different, but you should at least have the game designer creating the board, a battle occurring between Player 1 and Player 2, and units being both added to and removed from



Dumb Questions

Q: Where did those requirements for the Architecure Puzzle on page 340 come from?

A: From Gary, with some common sense added in. If you think about what Gary's asked for, a game system framework, and then read back over the customer conversation in Chapter 6, you could probably come up with these requirements on your own. We did add a few specifics, like being able to add a unit to a specific tile, but that's really just thinking through the problem.

Q: But why didn't we write a use case to figure out the requirements?

A: We could have. But remember, we're not trying to complete the Board module, as much as get the basic pieces in place. That's all we need to reduce the risk of completing this piece of Gary's system. In fact, if we got into too much detail, we might actually add risk to the project, by working on details that really aren't important at this stage of things.

Q: Now you're telling me that use cases add risk? That can't be right!

A: No, use cases don't add risk when used at the right time. Right now, we've come up with some key features that could cause us headaches if we don't figure them out. But that doesn't mean we need to perfect the Board interface; we just need to get an understanding of how it works, so if there are any potential problem spots, we can catch them and avoid problems down the line. So at this point, the details you'd need to write a good use case are a bit of overkill.

But once we've got the key features sketched out, and handled the major risks, we'll go back to each module and really start to add detail in. At that point, a use case is very helpful.

Q: So that's why we used a scenario, right? To avoid getting into lots of unneccessary detail?

A: Exactly. A scenario gives us lots of the advantages of a use case, without forcing us to get into lots of detail that we don't need to worry about right now.



-Architecture Puzzle (Revisited)

What's missing in Board.java?

Look closely at the scenario on the previous page. Did the requirements we used on page 340 cover everything in the completed scenario? If you think something is missing, write it in the blank below, and then add code to Board.java to handle the missing functionality.

2	A	
-	4	
•	_	

Architecture Puzzle Solution

For Gary's game system, let's start out by working on the Board module. Below is the interface we wrote to handle what we thought the basic tasks of a board would be. See how your solution compares with ours.

```
package headfirst.gsf.board;
                                                                 We put the Board class in
                                                                 a board-specific package.
                                                                This lines up with the
             import java.util.ArrayList;
                                                                modules we decided on
             import java.util.Iterator;
                                                                back in Chapter 6.
             import java.util.List;
                                                                 Here's a class we'll create
             import headfirst.gsf.unit.Unit; <
                                                                 in a minute, since we need
                                                                 it to finish up Board.
             public class Board (
                private int width, height;
                private List tiles;
                                                                  This constructor was laid
                                                                  out in the requirements. It
                public Board(int width, int height) (
                                                                  takes the width and height
                   this.width = width;
                                                                  in, and then calls initialize()
                  this.height = height;
                                                                  to set up the board.
                  initialize();
                                                                      We represented the grid on the
                private void initialize()
                                                                      board as an array of arrays, using
                                                                      width and height as the dimensions.
                   tiles = new ArrayList(width);
Bonus Design -
                  for (int i=0; i<width; i++)
Principle: Pull out
                     tiles.add(i, new ArrayList(height));
setup code into its
                     for (int j=0; j<height; j++) {
own method, so it
                        ((ArrayList)tiles.get(i)).add(j, new Tile());
doesn't make the
rest of your code
so confusing to read.
                                                At each coordinate, we add a
                                                new instance of Tile. We'll have to
                                                write that class to make Board
                                                work as well... check the next page
                                                for how we defined Tile.
```

```
These
                    public Tile getTile(int x, int y) {
   methods are
                       return (Tile) ((ArrayList)tiles.get(x-1)).get(y-1);
   pretty self-
    explanatory,
    and were
    part of the
                    public void addUnit(Unit unit, int x, int y) {
    requirements
                       Tile tile = getTile(x, y);
    on page 340.
                       tile.addUnit(unit);
We decided to
                    public void removeUnit(Unit unit, int x, int v) {
let the Tile class
                       Tile tile = getTile(x, v);
                                                                             You should have figured out
handle these
                   tile.removeUnit(unit);
                                                                             that we need a way to remove
operations, and
                                                                             units from the scenario
just delegate
                                                                             exercise on page 344. This
adding and
                                                                            is what was missing in our
 removing units to
                    public void removeUnits(int x, int y) {
                                                                            original requirements.
 that class.
                       Tile tile = getTile(x, y);
                     >tile.removeUnits();
                    public List getUnits(int x, int y) {
                       return getTile(x, y).getUnits();
                                                                     Here's another place where
                                                                     we delegate to the Tile class.
                                                                     Since a tile stores the units on
                                                                     it, it's really the tile's job to
                                                                     handle retrieving those units.
```

Q: Doesn't using an array of arrays limit you to a square

Dumb Questions

there are no

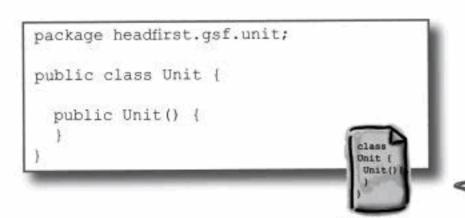
A: No, although it does limit you to a board that uses (x, y) coordinates. For example, you can use (x, y) coordinates in a board made up of hexagon-shaped tiles, if you structure the hexagon tiles correctly. But for the most part, an array of arrays is more ideally suited to a square-tiled, rectangular board.

Q: So isn't that limiting? Why not use a graph, or even a Coordinate class, so you're not tied to (x, y) coordinates and a rectangular board?

A: If you wanted maximum flexibility, that might be a good idea. For this situation, though, our requirements (back on page 340) actually specified (x, y) coordinates. So we chose a solution that wasn't quite as flexible, but certainly was simpler. Remember, at this stage, we're trying to reduce risk, not increase it by going with a solution that is a lot more complex than we really need.

The Tile and Unit classes

To actually make **Board** compile and work, we need to create a **Tile** and **Unit** class. Here's how we wrote those classes:



We made Unit as <u>absolutely simple</u> as possible. There are lots of details to be added later, but we don't need those details to make Board work right now.

Tile is in the same package as the Board class... they're tightly related.

Tile has a list of the units on it at any given time. -

Unit.java

These are the methods
that Board uses to
manipulate units. They're
protected, so only classes
in headfirst gsf. board can
access them.

```
package headfirst.gsf.board;
import java.util.LinkedList;
import java.util.List;
import headfirst.gsf.unit.Unit;

public class Tile {
    private List units;

    public Tile() {
        units = new LinkedList();
    }

    protected void addUnit(Unit unit) {
        units.add(unit);
    }

    protected void removeUnit(Unit unit) {
        units.remove(unit);
    }
}
```

Keep the right focus

You don't need to worry about everything that **Tile** and **Unit** will eventually need to do. Your focus is on making **Board** and its key features work, not on completing **Tile** or **Unit**. That's why we left **Unit** so bare, and added only a few methods to **Tile**.

Tile.java

Focus on one feature at a time to reduce risk in

your project.

Don't get distracted with features that won't help reduce risk.

Dumb Questions

If the Tile class handles adding and removing units, and you can get the tile at a coordinate from the Board using getTile(), why add those addUnit() and removeUnit() methods to Board. Couldn't you just call getTile(), and then use the Tile to do those things?

A: You could take that approach, and let all the Unit-related operations be handled directly through the Tile object returned from getTile(). We decided to add the Unit-related methods to Board, and have Board be the entry point for game designers. In fact, you'll see on the next page that we made Tile's methods protected, so that only classes in the same package as Tile—like Board—could call addUnit() and removeUnit() directly. So we've really ensured that Board is the object used to work with tiles, units, and eventually terrain.

Q: I still think it would be easy to go ahead and add some more of the methods we know we'll need to Unit and Tile. Why not spend a little time on those classes now?

A: You're not trying to code the entire game system framework at this point; you're just trying to tackle a few key features, and reduce the major risks to your project. Spending time writing the Unit class, or fleshing out the Tile class, really isn't going to help you reduce risk. Instead, do just enough to get the Board class working, because it's the Board class that we decided was part of the essence of the system, and where we had a risk of failing if we didn't get that piece in place.

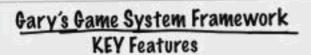
Once you've handled your key features, and reduced or eliminated the big risks to your project, then you'll have plenty of time to work on other features, like the Unit class. At this stage, though, you're trying to avoid spending time on anything that doesn't help you reduce the risks to your project succeeding.



You can download these Board-related classes for Gary's framework at http://www.headfirstlabs.com. Just look for Head First OOA&D, and find "Gary's Game System - Board classes."

More order, less chaos

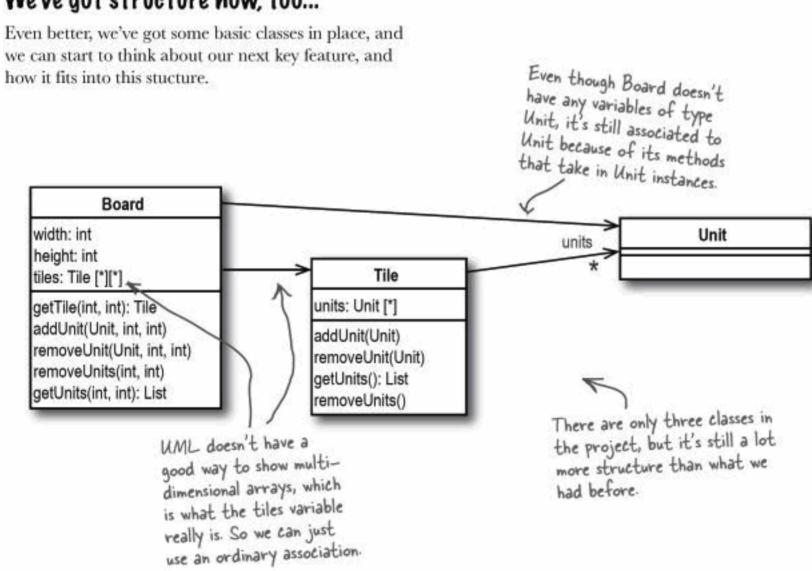
Our architecture and key feature list has helped us get the basic **Board** in place, and make sure we're capturing the essence of the system for the customer. Let's look back at our key feature list:



- 1. The board for the game—essence of the system
- 2. Game-specific units—essence, and what does this mean?
- 3. Coordinating movement—what is it, and how do we do it?

We've got the basic Board written, so we've handled this key feature enough to move on to another.

We've got structure now, too...



Which feature should we work on next?

We've got a Unit class now, so why don't we tackle "game-specific units" next?

Besides, we can also look at how Board and

Unit interact.

Build on what you've already got done whenever possible.

When you've got nothing but requirements and diagrams, you've just got to pick a place to start. But now that we do have some code and classes, it's easiest to pick another key feature that relates to what we've already built. And remember our definition for architecture?

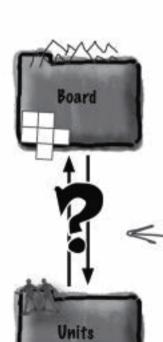
Architecture is your design structure, and highlights the most important

relationships

parts of your app, and the

between those parts.

You really can't talk about the relationships between parts if you don't have two parts that have a relationship. We know **Board** and **Unit** are related, and that "gamespecific units" are a key feature, so that's the obvious thing to work on next.



With some basic classes written, we can look at how classes interact, as well as begin to build on what we've already done.



Game-specific units... what does that mean?

The simplest way to understand a bit more about what "game-specific units" means is to talk to some of Gary's customers, the game designers who will be using his framework. Let's listen in on what they have to say:

Strategy is the key for our games. We use an advanced combat system where each unit has an attack strength, defense strength, and experience modifier.



I build sci-fi games, big huge space and planet battles. So I need to be able to have armies with lasers and create lots of spaceships.



Our customers are all about air battles, so we don't even need troops. I just want to be able to create a bunch of different types of planes, with different speeds, weapons, and that kind of thing.

No good war game is good without weapons... lots of different types of weapons. And our units can hold two each, so it gets really fun fast.

Our games are realistic and long-term... we even keep up with the ages and relationships between characters in our games.



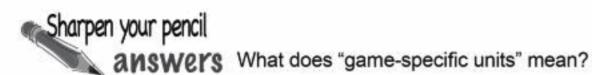
Sharpen your pencil

What does "game-specific units" mean?

Now that you've heard from several of the game designers who want to use Gary's game system framework, you should have a good idea of what our second key feature is all about. Write down in the blanks below your idea of what you need to do to support "game-specific units."

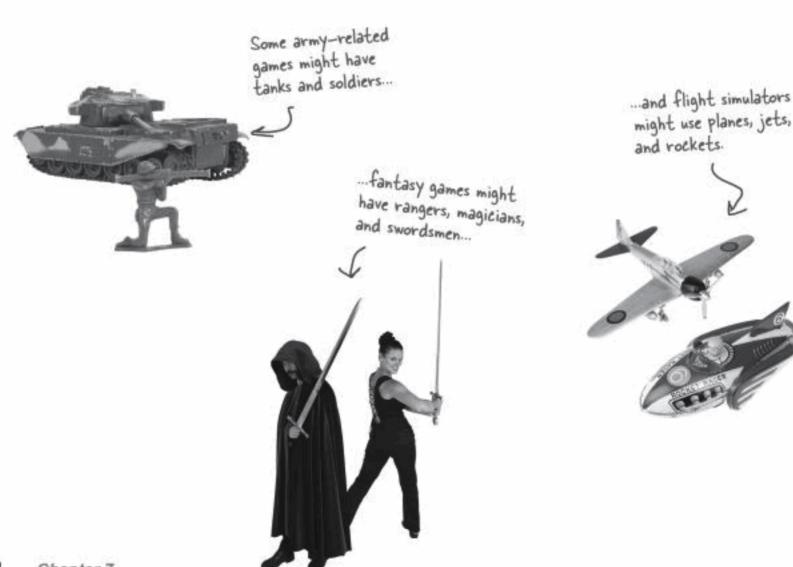
When you're done, compare your answers with ours on the next page.





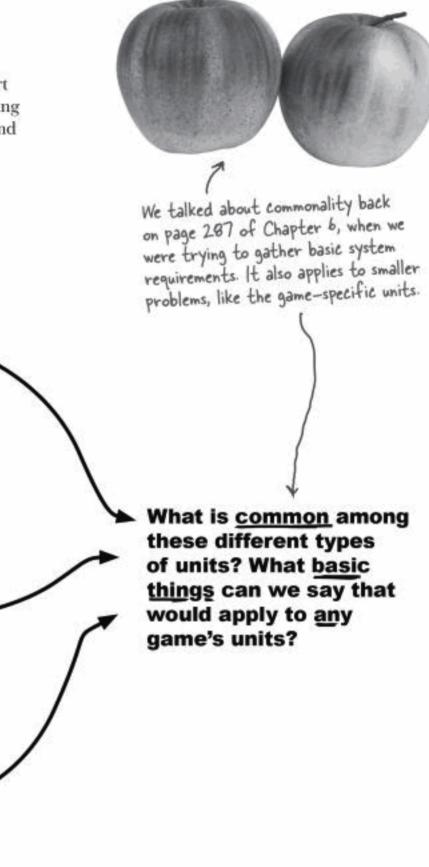
Now that you've heard from several of the game designers who want to use Gary's game system framework, you should have a good idea of what our second key feature is all about. Write down in the blanks below your idea of what you need to do to support "game-specific units."

Each game based on the framework has different types of units, with different attributes and capabilities. So we need to be able to have properties for a unit that are different for each game, and support multiple data types for those properties.



Commonality revisited

We're starting to learn more about what "game-specific units" means, but we still need to figure out how to actually add support for this feature to our game system framework. Let's start by taking a look at the different types of units the customers mentioned, and figure out what's common between them.

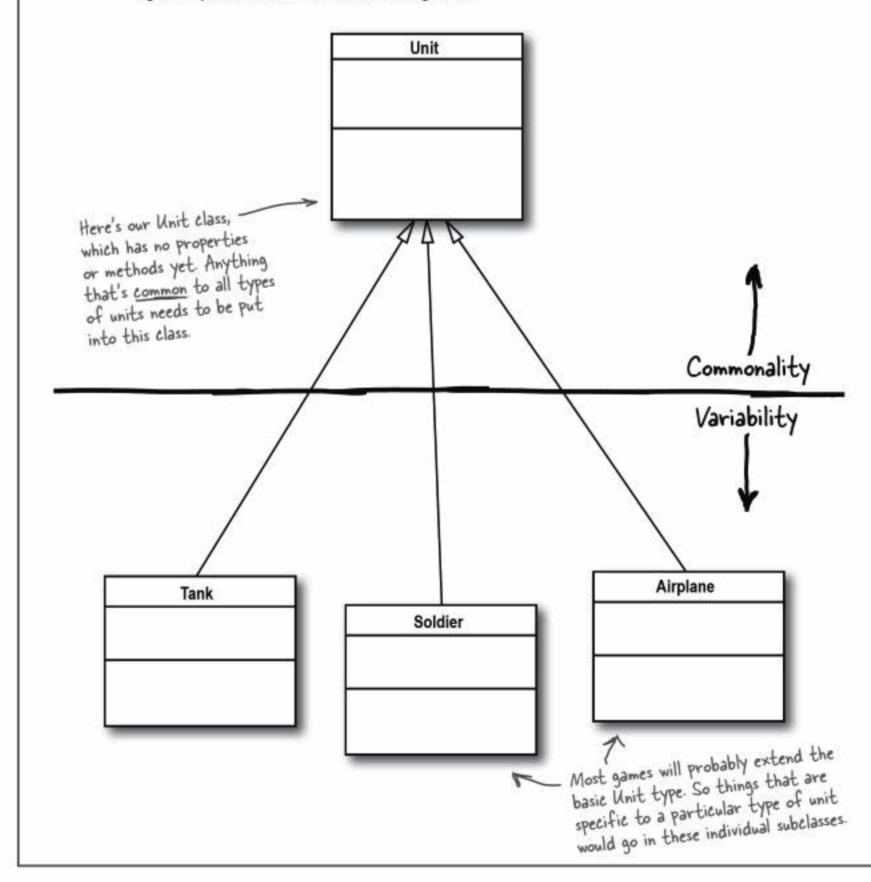


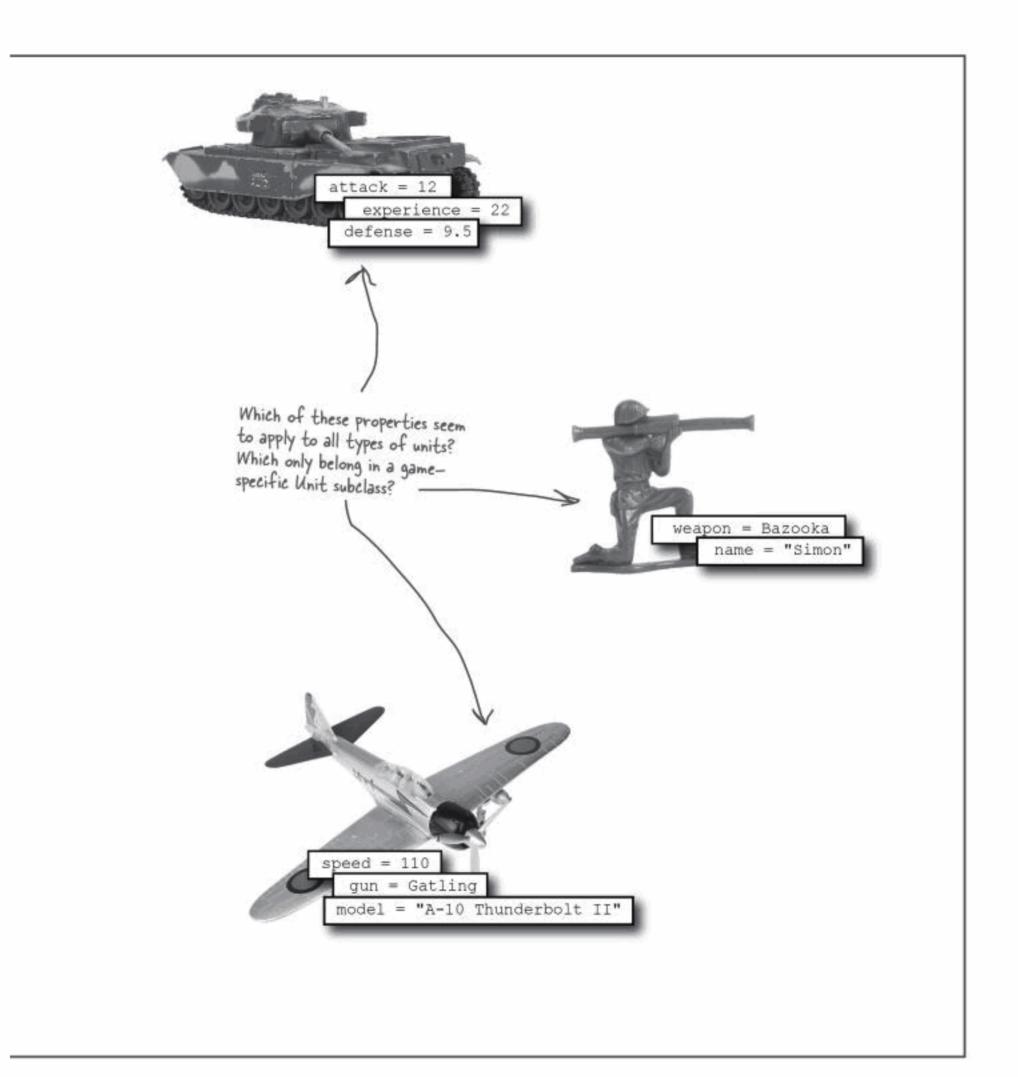
model = "A-10 Thunderbolt II"



Design Puzzle

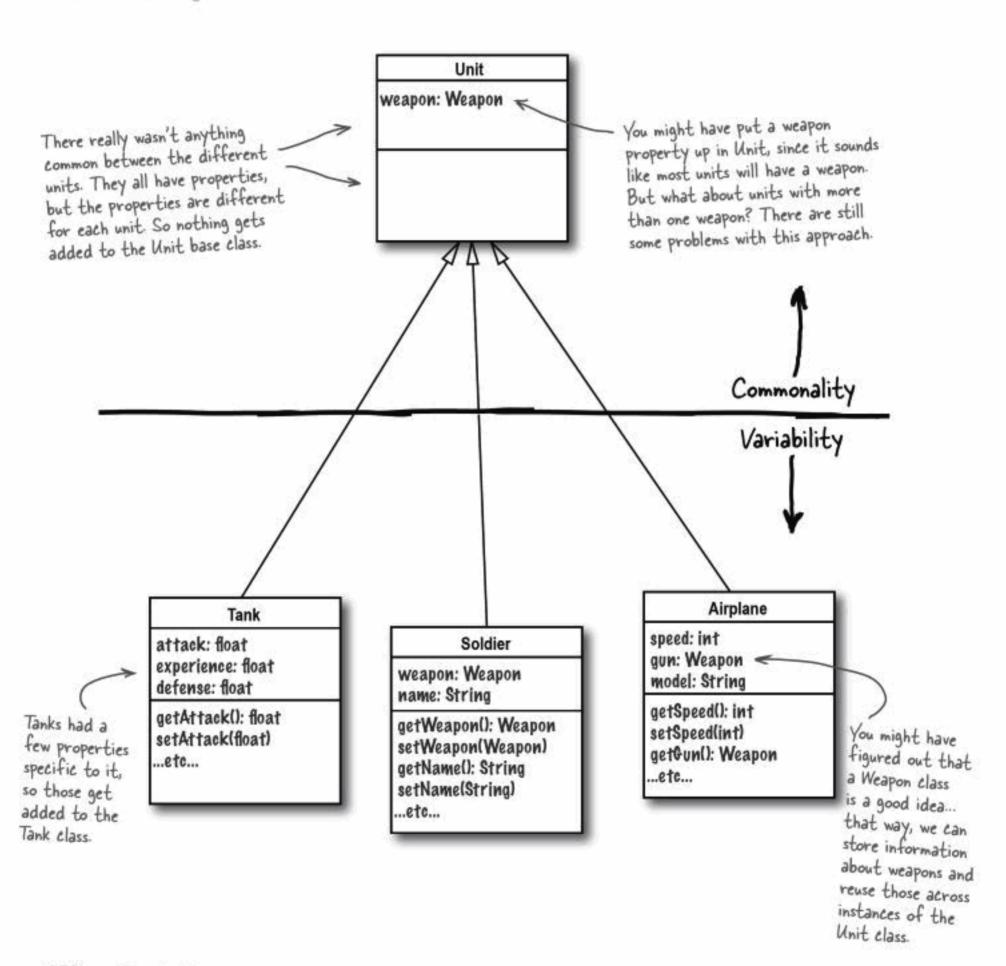
It's your job to figure out what's common, and should be a part of the basic Unit class, and what varies, and belongs in the game-specific subclasses of Unit. Write any properties and methods that you think belong in Unit in the class diagram for that class below, and then add properties and methods that you think belong in the game-specific subclasses to those diagrams.

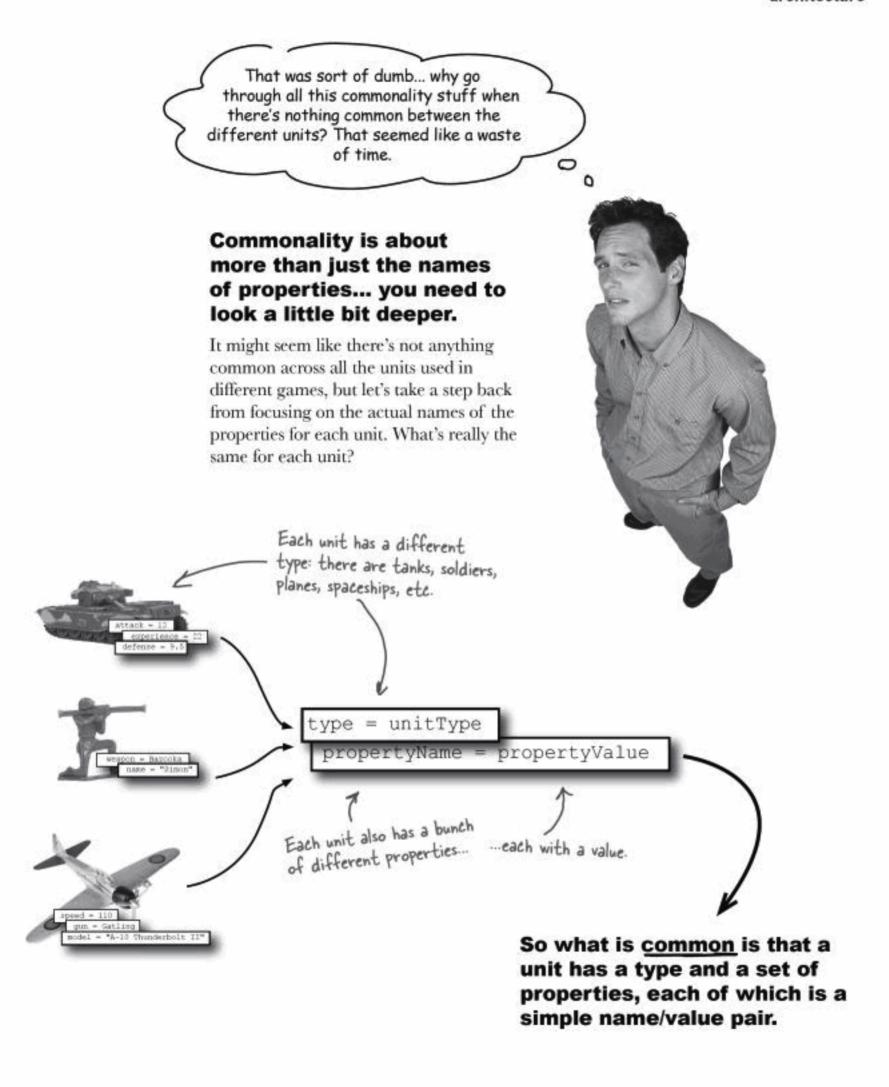




Solution #1: It's all different!

At first glance, you might have come up with a solution that looks something like this:





Solution #2: It's all the same!

This is really similar to how we At first glance, you might have come up with a solution that stored instrument properties looks something like this: back in Chapter 5. Unit Weapons (even multiple weapons per type: String unit), strength, speed, experience, properties: Map age, and anything else a game This time, we've made Unit a setType(String) designer might need can all be lot more generic. It supports getType(): String stored in the properties Map. a unit type, and a Map of setProperty(String, Object) getProperty(String): Object name/value properties. Commonality Variability Airplane Tank speed int attack float Soldier gun: Wapon experience, float weapon: Weapon model: String defense: float name: String getSpeekl: nut getAttack(): float getWeapon(): Weapon setSpeed(int) set A tack(float) setWeapon(Weapon) gordun(): Weapon getNamel): Strik .etc... etName(String) There's no longer a need for lots of Unit subclasses ... we can simply use the Unit class with a different type and proeprty set.

OK, this is ludicrous. First,
nothing was the same, and now everything
is the same? How in the world is this
helping me reduce risk or write better
software?

Commonality analysis: the path to <u>flexible</u> software

Wondering why we spent all that time on commonality analysis? Look back at the first solution on page 358, and then again at the second solution, on the left, and then fill out the table below to see what commonality has really bought us in terms of our design:



0

This first row is what we've looked at so far: 3 different unit types.

like a lot, but in massive war games, it's not so far-fetched

Number of unit types	Number of unit classes - Solution #1	Number of unit classes - Solution #2
3		
5		es.
10		.a.
25		
50		0.
100		5°

Vhich	solution do you think is better?	ution do you think is better?	
Why?			
6			
0			

Number of unit types	Number of unit classes - Solution #1	Number of unit classes - Solution #2
3	4	1
5	Ь	1
10	11	1.
25	26	1
50	51	1
100	<i>></i> 101	l i

With Solution #2, the single Unit class supported all types of units, with any number of different types of properties and attributes.

With Solution #1, you always had a Unit base class, and a subclass for each unit type.

Unit
pe: String roperties: Map
etType(String) etType(): String etProperty(String, Object) etProperty(String): Object

common, and put it in the Unit base class. The result was that game designers now only have to keep up with ONE unit class, instead of 25, 50, or 100!

We identified what was

With a single welldesigned Unit class, we can support any number of different unit types.

Good design will <u>always</u> reduce risk.

Dumb Questions

Q: I can see how this would help me with my design, but what does any of this have to do with reducing risk?

A: Good design always reduces risk. By figuring out how best to design the Unit class, we can get it right the first time... before we're deep into working on the entire game system framework, and might have to make drastic changes to Unit that affect lots of other code.

Not only have we figured out what "game-specific units" means, but we've defined the basic Unit class, and now other classes like Board can relate to it without worrying about its design drastically changing in the middle or near the end of the project's development cycle.

And still more order...

We've figured out another key feature, reduced risk to our project even further, and only have one feature left to worry about. —

Gary's Game System Framework KEY Features

1. The board for the game—essence of the system
2. Game-specific units—essence, and what does this mean?

3. Coordinating movement—what is it, and how do we do it?

Wait a second... we haven't written any code for the Unit class. Don't we need to do that before we go on to that last feature?

We're focusing on doing just the things that reduce risk.

Remember, the point of architecture is to **reduce risk**, and to **create order**. There are plenty of other things to work on in your application, but those are for after you've got a handle on how your application will be structured, and have the major risks reduced to the point where they are manageable.

We were trying to get a handle on the Unit class, and what "game-specific units" meant; at this point, we've done that:



This class diagram is all you need at this point. It gives you the structure of the Unit class, and answers the question, "What does 'game-specific units' mean?"

Unit

type: String properties: Map

setType(String) getType(): String

setProperty(String, Object) getProperty(String): Object

Q: When we worked on the Board, we did code the Board class, but now you say we shouldn't code the Unit class. What gives?

A: The question you need to be always asking at this stage of a project is, "Will this reduce the risk to my project succeeding?" If the answer is yes, you should go ahead; if it's no, you probably can leave the task for a later stage of the project.

In the case of the **Board**, we needed to have a basic understanding of what the game board does, so we went ahead and coded a basic implementation. But for **Unit**, a class diagram and understanding its basic functionality was all we really needed to do. In both cases, we were reducing risk to our project, rather than focusing on coding or not coding a certain class or package.

But couldn't we have just done a class diagram for Board, like we did for Unit, and stopped there?

A: You probably could have just done a class diagram. It's really a judgment call, and as long as you feel you're focusing on reducing the risk in your project, it's OK to stop with a class diagram, or take things a level or two deeper.

Dumb Questions

Q: Is it really good to ask the customer and users of a system about what it should do? Couldn't they lead us astray, or distract us?

A: It's usually a good idea to ask the customer, because it is their system that you're building. And really, the customer is only going to confuse you, or get you working on the wrong thing, if you're unsure of what you're supposed to be working on. As long as you go into a conversation clear on what your goals are, and you're listening for something specific, you should be able to filter out anything that might confuse or distract you.

O: I'm still not sure I would have ever come up with using a Map for storing properties in the Unit class on my own.

A: That's OK; that's what tools like commonality and the three Qs of architecture are for. They help you get to solutions that you might not think of on your own, in a way that works on any type of project.

In the case of the Unit class, the point isn't that we used a Map to store properties. It's that we figured out that all units are basically just a unit type and a set of name/value pairs. Once we figured that out, the details about how we stored those name/value pairs were a piece of cake.

Q: So there's really not a lot of code involved in OOA&D, is there?

A: OOA&D is all about code—it's about writing great software, every time. But the way you get to good code isn't always by sitting down and writing it right away. Sometimes the best way to write great code is to hold off on writing code as long as you can. Plan, organize, architect, understand requirements, reduce risks... all these make the job of actually writing your code very simple.

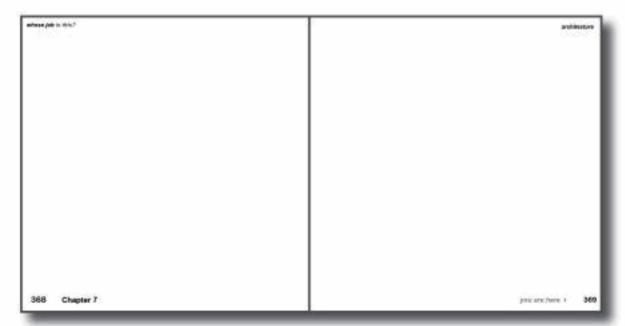
Sometimes the best way to write great code is to hold off on writing code as long as you can.



BE the Author

All that's left is to handle coordinating game movement. But what would you do next to figure that out? Your job is to outline the next few pages of Head First OOA&D, and figure out how you'd take care of this last key feature.





*Hint: check out what we did for the last key feature that we weren't clear on how to get started.

What does it mean? Ask the customer.

When you're not sure what a feature really means, one of the best things you can do is ask the customer. We did this with the game-specific units, so let's try the same thing for figuring out what coordinating movement means. Want to see the answers to the BE the Author exercise? Read the next four pages and see how close your pages are to what we did.

Each unit has a movement property
that says how many squares it can move,
and the game checks the terrain to see if
the move is legal.

This looks pretty straightforward... it's a fairly simply calculation.

We hate games that aren't realistic... like when airplanes can fly through buildings! Our games check all the surrounding tiles for other units, and then apply a wind factor to the plane's speed property.



This is quite a bit more complicated... and totally different from the other game designer's requirements.

They're eracking up at yet another air game that lets you fly places you shouldn't be able to.

Do you know what "coordinating movement" means?

Listening to the customers should have given you a pretty good idea of what the third key feature of Gary's game system framework is all about. Write what you think that feature really means in the blanks below:

Now	do	S 0	me		
COMM	NON	ıal	itv	ana	vsis

Next you need to try and figure out what's common about the different movement scenarios that the customers on page 366 have been talking about. Are there some basic things that apply to all the different types of movement? If you think that there are, write those common things in the blanks below:

So now what would you do?

If you have an understanding of what "coordinating movement" means, and you know what things are common across all games, you should have an idea about what you need to do to the game framework to make this feature work. Write your ideas down in this final set of blanks: You can use these three basic steps anytime you're unsure about what a feature means, and how you need to implement that feature in your system.

1. Ask the customer

What does the feature mean?

2. Commonality analysis

How do I realize that feature in my system?

3. Implementation plan

Is there anything common here?

Here's what we thought we needed to do based on what Gary's customers were saying about movement:

Units should be able to move from one tile on the board to another. Movement is based on a calculation or algorithm specific to each game, and sometimes involves the game-specific properties of a unit.

So what exactly is common among all the different possible movement scenarios? Remember what the customers said?

We hate games that aren't realistic... like when airplanes can fly through buildings! Our games check all the surrounding tiles for other units, and then apply a wind factor to the plane's speed property.

In this situation, there's an algorithm to see if a move is legal, and another algorithm to figure out how far a unit can go, based partly on that unit's properties.

Each unit has a movement property that says how many squares it can move, and the game checks the terrain to see if the move is legal.

0

In this case, there's a check to see if a move is legal, and another check of a unit's movement property.

	What's common?	What's variable?
	There's a check prior to a move to see if the move is legal.	The algorithm to check a move's legality is different for every game.
-	A unit's properties are used to see how far the unit can move.	The number and specific properties See a recurring theme here?
<-	Factors other than the unit affect movement.	The factors that affect movement are different for every game.

This is where things like wind speed come into play.

It's "different for every game"

Did you see what kept showing up in our chart? Every time we found some commonality, the variability column had the same words: "different for every game."

When you find more things that are different about a feature than things that are the same, there may not be a good, generic solution.

In the case of Gary's system, if there's no generic solution, it really doesn't belong as part of the game framework.

Gary, we've thought it through, and we think we should let the game designers handle movement on their own. Anything we do in the framework would just make things a pain for them.

OK, it seems like you've thought things through, so I'm OK with that. Game designers love having more control, anyway.



Dumb Questions

Q: How is this really that different from game-specific units?

A: With units, we did find some commonality: every unit had a type, and then name/value properties. With movement, every single game looked like it would handle things differently. So it made sense to leave movement to the game designers, rather than come up with a solution that was so generic that it was essentially useless.

Q: But there is some commonality, isn't there? A movement algorithm, and a check to see if a move is legal, right?

A: You're right. So, in theory, you could write a Movement interface, with a method like move () that took in a MovementAlgorithm and a LegalMoveCheck, or something similar. And then each game designer could extend MovementAlgorithm and LegalMoveCheck. If you thought of something like this, nice work! You're really ahead of the game.

But then ask yourself: what does this really gain? Game designers are going to have to learn your interfaces, and if they don't have a legality check, they might pass in null for the LegalMoveCheck parameter, and what would the interface for MovementAlgorithm look like, and... well, you're probably adding complexity, rather than really removing it.

Your job is to reduce risk and complexity, not increase it. We decided that it would be simpler to let game designers handle movement, and just change the position of units on the board (using methods on Board, which we did take care of for them). Great. So we've got a little sheet of paper with some checkmarks, a few classes that we know aren't finished, and lots of UML diagrams. And I'm supposed to believe this is how you write great software?

Customers don't pay you for great code, they pay you for great software.

Absolutely! Remember, great <u>software</u> is more than just great code.

Great code is well-designed, and generally functions like it's supposed to. But great software not only is welldesigned, it comes in on time and does what the customer really wants it to do.

That's what architecture is about: reducing the risks of you delivering your software late, or having it not work like the customer wants it to. Our key feature list, class diagrams, and those partially done classes all help make sure we're not just developing great code, but that we're developing great software.



Reducing risk helps you write great software

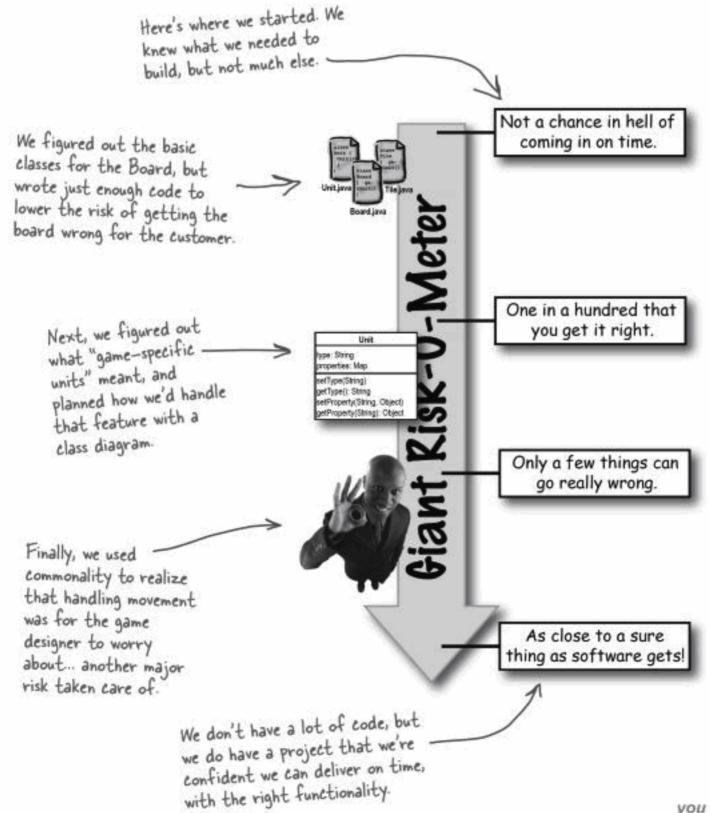
With all three key features figured out, we've got a handle on the major risks to our project succeeding. Look at how each step we've taken in this chapter has reduced the risks to our project:

Gary's Game System Framework KEY Features

1. The board for the game—essence of the system

2. Game-specific units—essence, and what does this mean?

Coordinating movement—what is it, and how do we do it?



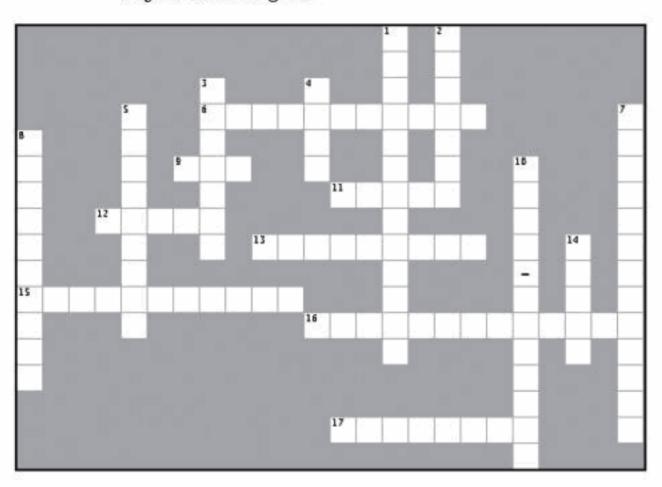


- Architecture helps you turn all your diagrams, plans, and feature lists into a well-ordered application.
- The features in your system that are most important to the project are architecturally significant.
- Focus on features that are the essence of your system, that you're unsure about the meaning of, or unclear about how to implement first.
- Everything you do in the architectural stages of a project should reduce the risks of your project failing.
- If you don't need all the detail of a use case, writing a scenario detailing how your software could be used can help you gather requirements quickly.
- When you're not sure what a feature is, you should ask the customer, and then try and generalize the answers you get into a good understanding of the feature.
- Use commmonality analysis to build software solutions that are flexible.
- Customers are a lot more interested in software that does what they want, and comes in on time, than they are in code that you think is really cool.



OOA&D Cross

The march of the crossword continues. Have you gotten every answer so far? Here's another set of clues to help you store all this architectural info in your brain for good.



Across

- Focus on the things in your system that are architecturally ______ first.
- These are the features that you should focus on first.
- 11. Use cases add risk when used at this time.
- The essence of a system is what the system is at its most ______.
- 13. Focusing on more than one feature at a time does this to the risk in your project.
- Use this type of analysis when you're not sure how to implement a confusing set of features.
- Architecture highlights these parts of your application. (2 words)
- Commonality analysis is one path to this type of software.

Down

- 1. Always start a project by focusing on this.
- The second Q of architecture is about the _____ of a feature.
- 3. The first Q of architecture is about this.
- You focus on key features to reduce this in your project.
- These are a way to get basic requirements without the detail of a use case.
- 7. This is not the same as great code.
- You usually trade off flexibility for this in your project's design.
- You use architecture to turn a mess into this kind of application.
- 14. You write this type of software the same way, whether it's a big system or a small one.

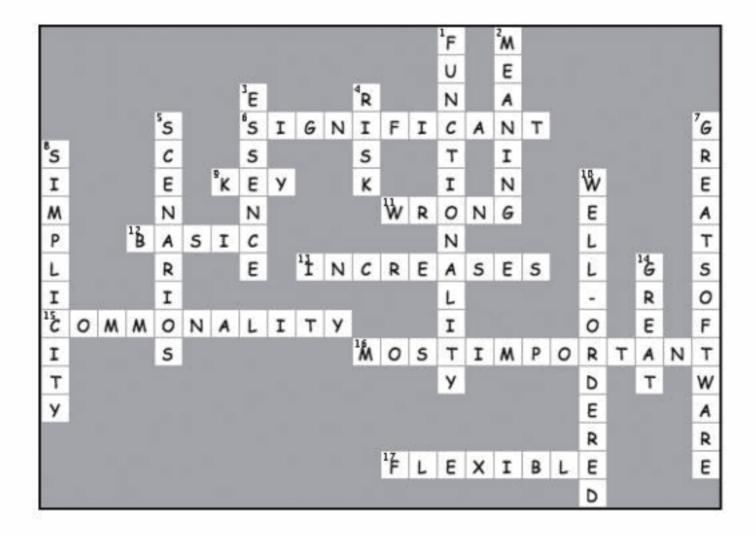
Sharpen your pencil

answers What's missing in Board.java?

Look closely at the scenario on the last page. Did the requirements we used on page 340 cover everything in the completed scenario? If you think something is missing, write it in the blank below, and then add code to Board.java to handle the missing functionality.

The scenario talks about removing units, but there is no requirement to remove units on page 340.

We added a removeUnit() and removeUnits() method to Board java to handle this requirement.



Originality is Overrated

Baby, somebody better call heaven, 'cause they're missing an angel tonight!

I must have heard that line a thousand times, but it works on me every time!



Imitation is the sincerest form of not being stupid.

There's nothing as satisfying as coming up with a completely new and original solution to a problem that's been troubling you for days—until you find out someone else **solved the same problem**, long before you did, and did an even better job than you did! In this chapter, we're going to look at some **design principles** that people have come up with over the years, and how they can make you a better programmer. Lay aside your thoughts of "doing it your way"; this chapter is about **doing it the smarter**, **faster way**.

Design principle roundup

So far, we've really been concentrating on all the things that you do before you start coding your application. Gathering requirements, analysis, writing out feature lists, and drawing use case diagrams. Of course, at some point you actually are going to have to write some code. And that's where design principles really come into play.



A design principle is a basic tool or technique that can be applied to designing or writing code to make that code more maintainable, flexible, or extensible.

You've already seen a few design principle in earlier chapters:

00 Principles

Encapsulate what varies.

Code to an interface rather than to an implementation.

Each class in your application should have only one reason to change.

Classes are about behavior and functionality.

In this chapter, we're going to look at several more key design principles, and how each one can improve the design and implementation of your code. We'll even see that sometimes you'll have to choose between two design principles... but we're getting ahead of ourselves. Let's begin by looking at the first of our design principles. Using proven 00 design principles results in more maintainable, flexible, and extensible software.

Principle #1: The Open-Closed Principle (OCP)

Our first design principle is the OCP, or the Open-Closed principle. The OCP is all about **allowing change**, but doing it **without requiring you to modify existing code**. Here's how we usually define the OCP:



Open-Closed Principle

Classes should be open for extension, and closed for modification.



Suppose you have a class with a particular behavior, and you've got that behavior coded up just the way you want it. Make sure that nobody can change your class's code, and you've made that particular piece of behavior **closed for modification**. In other words, nobody can change the behavior, because you've locked it up in a class that you're sure won't change.

...but open for extension

But then suppose someone else comes along, and they just have to change that behavior. You really don't want them messing with your perfect code, which works well in almost every situation... but you also want to make it possible for them to use your code, and extend it. So you let them subclass your class, and then they can override your method to work like they want it to. So even though they didn't mess with your working code, you still left your class **open for extension**.



You close classes by not allowing anyone to touch your working code.

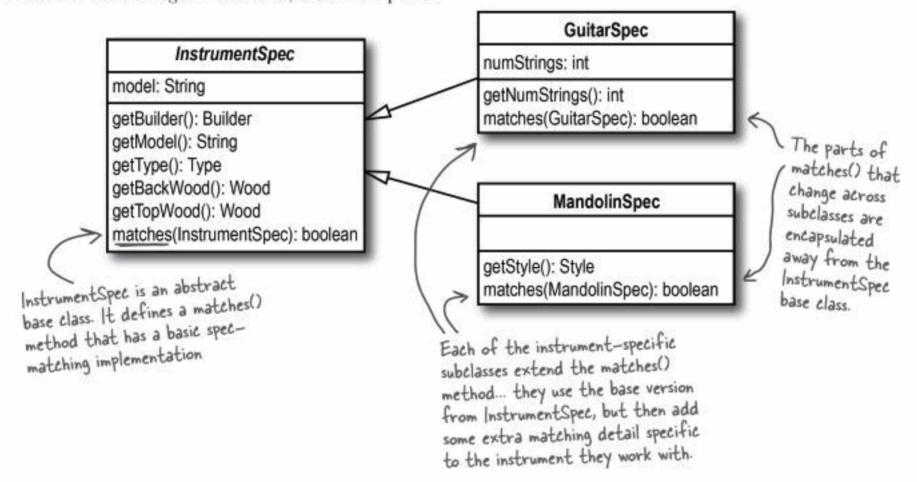




You open classes by allowing them to be subclassed and extended.

Remember working on Rick's Stringed Instruments?

You probably didn't realize it, but we were using the Open-Closed Principle when we wrote those **InstrumentSpec** classes for Rick's Stringed Instruments, back in Chapter 5:

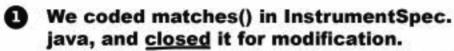


InstrumentSpec is closed for modification; the matches() method is defined in the base class and doesn't change.

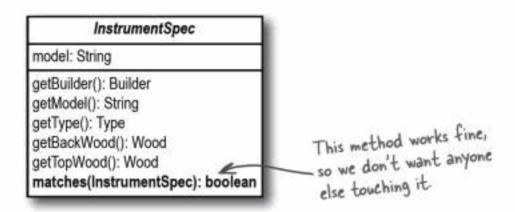
But it's <u>open</u> for <u>extension</u>, because all of the subclasses can <u>change</u> the behavior of matches().

The OCP, step-by-step

Let's take what we did back in Chapter 5, and look at in terms of the OCP, one step at a time.



This version of matches () works just fine, and we don't want anyone messing with it. In other words, once we're done coding InstrumentSpec and this version of matches (), they shouldn't change.

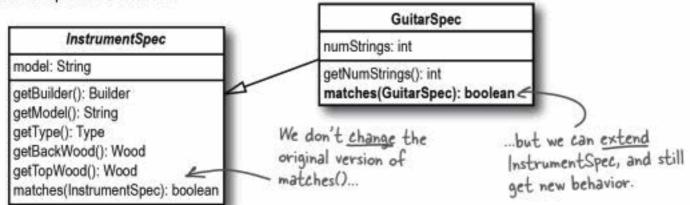


But we needed to <u>modify</u> matches() to work with instrument-specific spec classes.

Even though matches () works great for other InstrumentSpec objects, it doesn't quite do what it should for guitars and mandolins. So even though matches () is closed for modification, we need a way to extend and change it... otherwise, InstrumentSpec isn't very flexible, which is a big problem.

So we extended InstrumentSpec, and overrode matches() to change its behavior.

We don't want to change the code in InstrumentSpec, but we can extend it, with GuitarSpec and MandolinSpec, and then override matches () in each of those classes to add instrument-specific behavior.







Gee, inheritance is powerful. Really, this is supposed to be some sort of great design principle? Come on.



The OCP is about <u>flexbility</u>, and goes beyond just inheritance.

It's certainly true that inheritance is a simple example of the open-closed principle, but there's a lot more to it than just subclassing and overriding a method. Anytime you write working code, you want to do your best to make sure that code stays working... and that means not letting other people change that code.

But there are going to be times when that code still needs to be changed, maybe for just one or two particular situations. Rather than just diving into your code and making a bunch of changes, the OCP lets you **extend** your working code, without **changing** that code.

There are lots of different ways to accomplish this, and while inheritance is often the easiest to implement, it's certainly not the only option. In fact, we'll talk about another great way to achieve this later in the chapter, when we talk about composition.

Sharpen your pencil Find the OCP in your own project.

Think about the project you're currently working on. Can you find any places when you've used the OCP already? If so, write how you used the OCP in the blanks be		
Now think about a place in your project where you should be using the Open-Closed Principle, but you aren't yet. Write down in the blanks below what you think you need to do to put the OCP into place in your current project:		

Dumb Questions

Q: What's the big deal about modifying code in a base class, or a class that you've already written?

A: Once you have a class that works, and is being used, you really don't want to make changes to it unless you have to. But remember, CHANGE is the great constant in software development. With the OCP, we allow for change through extension, rather than having to go back and modify your existing code. Subclasses can add and extend the base class's behavior, without messing around with code that you already know is working and making the customer happy.

Q: Isn't the OCP just another form of encapsulation?

A: It's really a combination of encapsulation and abstraction. You're finding the behavior that stays the same, and abstracting that behavior away into a base class, and then locking that code up from modification. But then when you need new or different behavior, your subclasses handle the changes by extending the base class. That's where encapsulation comes in: you're encapsulating what varies (behavior in the subclasses) away from what stays the same (the common behavior in the base class).

Q: So the only way to use the OCP is by extending another class?

A: No, anytime your code is closed for modification but open for extension, you're using the OCP. So for example, if you had several private methods in a class, those are closed for modification—no other code can mess with them. But then you could add several public methods that invoked those private methods in different ways. You're extending the behavior of the private methods, without changing them. That's another example of the OCP in action.

Principle #2: The Don't Repeat Yourself Principle (DRY)

Next up is the Don't Repeat Yourself principle, or DRY for short. This is another principle that looks pretty simple, but turns out to be critical in writing code that's easy to maintain and reuse.

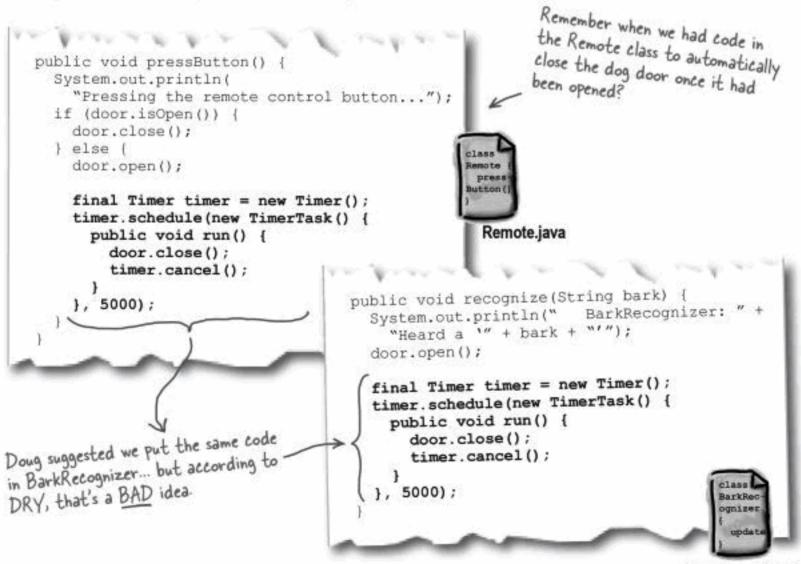


Don't Repeat Yourself

Avoid duplicate code by abstracting out things that are common and placing those things in a single location.

A prime place to apply DRY ...

You've seen the DRY principle in action, even if you didn't realize it. We used DRY back in Chapter 2, when Todd and Gina wanted us to close the dog door automatically after it had been opened.



BarkRecognizer.java

1. Let's abstract out the common code.

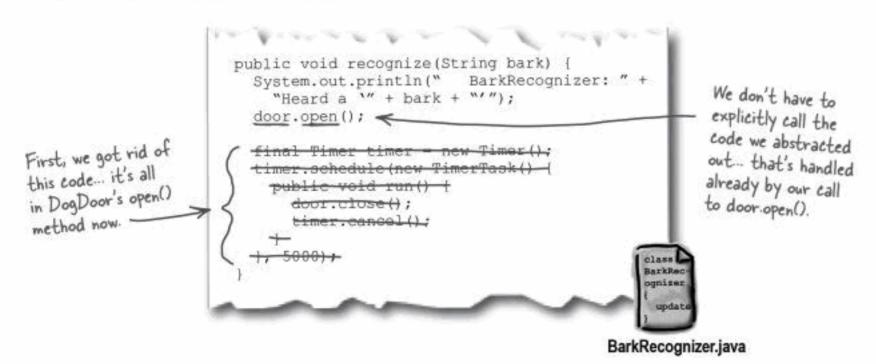
Using DRY, we first need to take the code that's common between **Remote** and **BarkRecognizer**, and put it in a single place. We figured out back in Chapter 2 the best place for it was in the **DogDoor** class:

```
public class DogDoor {
                      public void open() {
                        System.out.println("The dog door opens.");
                        open = true;
Using DRY, we pull
out all this code
                        final Timer timer = new Timer();
from Remote and
                        timer.schedule(new TimerTask() {
                          public void run() {
BarkRecognizer,
                             close();
and put it in ONE
                             timer.cancel();
place: the DogDoor
 class. So no more
                        }, 5000);
 duplicate code, no
 more maintenance
 nightmares.
                                                                  DogDoor.java
```

2. Now remove the code from other locations...

3. ...and reference the code from Step #1.

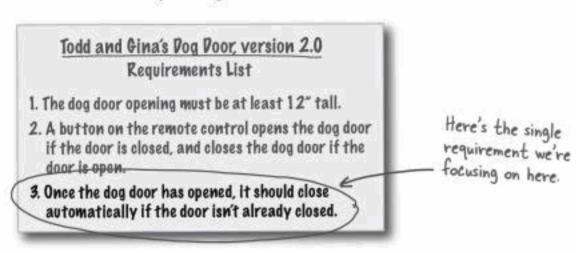
The next two steps happen at the same time. Remove all the code that you put in a single place in Step #1, and then reference the code you abstracted out explicitly if you need to:



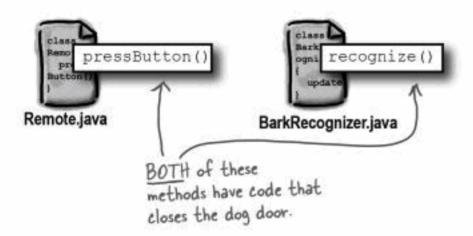
DRY is really about ONE requirement in ONE place

Abstracting out duplicate code is a good start to using DRY, but there's more to it than just that. When you're trying to avoid duplicate code, you're really trying to make sure that you only implement each feature and requirement in your application one single time.

In the dog door we just looked at, the feature we were trying to implement was automatically closing the door.



Originally, though, we implemented that single feature in two places: Remote.java and BarkRecognizer.java.



By using DRY, we removed the duplicate code. But more importantly, we moved the implementation of this requirement, automatically closing the door, into one place, instead of two places:



Dumb Questions

Q: So DRY isn't about duplicate code, and avoiding copy-and-paste?

A: DRY is about avoiding duplicate code, but it's also about doing it in a way that won't create more problems down the line. Rather than just tossing code that appears more than once into a single class, you need to make sure each piece of information and behavior in your system has a single, clear place where it exists. That way, your system always knows exactly where to go when it needs that information or behavior.

Q: If DRY is related to our features and requirements, then shouldn't we apply it to gathering those features and requirements as well as writing our code?

A: Absolutely, and that's a great idea! Whether you're writing requirements, developing use cases, or coding, you want to be sure that you don't duplicate things in your system. A requirement should be implemented one time, use cases shouldn't have overlap, and your code shouldn't repeat itself. DRY is about a lot more than just code.

Q: And this is all to avoid maintenance problems later, right?

A: Right. But it's more than just avoiding a need to update code in more than one place. Remember, DRY is about having a *single source* for a particular piece of information or behavior. But that single source has to make sense! You wouldn't want the bark recognizer to be the single source for closing the dog door, would you? Do you think the dog door should be asking the recognizer to close itself?

So DRY is not just removing duplication, it's also about making good decisions about how to break up your system's functionality.



DRY is about having each piece of information and behavior in your system in a single, sensible place.



DRY is about a lot more than just finding duplicate code in your system. It also applies to your features and requirements. It's time to put DRY into action on your own now, and to do it in more than just code.

The problem:

Todd and Gina have come up with yet more features for their dog door. It's your job to make sure the feature list we've assembled doesn't have any duplication issues, and that each feature is handled once and only once in the system you're designing for them.

Your task:

- Read through the requirements and features list on the right. We've bolded the requirements and features that have been added since you last worked on the dog door.
- 2 Look through the new features and requirements, and see if you see any possible duplication in the new things you'd need to build.
- Solution Annotate the requirements and features list indicating what you think has been duplicated.
- Rewrite the duplicate requirements at the bottom of the list so that there is no more duplication.
- Write a new definition for the DRY principle in the space below, and make sure you talk about more than just duplicate code.

Direction for DRY that includes what you've learned over the last few pages.

Don't Repeat Yourself

These are the requirements you've already seen...

...and these are the new features and requirements.

Todd and Gina's Pog Poor, version 3.0 Requirements and Features List

- 1. The dog door opening must be at least 12" tall.
- A button on the remote control opens the dog door if the door is closed, and closes the dog door if the door is open.
- 3. Once the dog door has opened, it should close automatically if the door isn't already closed.
- 4. A bark recognizer must be able to tell when a dog is barking.
- 5. The bark recognizer must open the dog door when it hears barking.
- 6. The dog door should alert the owner when something inside the house gets too close for the door to open without knocking it over.
- 7. The dog door will open during certain hours of the day.
- 8. The dog door can be integrated into the house's overall alarm system to ensure the alarm doesn't go off when the dog door opens and closes.
- The dog door should make a noise if the door cannot open because of a blockage outside.
- 10. The dog door will track how many times the dog enters and leaves the inside of the house.
- When the dog door closes, the household alarm system re-arms if it was active before the door opened.

Write any new or updated requirements, without duplication, here at the bottom of the list



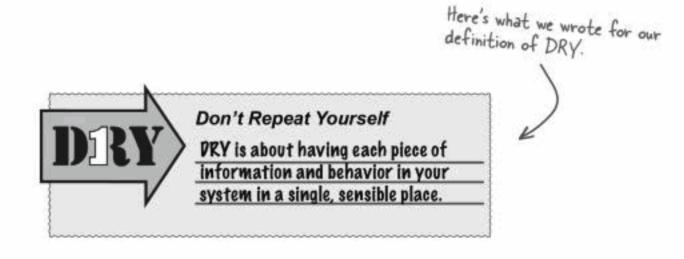
DRY is about a lot more than just finding duplicate code in your system. It also applies to your features and requirements. Your job was to put DRY into action on your own, in the context of requirements rather than just code.

The problem:

Todd and Gina have come up with yet more features for their dog door. It's your job to make sure the feature list we've assembled doesn't have any duplication issues, and that each feature is handled once and only once in the system you're designing for them.

Your task:

- Read through the requirements and features list on the right. We've bolded the requirements and features that have been added since you last worked on the dog door.
- 2 Look through the new features and requirements, and see if you see any possible duplication in the new things you'd need to build.
- 3 Annotate the requirements and features list indicating what you think has been duplicated.
- Rewrite the duplicate requirements at the bottom of the list so that there is no more duplication.
- Write a new definition for the DRY principle in the space below, and make sure you talk about more than just duplicate code.



Todd and Gina's Pog Poor, version 3.0 Requirements and Features List

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- 9. The dog door should make a noise if the door cannot open because of a blockage outside.
- 10. The dog door will track how many times the dog enters and leaves the inside of the house.
- When the dog door closes, the household alarm
 system re-arms if it was active before the door opened.

The door alerts the owner if there is an obstacle inside or outside of the house that stops the door from operating.

When the door opens, the house alarm system will disarm, and when the door closes, the alarm system will re-arm (if the alarm system is turned on).

Here's what we did to the requirements list.

#8 and #11 both relate to the house alarm... they're really duplicates of the same basic functionality, too.

Here's our new requirement from #8 and #11.

#b and #9 are almost identical. One focuses on the inside, and the other on the outside, but the basic functinality is the same.

Requirements #7 and #10 were fine, and stayed the same.

there's how we combined and rewrote #6 and #9.

Principle #3: The Single Responsibility Principle (SRP)

The SRP is all about responsibility, and which objects in your system do what. You want each object that you design to have just one responsibility to focus on—and when something about that responsibility changes, you'll know exactly where to look to make those changes in your code.



Single Responsibility Principle

Every object in your system should have a single responsibility, and all the object's services should be focused on carrying out that single responsibility.

> Hey, we've talked about this before... this is the same as a class having only one reason to change, isn't it?

You've implemented the Single Responsibility Principle correctly when each of your objects has only one reason to change.



Dumb Questions

O: SRP sounded a lot like DRY to me. Aren't both about a class doing the one thing it's supposed to do?

A: They are related, and often appear together. DRY is about putting a piece of functionality in a single place, such as a class; SRP is about making sure that a class does only one thing, and that it does it well.

In good applications, one class does one thing, and does it well, and no other classes share that behavior.

Q: Isn't having each class do only one thing kind of limiting?

A: It's not, when you realize that the one thing a class does can be a pretty big thing. For example, the Board class in Gary's Games does a lot of different small tasks, but they're all related to a single big thing: handling the board in a game. It does that one thing, and that's all the Board class does, so it's a great example of using the SRP.

Q: And using SRP will help my classes stay smaller, since they're only doing one thing, right?

A: Actually, the SRP will often make your classes bigger. Since you're not spreading out functionality over a lot of classes—which is what many programers not familiar with the SRP will do—you're often putting more things into a class.

But using the SRP will usually result in less classes, and that generally makes your overall application a lot simpler to manage and maintain.

O: This sounds a lot like cohesion, are they the same thing?

A: Cohesion is actually just another name for the SRP. If you're writing highly cohesive software, then that means that you're correctly applying the SRP.



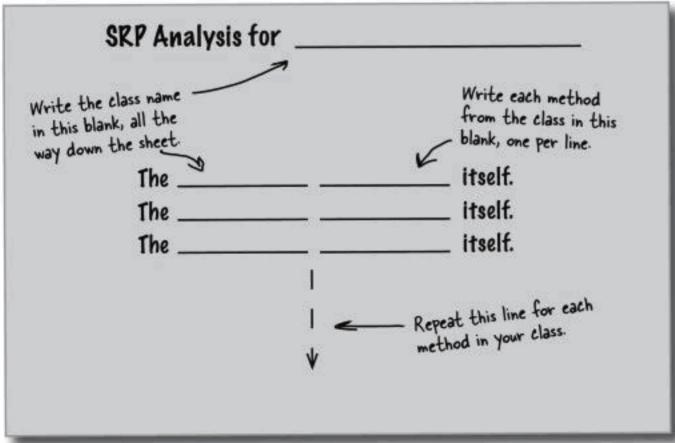
Spotting multiple responsibilities

Most of the time, you can spot classes that aren't using the SRP with a simple test:

- On a sheet of paper, write down a bunch of lines like this: The [blank] [blanks] itself. You should have a line like this for every method in the class you're testing for the SRP.
- In the first blank of each line, write down the class name; in the second blank, write down one of the methods in the class. Do this for each method in the class.
- Read each line out loud (you may have to add a letter or word to get it to read normally). Does what you just said make any sense? Does your class really have the responsibility that the method indicates it does?

If what you've just said doesn't make sense, then you're probably violating the SRP with that method. The method might belong on a different class... think about moving it.

Here's what your SRP analysis sheet should look like.



Sharpen your pencil

Apply the SRP to the Automobile class.



Do an SRP analysis on the Automobile class shown below. Fill out the sheet with the class name methods in Automobile, like we've described on the last page. Then, decide if you think it makes sense for the Automobile class to have each method, and check the right box.

53	Automobile	
We looked at this class in CATASTROPHE back in Chapter 5.	start() stop() changeTires(Tire [*]) drive() wash() checkOil() getOil(): int	

Yes, we realize you can peek back at Chapter 5 and cheat here, but we're trusting you not to. Try the exercise on your own first, and only look back at what we did in Chapter 5 if you get stuck.

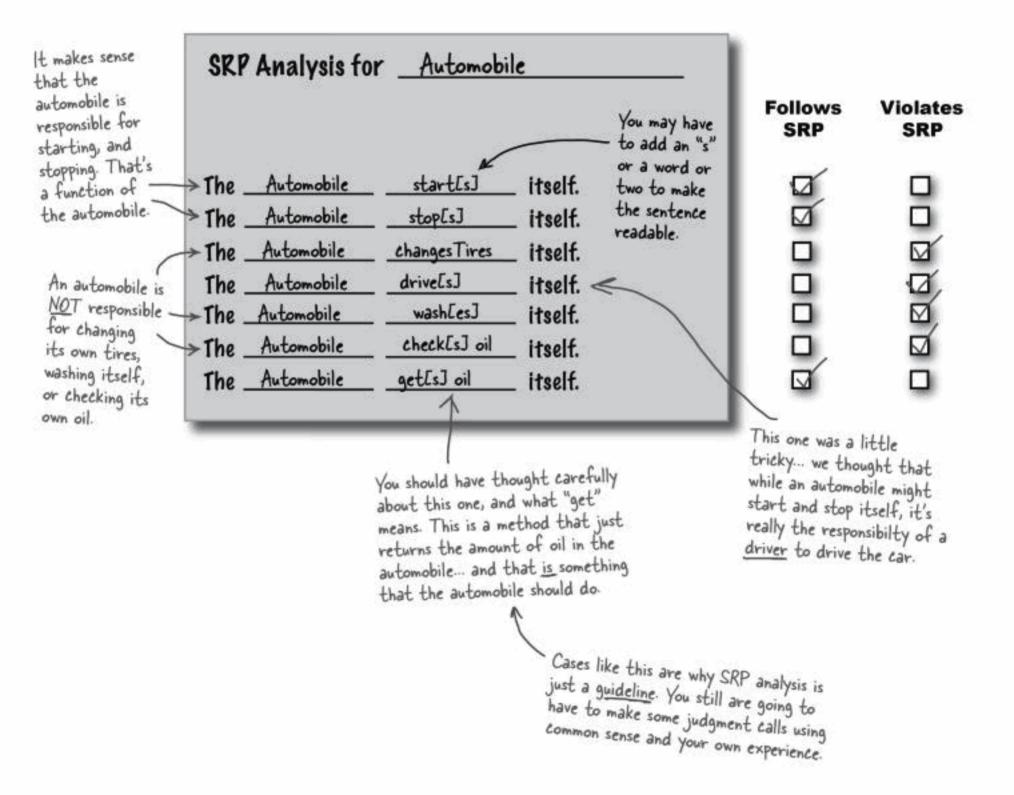
SRP Analysis for _	
The	itself.
The	itself.
	itself.
The	itself.

Follows SRP	Violates SRP
	000
ō	
If what you re make sense, the on that line is violating the Sh	en the method Probably



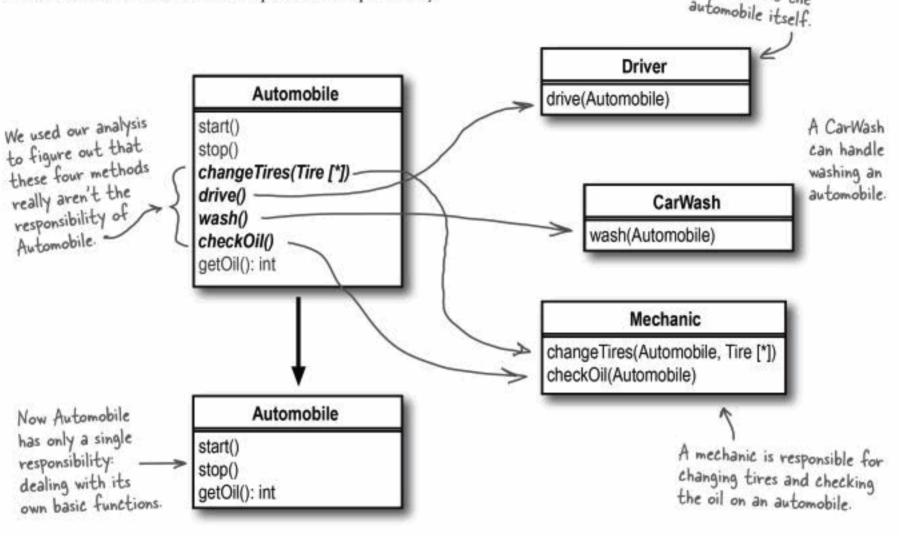
Apply the SRP to the Automobile class.

Your job was to do an SRP analysis on the Automobile class shown below. You should have filled out the sheet with the class name methods in Automobile, and decided if you think it makes sense for the Automobile class to have each method.



Going from multiple responsibilities to a single responsibility

Once you've done an analysis, you can take all the methods that don't make sense on a class, and move those methods to classes that do make sense for that particular responsibility.



there are no

Dumb Questions

D: How does SRP analysis work when a method takes

O: Bu

How does SRP analysis work when a method takes parameters, like wash(Automobile) on the CarWash class?

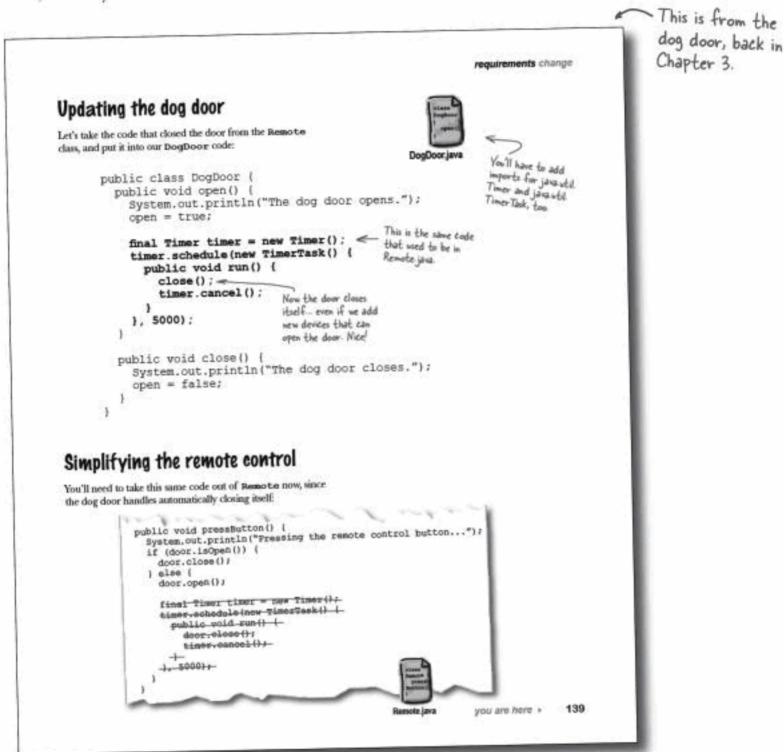
A: Good question! For your SRP analysis to make any sense, you need to include the parameter of the method in the method blank. So you would write "The <u>CarWash washes [an] automobile itself.</u>" That method makes sense (with the <u>Automobile</u> parameter), so it would stay on the <u>CarWash</u> class.

Q: But what if CarWash took in an Automobile parameter as part of its constructor, and the method was just wash()? Wouldn't SRP analysis give you a wrong result?

A: It would. If a parameter that might cause a method to make sense, like an Automobile for the wash () method on CarWash, is passed into a class's constructor, your SRP analysis might be misleading. But that's why you always need to apply a good amount of your own common sense and knowledge of the system in addition to what you learn from the SRP analysis.

<u>SRP-Sightings</u>

The SRP has already made a few appearances in our work so far; now that you're getting familiar with the SRP, it's time for you to figure out where and how it's been used. Your task is to look at the page below and figure out how SRP was used, and why.

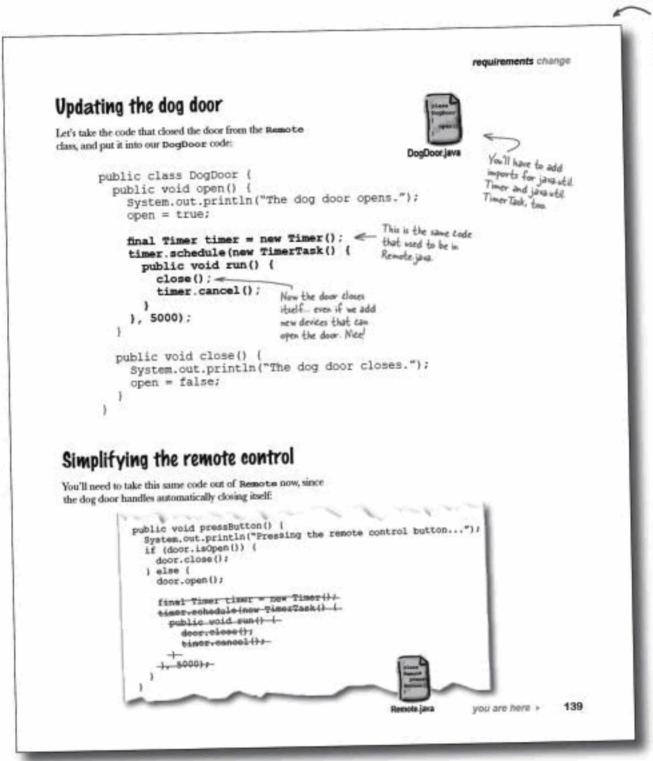




	How do you think the Single Responsibility Principle was used in Todd and Gina's dog door? Write your answer in the blanks below:
	Now see if you can find two more instances in the book's examples so far where we've used the SRP to make our design better and more flexible. You can find the SRP in the dog door, Rick's instrument inventory searcher, or Gary's game framework. Write down each instance you found, and how you think the SRP is being used.
	First Instance
	Example application: Rick's Instruments Doug's Dog Doors Gary's Games
Write in how	How SRP is being used: ———————————————————————————————————
you think ->	being used in.
the SRP was applied in this example.	There's the SRP!
Turz cum.	Second Instance
	Second Instance Example application:Rick's InstrumentsDoug's Dog DoorsGary's Games
	How SRP is being used:

SRP-Sightings Revealed!

Let's look back on the times that SRP has already shown up in our software. Here are the SRP sightings we came up with; see if your answers are similar.



This is from the dog door, back in Chapter 3.



How do you think the Single Responsibility Principle was used in Todd and Gina's dog door? Write your answer in the blanks below:

We moved the code to close the dog door out of Remote.java, and avoided duplicating the same code in the BarkRecognizer (PRY in effect there!). We also made sure that the PogPoor class handled all tasks relating to the operation of the dog door—it has that single responsibility.

Here's what we wrote about how SRP (and DRY) helped us out with the dog door.

Now see if you can find two more instances in the book's examples so far where we've used the SRP to make our design better and more flexible. You can find the SRP in the dog door, Rick's instrument inventory searcher, or Gary's game framework. Write down each instance you found, and how you think the SRP is being used.

First Instance

Example application: X Rick's Instruments ___ Doug's Dog Doors ___ Gary's Games

How SRP is being used:

We created a matches() method on InstrumentSpec, rather than leaving the code to compare instruments in the search() method of Inventory. So an InstrumentSpec handles everything related to an instrument's properties—that code isn't spread out over other classes. That's SRP in action.

You don't have to have
the same examples
that we found. Just
make sure the SRP
was applied in similar
ways to the ones we
wrote down here, and
you've got it.

Second Instance

Example application: ___Rick's Instruments ___Doug's Dog Doors ___XGary's Games

How SRP is being used:

When we used a Map to store properties for all types of units in the Unit class, we were using the SRP. So instead of having game-specific Units have to deal with their properties, and still have the base Unit class dealing with a different set of properties, we moved all property-related functionality into the nit class. So handling the properties feature is taken care of in ONE single place—the Unit class.



Contestant #4: The Liskov Substitution Principle (LSP)

Next up in our design principle parade is the Liskov Substitution Principle, or the LSP. It's definition is as simple as it gets:



Liskov Substitution Principle

Subtypes must be substitutable for their base types.

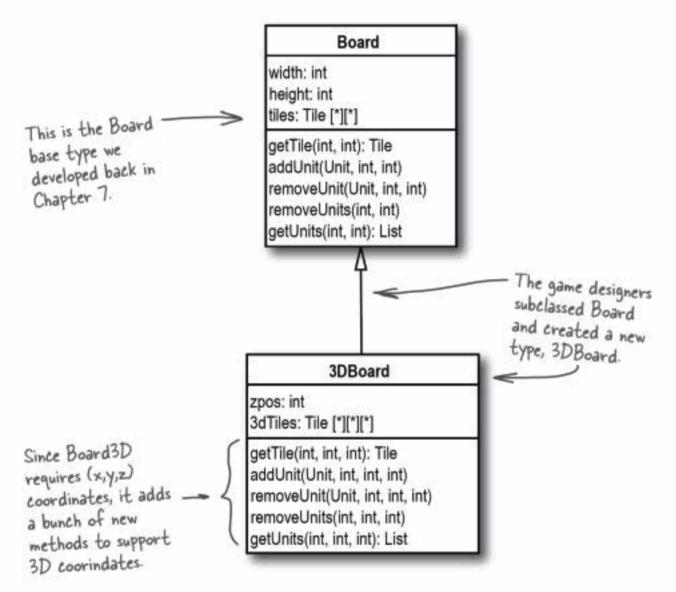
OK, earlier you convinced
me that the OCP is more than just
basic inheritance, but here you are
with the subclassing thing again. We're
programmers, we know how to use
inheritance correctly by now.

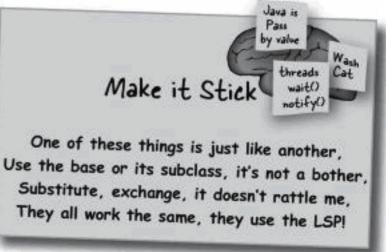


The LSP is all about well-designed inheritance. When you inherit from a base class, you must be able to substitute your subclass for that base class without things going terribly wrong. Otherwise, you've used inheritance incorrectly!

Misusing subclassing: a case study in misusing inheritance

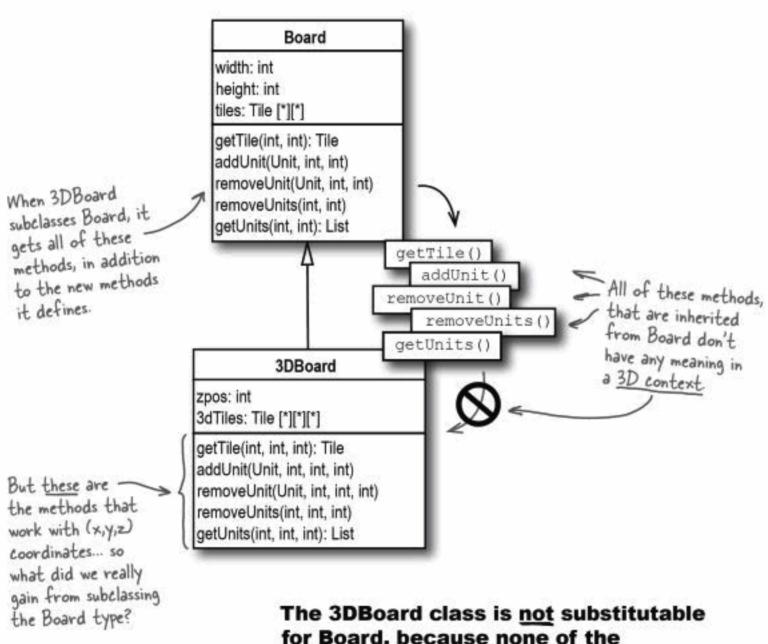
Suppose that Gary's Games has a new client who wants to use their game system framework to create World War II air battles. They need to take the basic **Board** base type, and extend it to support a 3-dimensional board to represent the sky. Here's what they've done:





LSP reveals hidden problems with your inheritance structure

At first glance, it may seem like subclassing **Board** and using inheritance is a great idea. But look closer, there are lots of problems that this approach creates:



The 3DBoard class is <u>not</u> substitutable for Board, because none of the methods on Board work correctly in a 3D environment. Calling a method like getUnits(2, 5) <u>doesn't make sense</u> for 3DBoard. So this design violates the LSP.

Even worse, we don't know what passing a coordinate like (2,5) even means to 3DBoard. This is not a good use of inheritance.

"Subtypes must be substitutable for their base types"

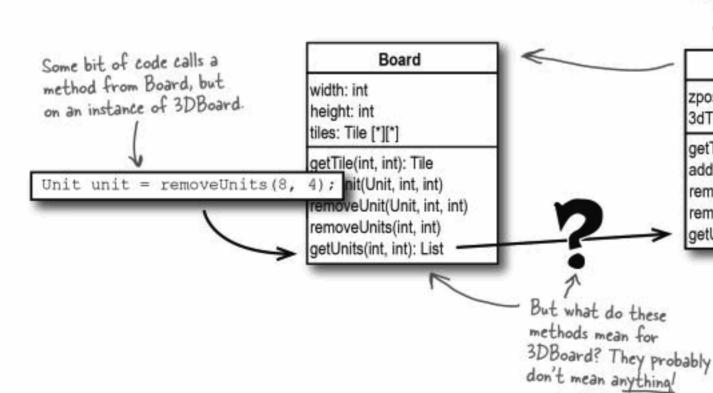
We already said that LSP states that a subtype must be substitutable for its base type. But what does that really mean? Technically, it doesn't seem to be a problem:

But when you start to actually use that instance of 3DBoard like a Board, things can get confusing very fast:

Remember, board here is actually an instance of the subtype, 3DBoard.

But what does this method mean on 3DBoard?

So even though **3DBoard** is a subclass of **Board**, it's not substitutable for **Board**... the methods that **3DBoard** inherited don't have the same meaning as they do on the superclass. Even worse, it's not clear what meaning those methods do have! Inheritance (and the LSP) indicate that any method on Board should be able to be used on 3DBoard... that 3DBoard can stand in for Board without any problems.



3DBoard

zpos: int
3dTiles: Tile [*][*][*]

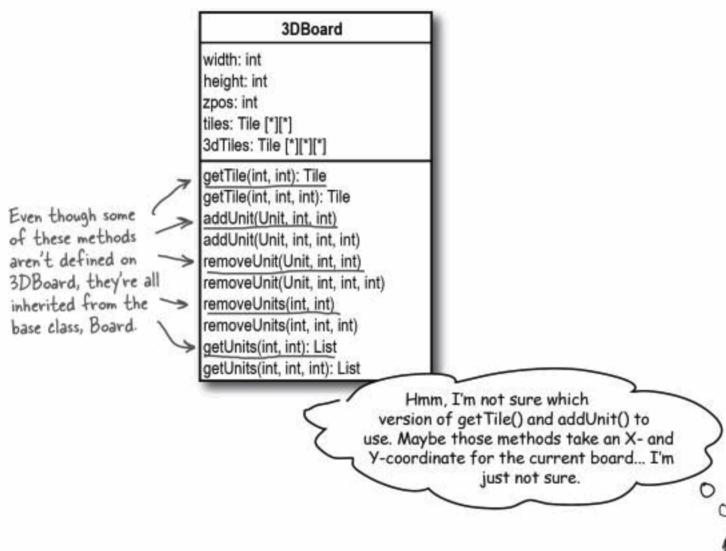
getTile(int, int, int): Tile
addUnit(Unit, int, int, int)
removeUnit(Unit, int, int, int)
removeUnits(int, int, int)
getUnits(int, int, int): List



Violating the LSP makes for confusing code

It might seem like this isn't such a big deal, but code that violates LSP can be confusing, and a real nightmare to debug. Let's think a bit about someone who comes to use the badly designed **3DBoard** for the first time.

They probably start out by checking out the class's methods:



It's hard to understand code that misuses inheritance.

When you use inheritance, your subclass gets all the methods from its superclass, even if you don't want those methods. And if you've used inheritance badly, then you're going to end up with a lot of methods that you don't want, because they probably don't make sense on your subclass.

So what can you do to avoid this? First, be sure your subclasses can substitute for their base types, which is just following the LSP. Second, learn about some **alternatives** to using inheritance in your code...

Solving the 3DBoard problem without using inheritance

It's not enough to just know that inheritance isn't the answer... now we've got to figure out what we should have done. Let's look at the Board and 3DBoard classes again, and see how we can The Board class has create a 3-dimensional board without using inheritance. functionality that 3DBoard needs, but it's not the base type for 3DBoard. Board width: int height: int tiles: Tile [*][*] getTile(int, int): Tile addUnit(Unit, int, int) removeUnit(Unit, int, int) removeUnits(int, int) getUnits(int, int): List boards Instead of extension, we're using an association. So 3DBoard 3DBoard can can use the behavior of Board, store an array without having to extend from of Board it and violate the LSP. 3DBoard objects, and end up with a zpos: int 3dTiles: Tile [*][*][*] 3D collection The 3DBoard methods use -> the zpos coordinate to figure of boards. getTile(int, int, int): Tile out which Board instance in addUnit(Unit, int, int, int) the array to use, and then removeUnit(Unit, int, int, int) delegates the (x,y) coords to removeUnits(int, int, int) that Board's functions. getUnits(int, int, int): List These methods look a lot This is a form of delegation like the methods in Board,

The 3DBoard class delegates

a lot of its functionality to

the individual Board instances.

So what options are there besides inheritance?

but they need to use the

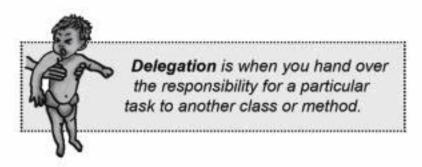
isn't a good option here.

functionality in Board, rather

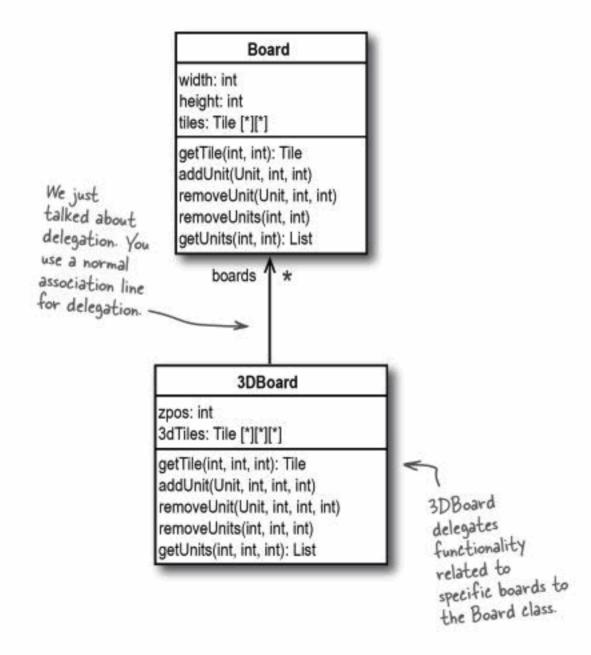
than extend it. So inheritance

<u>Pelegate</u> functionality to another class

You've already seen that delegation is when one class hands off the task of doing something to another class. It's also just one of several alternatives to inheritance.

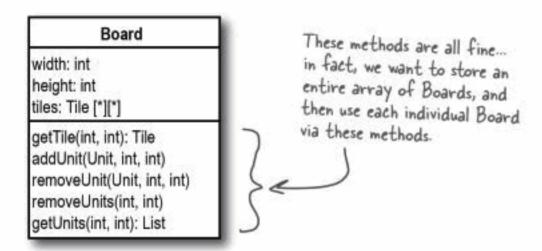


Delegation was what we used to solve the **3DBoard** problem we've been looking at, without resorting to inheritance:

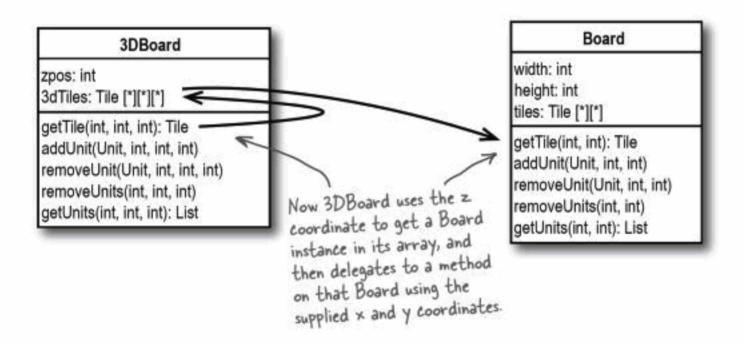


When to use delegation

Delegation is best used when you want to use another class's functionality, as is, without changing that behavior at all. In the case of **3DBoard**, we wanted to use the various methods in the **Board** class:



Since we don't want to change the existing behavior, but we do want to use it, we can simply create a delegation relationship between **3DBoard** and **Board**. **3DBoard** stores multiple instances of **Board** objects, and delegates handling each individual board-related task.

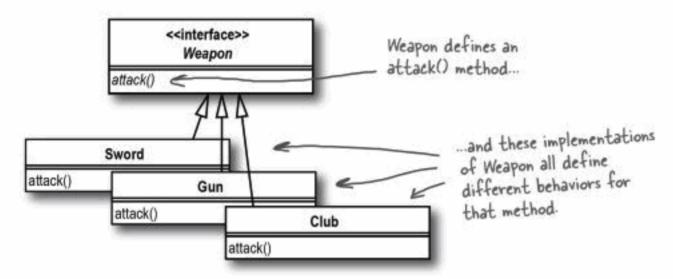


If you need to use functionality in another class, but you don't want to change that functionality, consider using delegation instead of inheritance.

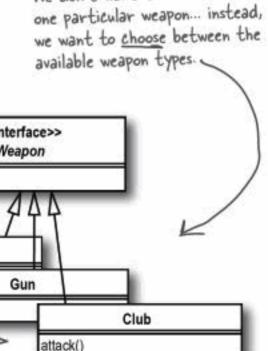
Use composition to assemble behaviors from other classes

Sometimes delegation isn't quite what you need; in delegation, the behavior of the object you're delegating behavior to never changes. 3DBoard always uses instances of Board, and the behavior of the Board methods always stay the same.

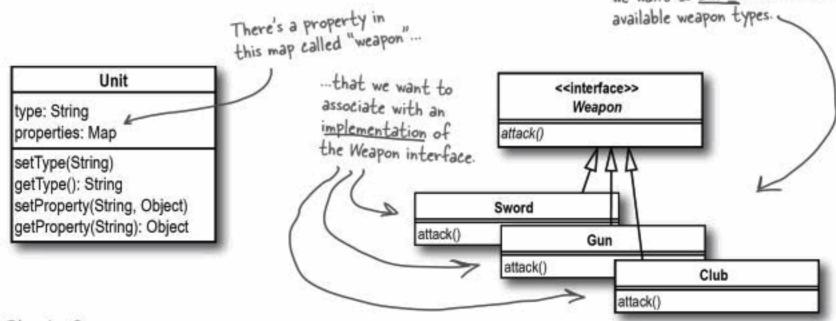
But in some cases, you need to have more than one single behavior to choose from. For example, suppose we wanted to develop a Weapon interface, and then create several implementations of that interface that all behave differently:



Now we need to use the behavior from these classes in our Unit class. One of the properties in our properties Map will be "weapon", and the value for that property needs to be an implementation of the Weapon class. But a Unit might change weapons, so we don't want to tie the weapon property to a specific implementation of Weapon; instead, we just want each Unit to be able to reference a Weapon, regardless of which implementation of Weapon we want to use.

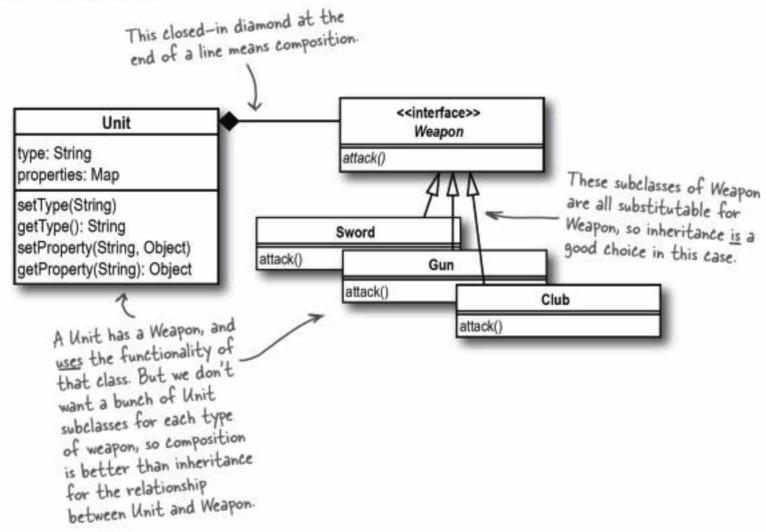


We don't want to be stuck with

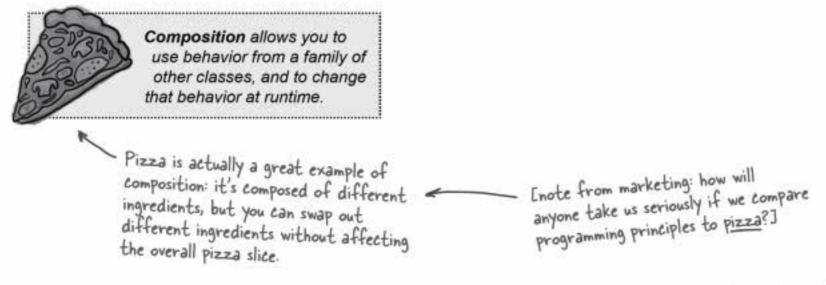


When to use composition

When we reference a whole family of behaviors like in the Unit class, we're using **composition**. The **Unit**'s weapons property is **composed** of a particular **Weapon** implementation's behavior. We can show this in UML like this:



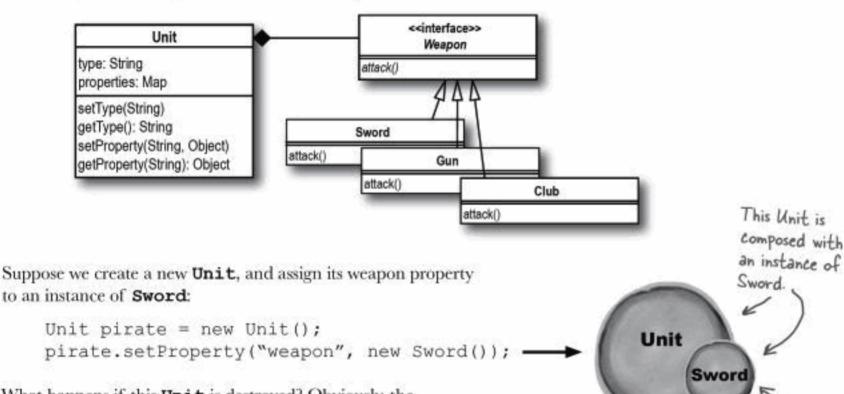
Composition is most powerful when you want to use behavior defined in an interface, and then <u>choose</u> from a variety of implementations of that interface, at both compile time and run time.



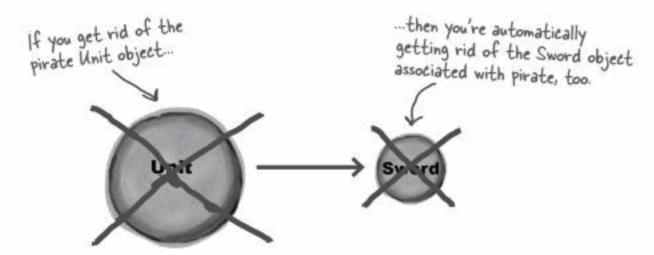
When the pizza is gone, so are the ingredients...

There's one important point we haven't mentioned so far about composition. When an object is composed of other objects, and the owning object is destroyed, the objects that are part of the composition go away, too. That's a little confusing, so let's take a closer look at what that actually means.

Here's our Unit class again, which has a composition relationship to the **Weapon** interface and its implementations:



What happens if this **Unit** is destroyed? Obviously, the pirate variable is trashed, but the instance of Sword referenced by pirate is also thrown away. It doesn't exist outside of the pirate object.



an instance of Sword.

> This Sword object does not exist outside of the context of this particular Unit

In composition, the object composed of other behaviors <u>owns</u> those behaviors. When the object is destroyed, <u>so are all of its behaviors</u>.

The behaviors in a composition do not exist outside of the composition itself.

I get it... composition is really about ownership. The main object owns the composed behavior, so if that object goes away, all the behavior does, too.

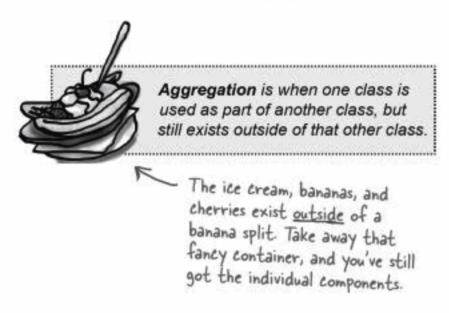




Can you think of an example where the ownership aspect of composition would be a negative in your application? When might you want the composed objects to exist outside of the composing class?

Aggregation: composition, without the abrupt ending

What happens when you want all the benefits of composition—flexibility in choosing a behavior, and adhering to the LSP—but your composed objects need to exist outside of your main object? That's where aggregation comes in.



You've already used aggregation...

We've been using aggregation already, in Rick's Stringed InstrumentSpec is used as part of Instruments, from Chapter 5: an Instrument, but the spec can also exist outside of an Instrument A line with an open (like when it's supplied by a diamond at the end customer for searching). means aggregation. spec Instrument InstrumentSpec properties: Map serialNumber: String price: double getProperty(String): Object getProperties(): Map getSerialNumber(): String matches(InstrumentSpec): boolean getPrice(): double setPrice(float) getSpec(): InstrumentSpec We were able to avoid all those instrumentspecific subclasses by using aggregation here.

Aggregation versus composition

It's easy to get confused about when you should use composition, and when you should use aggregation. The easiest way to figure this out is to ask yourself, Does the object whose behavior I want to use exist outside of the object that uses its behavior?

If the object does make sense existing on its own, then you should use aggregation; if not, then go with composition. But be careful! Sometimes the slightest change in the usage of your objects can make all the difference.

Five-Minute Mystery

Joel leaned back in his seat, arched his back, and thought again about buying that new Aeron chair once his stock options came in. Being a game programmer was hard work, and Joel was the last coder in the office yet again.

"People are gonna go nuts over Cows Gone Wild," he thought. He pulled up the user guide for Gary's Game System Framework, and started to think about how he was going to implement the cowboys, one of the last features he had to deal with. Suddenly, his eyes lit

> upon the Unit class, and he realized that he could use Units for cowboys, and the Weapon interface for lassos, revolvers, and even branding irons.

Joel created Lasso, Revolver, and BrandingIron classes, and made sure they all implemented the Weapon interface. He even added a Weapon property to his Building class, so the cowboys could hang their gear up at the end of long days chasing the cows.

"This is so money... a little bit of composition, and I'll bet bossman Brad will put me as the lead designer in the game credits." He quickly drew up a class diagram of what he had done for the morning shift, colored in his composition diamond between the Unit and Weapon classes, and headed for Taco Bell on the way back to his apartment.

Little did Joel know that when he got back into work the next day, Brad would be yelling at him, instead of congratulating him...

What did Joel do wrong?

Inheritance is just one option

We started out this section talking about the LSP, and the basic idea that subclasses must be substitutable for their base classes. More importantly, though, now you have several ways to reuse behavior from other classes, beyond inheritance.

Let's take a quick look back at our options for reusing behavior from other classes, without resorting to subclassing.

Delegation

Delegate behavior to another class when you don't want to change the behavior, but it's not your object's responsibility to implement that behavior on its own.

Composition

You can reuse behavior from one or more classes, and in particular from a family of classes, with **composition**. Your object completely owns the composed objects, and they do not exist outside of their usage in your object.

As N

Aggregation

When you want the benefits of composition, but you're using behavior from an object that does exist outside of your object, use aggregation. If you favor delegation, composition, and aggregation over inheritance, your software will usually be more flexible, and easier to maintain, extend, and reuse.

All three of these 00 techniques allow you to reuse behavior without violating the LSP.



Dumb Questions

Q: I thought subclassing was a good thing. Now you're saying it's a bad thing?

A: No, subclassing and inheritance are key to any good OO programming language. The LSP is not about subclassing, though; it's about when to subclass. If your subclass really is substitutable for its base type, then you've probably done a good job using inheritance. If your subclass is not substitutable for its base type, then you might look at other OO solutions like aggregation or delegation.

Q: But it is OK to use delegation, composition, or aggregation in a class that really shouldn't extend another class?

A: Sure. In fact, the LSP doesn't apply at all to aggregate or delegate classes, because those are two great ways to fix an inheritance tree that doesn't conform to the LSP. You might even say that good use of the LSP goes hand-in-hand with more delegation, composition, and aggregation.

O: Do we really need to apply the LSP all the time to figure this out? Isn't this just writing good OO software?

A: Lots of times, you don't need to worry about the formal name of a design principle to write good code. For example, look back at the **Board** example on page 401; to make **3DBoard** extend **Board**, all of the methods had to be changed! That should be a real tip-off that you're got some inheritance problems.

There were a lot of weird UML symbols in there. How am I supposed to remember what they all mean?

A: You really don't need to memorize these symbols at all. While UML provides specific notation for aggregation and composition, they are all just different forms of association. So just like we did with delegation, you can use a normal line with an arrow, a normal association, for composition and aggregation.

Q: But won't that be confusing to developers if they don't know what type of association should be used?

A: That's possible, but it also allows for a lot more flexibility. Suppose that you decide later on that when an army is destroyed, you don't want the individual units destroyed as well. So you might change the relationship between army and unit from composition to aggregation.

If you're using a basic association arrow, you won't need to change your class diagram at all. It also gives the developer freedom to come up with their own ideas about how to implement the association.

There's nothing wrong with using the aggregation and composition symbols, but you shouldn't get too hung up on it, especially if you're early on in the development cycle. You never know what might change later, and flexibility is always better than rigidity in your design.



A bunch of classes involved in OO principles, all in full costume, are playing a party game, "Who Am I?" They give a clue, and you try to guess who they are, based on what they say. Assume they always tell the truth about themselves. If they happen to say something that could be true for more than one of them, choose all for whom that sentence can apply. Fill in the blanks next to the sentence with the names of one or more attendees. The first one's on us.

Tonight's attendees:

Subclass Delegated Class Aggregated Class Delegating Class Composite Class

→ Unmask the principles on page 420

I'm substitutable for my base type.	· ····································
I let someone else do things for me.	
My behavior is used as part of another class's behavior.	
I change the behavior of another class.	· <u>2</u>
I don't change the behavior of another class.	<u></u>
I can combine the behavior of other classes together.	:
I'm not gonna go away, even if other related classes do.	<u></u>
I get my behavior and functionality from my base type.	



- The Open-Closed Principle keeps your software reusable, but still flexible, by keeping classes open for extension, but closed for modification.
- With classes doing one single thing through the Single Responsibility Principle, it's even easier to apply the OCP to your code.
- When you're trying to determine if a method is the responsibility of a class, ask yourself, Is it this class's job to do this particular thing? If not, move the method to another class.
- Once you have your OO code nearly complete, be sure that you Don't Repeat Yourself. You'll avoid duplicate code, and ensure that each behavior in your code is in a single place.
- DRY applies to requirements as well as your code: you should have each feature and requirement in your software implemented in a single place.
- The Liskov Substitution Principle ensures that you use inheritance correctly, by requiring that subtypes be substitutable for their base types.

- When you find code that violates the LSP, consider using delegation, composition, or aggregation to use behavior from other classes without resorting to inheritance.
- If you need behavior from another class but don't need to change or modify that behavior, you can simply delegate to that class to use the desired behavior.
- Composition lets you choose a behavior from a family of behaviors, often via several implementations of an interface.
- When you use composition, the composing object owns the behaviors it uses, and they stop existing as soon as the composing object does.
- Aggregation allows you to use behaviors from another class without limiting the lifetime of those behaviors.
- Aggregated behaviors continue to exist even after the aggregating object is destroyed.

Tools for your OOA&D Toolbox

We've got a lot more OO principles to add to the toolbox. Let's add what we've learned to our notes—and remember: these principles are best used together, not separately!

Requirements

Good requirement works like your

Make sure your by developing u

Analysis and Design

Well-designed software is easy to cha and extend.

Use basic 00 principles like encapsula

00 Principles

Your use (or missing have

Use your

things you

Encapsulate what varies.

Code to an interface rather than to an implementation.

Your requ grow) ove Each class in your application should have only one reason to change.

Classes are about behavior and functionality.

Classes should be open for extension, but closed for modification (the OCP)

Avoid duplicate code by abstracting out things that are common and placing them in a single location (the DRY principle)

Every object in your system should have a single responsibility, and all the object's services should be focused on carrying out that single responsibility (the SRP)

Subclasses should be suitable for their base classes (the LSP)

Solving Big Problems

Listen to the customer, and figure out what they want you to build.

Put together a feature list, in language the customer understands.

e your features are what the actually wants.

ueprints of the system using use ams (and use cases).

big system up into lots of tions.

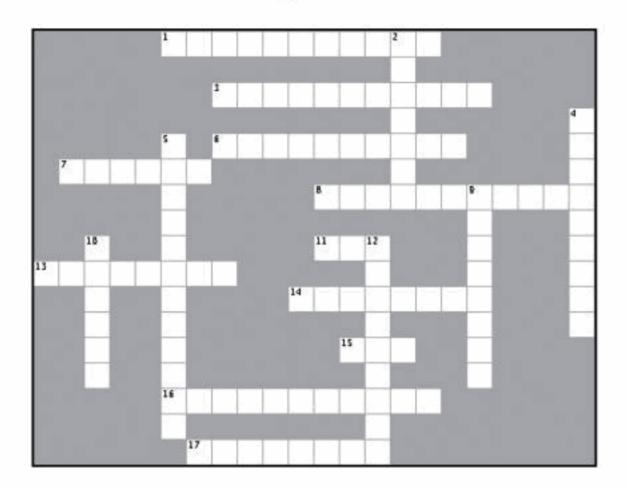
patterns to the smaller the system.

OAFD principles to design and aller section.



OOA&D Cross

This one is a particularly tough puzzle: almost all the answers are more than one word. Good luck, and keep that left brain working.



Across

- 1. A variation on composition.
- 3. This is when one object owns behaviors from other objects.
- This is when you hand over responsibility for a particular behavior.
- 7. He was all about substitution.
- 8. The LSP reveals problems related to this.
- You should keep a single piece of code in this many places.
- You should have each piece of your information and this in a single, sensible place.
- 14. ____ out things that are common in your code.
- Each object in your system should have this many responsibilities.
- This is overrated in good OO software design.
- 17. Another term for SRP is this.

Down

- Aggregated objects exist _____ of the classes that use them.
- 4. Subtypes must be substitutable for these.
- 5. Classes should be closed for this.
- 9. 00 principles work best when used this way.
- A well-designed class has only one reason to do this.
- 12. Classes should be open for this.



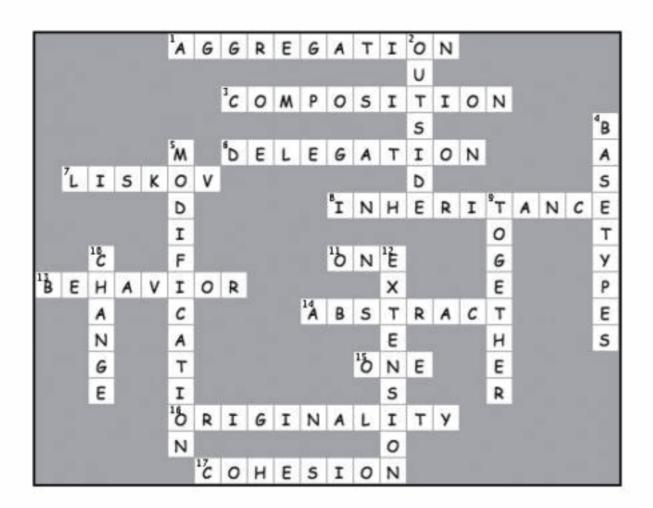
A bunch of classes involved in OO principles, all in full costume, are playing a party game, "Who Am I?" They give a clue, and you try to guess who they are, based on what they say. Assume they always tell the truth about themselves. If they happen to say something that could be true for more than one of them, choose all for whom that sentence can apply. Fill in the blanks next to the sentence with the names of one or more attendees. The first one's on us.

Tonight's attendees:

Subclass Delegated Class Aggregated Class Delegating Class Composite Class

their existence.

subclass I'm substitutable for my base type. This is a basic delegating class, composite class delegation I let someone else do things for me. definition, but a class My behavior is used as part of that uses aggregated class another class's behavior. composition uses other classes for I change the behavior of subclass behavior, also. another class. I don't change the behavior of A subclass is delegated class, aggregated class, another class. the only class delegating class, composite class that changes another class's I can combine the behavior of behavior. composite class, delegating class other classes together. I'm not gonna go away, even if aggregated class, delegated class other related classes do. In aggregation and delegation, I get my behavior and subclass object functionality from my base type. instances are tied together, but not dependent on each other for







Joel's big mistake was revealed in this line:

He even added a Weapon property to his Building class, so the cowboys could hang their gear up at the end of long days chasing the cows.

When Joel decided that cowboys could hang up their weapons, he committed to the Lasso, Revolver, and BrandingIron classes existing outside of any individual Unit instance. No cowboy owned the gear; they just used the behavior of the gear for a time.

Since the Weapon implementations exist outside of a specific cowboy, Joel should have used aggregation instead of composition. Different cowboys could use the same Weapon implementation at different times, and those weapons should stay in existence, even if the cowboy using them was trampled by a mad cow.

9 iterating and testing

The Software is Still for the Customer

I spent forever wondering what I could give you to show how much I think of your ideas, and then I had it: a beautiful new set of tests!

Oh, Jim! You really do care about what I want, don't you?



It's time to show the customer how much you really

Care. Nagging bosses? Worried clients? Stakeholders that keep asking,
"Will it be done on time?" No amount of well-designed code will please
your customers; you've got to show them something working. And now
that you've got a solid OO programming toolkit, it's time to learn how you
can prove to the customer that your software works. In this chapter, we
learn about two ways to dive deeper into your software's functionality, and
give the customer that warm feeling in their chest that makes them say,

Yes, you're definitely the right developer for this job!

Your toolbox is filling up

We've learned quite a bit so far, and our toolbox of analysis and design tools is getting pretty full. We even added some OO programming techniques in the last chapter:

LSP POOP
DIRY

Our OO principles from Chapter 8 help us write well-designed, flexible OO software.

We've got a whole slew of principles and techniques to gather requirements, analyze and design, and solve all types of software problems.

Requirements Analysis and Design Solving Big Problems Use have 00 principles like excapsulation and wheretance to make your software Listen to the customer, and figure out what him just you to build 00 Principles Erature list, in language Code to an interface vather than as atures are what the Clause should be open for extension, but closed for modification (the OCP) Aroid displicate code by abotivating out things way into late of that are common and placing them in a single location (the DRY principle) Every object in your updam chaild have a single responsibility, and all the object's service should be focused an carrying out that single responsibility (the SSP) Salucianes should be suitable for their bis classes (the LSP)

In Chapters 6 and 7, we used use case diagrams and a key feature list to turn a simple vision statement into an application architecture.



1. Make sure your software does what the customer wants it to do.

2. Apply basic 00 principles to add flexibility.

The 3 steps to writing great software showed up back in Chapter I, but we've been using them throughout every chapter.

3. Strive for a maintainable, reusable design. That's great, really, you're an amazing developer, I'm sure. But I really don't care about any of that... where's my application?

But you're still writing your software for the CUSTOMER!

All the tools and techniques you've been learning are terrific... but none of them matter if you don't use them to produce great software that makes your customer happy.

And most of the time, your customer won't care about all the OO principles and diagrams you create. They just want the software to work the way that it's supposed to.



We really don't have anything to show Gary yet. All we've done is start on a few of these key features, like the Board class and the Unit class diagram.



You write great software iteratively.

Work on the big picture, and then iterate over pieces of the app until it's complete.

Joe: Yeah, maybe we shouldn't have spent all this time on so many diagrams, and all this architecture stuff. We've got nothing to show Gary except a bunch of ovals with things like "Play Game" written inside them.

Frank: Come on guys, we've got a lot more done than that. It's going to be simple to finish up the Board class, because we've already got a start on writing a lot of that functionality.

Jill: Well, sure, but that's the only class we've written any code for. How are we supposed to show that to Gary?

Joe: Well, I guess we could write the Unit class pretty easily, since we did that class diagram. So it wouldn't take a lot more time to write the code for that class.

Frank: Exactly. And, really, we know how to write all of these classes. We can just take each class, or even an entire package, and apply all those OO principles and analysis and design techniques to each chunk of functionality.

Jill: But we've got to work on functionality now. We don't have time for a bunch more big-picture analysis and design.

Frank: But that's just the thing, Jill: we don't need to change what we're doing, we just need to iterate deeper.

Joe: Iterate deeper? What does that mean?

Frank: It just means we keep doing analysis and design, but now on each individual part of Gary's game system framework.

Jill: And as we build up the application, we'll have lots of pieces working that we can show to Gary, right?

Joe: And we get to use all these tools we've got to make sure the software is well-designed, too, right?

Frank: Exactly. But first, we've got a choice to make...

Iterating deeper: two basic choices

When it comes to developing software, there is more than one way to iterate into specific parts of your application. You've got to take on smaller pieces of functionality, but there are two basic approaches to figuring out which small pieces to work on—and even what a "small piece" means in terms of your application.

You can choose to focus on specific features of the application. This approach is all about taking one piece of functionality that the customer wants, and working on that functionality until it's complete.



Feature driven development

...is when you pick a specific feature in your app, and plan, analyze, and develop that feature to completion.

You can also choose to focus on specific flows through the application. This approach takes a complete path through the application, with a clear start and end, and implements that path in your code.



Use case driven development

...is when you pick a scenario through a use case, and write code to support that complete scenario through the use case.

Both approaches to iterating are driven by good requirements.

Because requirements come from the customer, both approaches focus on delivering what the customer wants.

You'll often see the terms "flow" and "scenario" used interchangeably.

Feature driven development

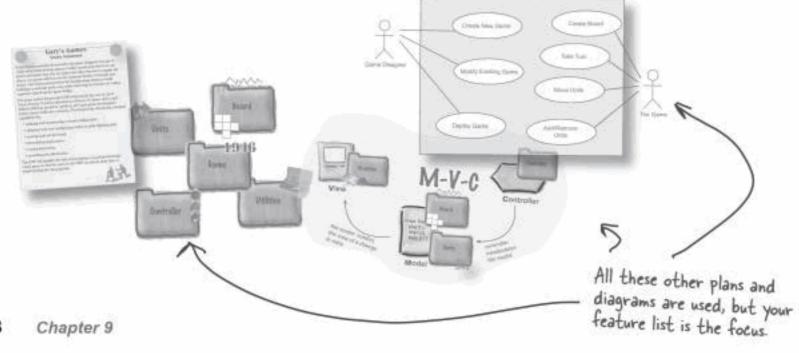
When you're using **feature driven development**, you work on a single feature at a time, and then iterate, knocking off features one at a time until you've finished up the functionality of an application.

Gary's Game System Framework
Feature List

- 1. The framework supports different types of terrain.
- The framework supports different time periods, including fictional periods like scifi and fantasy.
- The framework supports multiple types of troops or units that are game-specific.
- The framework supports add-on modules for additional campaigns or battle scenarios.
- The framework provides a board made up of square tiles, and each tile has a terrain type.
- 6. The framework keeps up with whose turn it is.
- The framework coordinates basic movement.

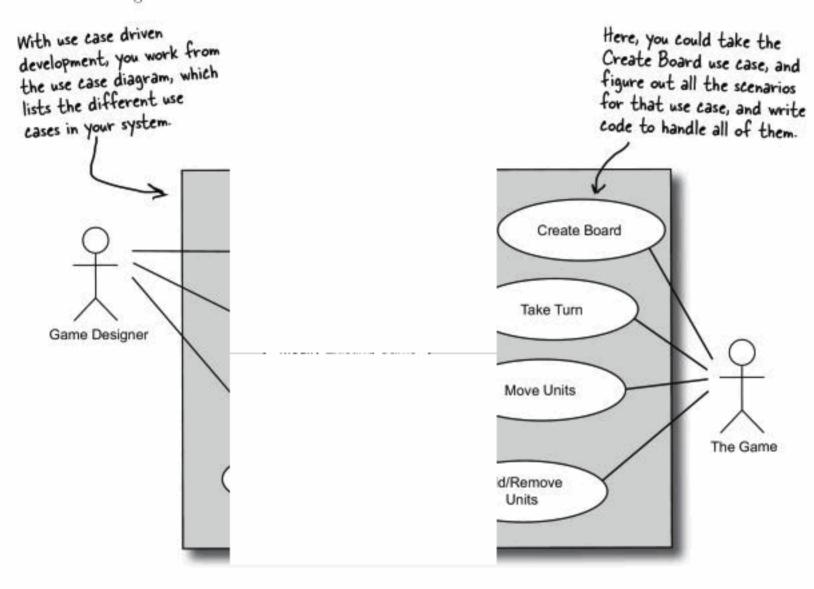
With feature driven development, you pick a single feature, and the focus is on the feature list of your app.

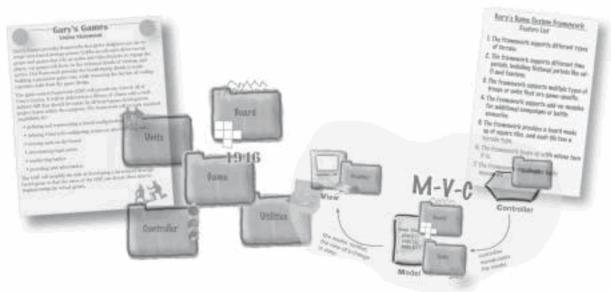
So we might take feature #1, and work on the Terrain class, as well as the Tile class, to support different types of terrain.



Use case driven development

With use case driven development, you work on completing a single scenario through a use case. Then you take another scenario and work through it, until all of the use case's scenarios are complete. Then you iterate to the next use case, until all your use cases are working.





Two approaches to development

There's just one basic way to write code, isn't there? Well, there are actually a ton of different ways to go about iterating deeper and finishing up parts of your application. Most of these different approaches fall into the two basic categories we've been looking at, though. So how do you decide which to use?

What's the difference between feature driven and use case driven development?

Feature driven development is more granular



Use case driven development is more "big picture"



Works well when you have a lot of different features that don't interconnect a whole lot.

Allows you to show the customer working code faster.

Is very functionality-driven. You're not going to forget about any features using feature driven development.

Works particularly well on systems with lots of disconnected pieces of functionality. Works well when your app ha of processes and scenarios ra than individual pieces of func-

Allows you to show the custor bigger pieces of functionality at each stage of development.

Is very user-centric. You'll code for all the different ways a user can use your system with use case driven development.

Works particuarly well on transactional systems, where the system is largely defined by lengthy, complicated processes.



Welcome to "Name That Approach!" Below are several statements, and each one is about a particular approach to iterating over parts of your system. Your job is to figure out which approach each statement refers to. Note that sometimes, a statement might apply to both approaches.

-,:	Use Case Driven	Feature Driven
This approach deals with really small pieces of your application at a time.		
This approach lets you focus on just a part of your application at a time.		
This approach is all about a complete process in your application.		
Using this approach, you can always test to see if you've completed the part of the application you're working on.		
When you use this approach, your focus is on a diagram, not a list.		



Welcome to "Name That Approach!" Below are several statements, and each one is about a particular approach to iterating over parts of your system. Your job is to figure out which approach each statement refers to. Note that sometimes, a statement might apply to both approaches.

Use Case Driven	Feature Driven
1	
	Use Case Driven

Let's use feature driven development

Since Gary's losing patience, let's go with feature driven development. We can take just a single feature and work it through to completion, and it shouldn't take as much time as it would to write the code to support an entire use case.

Anytime you've got a customer impatient to see results, you should consider feature driven development, and starting with a feature you've already done some work on.

We go back to our feature list, from Chapters b and 7.

Gary's Game System Framework Feature List

- The framework supports different types of terrain.
- The framework supports different time periods, including fictional periods like scifi and fantasy.
- 3. The framework supports multiple types of troops or units that are game-specific.
- 4. The framework supports add on modules for additional campaigns or battle scenarios.
- The framework provides a board made up of square tiles, and each tile has a terrain type.
- The framework keeps up with whose turn it is.
- The framework coordinates basic movement.

We already have the class diagram for Unit, so let's write the code for that class, and knock off feature #3.



type: String properties: Map

setType(String) getType(): String setProperty(String, Object) getProperty(String): Object

We also know that most of our other features depend on this class, so that makes it an even better candidate to start with.



If you decided to go with use case driven development, what would you start working on first?

Analysis of a feature

Once you've decided on a feature to start with, you've got to do some more analysis. Let's start with what we had written down on the feature list:

The framework supports multiple types of troops or units that are game-specific.

We also have the start of a class diagram, from Chapter 7:

 Here's what we've got so far... but this is still a pretty generic description of what we need to code.

Unit

type: String properties: Map

setType(String) getType(): String

setProperty(String, Object) getProperty(String): Object This looks like the blueprint for a good Unit class. So is anything missing?

It looks like we've got everything we need to start coding, right? To help us make sure we haven't forgotten anything, let's go back to using some textual analysis.

We don't have a use case to analyze, but we can revisit the vision statement for Gary's games, and see if we're covering everything that Gary wanted his units to do.

> Here's Gary's vision statement, from way back in Chapter b.

Compare the class diagram for Unit with this vision statement. Are there things missing from our class diagram?

What else might Gary expect to see when you say, "I'm done with writing code for the units in your framework?"



Gary's Games Vision Statement



Gary's Games provides frameworks that game designers can use to create turn-based strategy games. Unlike arcade-style shoot-'em-up games and games that rely on audio and video features to engage the player, our games will focus on the technical details of strategy and tactics. Our framework provides the bookkeeping details to make building a particular game easy, while removing the burden of coding repetitive tasks from the game design.

The game system framework (GSF) will provide the core of all of Gary's Games. It will be delivered as a library of classes with a well-defined API that should be usable by all board game development project teams within the company. The framework will provide standard capabilities for:

- · Defining and representing a board configuration
- · Defining troops and configuring armies or other fighting units
- · Moving units on the board
- · Determining legal moves
- · Conducting bandes
- · Providing unit information

The GSF will simplify the task of developing a turn-based strategic board game so that the users of the GSF can devote their time to implementing the actual games.

Fleshing out the Unit class

In our class diagram, all we've really figured out is how to represent the properties of a unit. But in Gary's vision statement, he's expecting his game system framework to support a lot more than just those game-specific properties.

Here are the things we came up with that Gary is expecting units in his framework to do: This makes sense, because the key feature we were focusing on in Chapter 7 was not the entire Unit class, but just game-specific properties of a Unit.

Each unit should have properties, and game designers can add new properties to unit types in their own games. Our class diagram is focused on this particular aspect of the Unit class right now.

Units have to be able to move from one tile on a board to another.

You should have some ideas about how to handle this from our work on a related key feature back in Chapter 7.

Units can be grouped together into armies.

These new features are all pulled straight from Gary's vision statement

Wow, great. Another list
of things you're going to do. Look,
I trust you and all, but I need to
see something more than scraps
of paper to believe your code is
working.

Gary isn't satisfied with your use cases and lists... what do you think would make Gary believe that what you're working on will satisfy his requirements?



0

Unit properties

Unit movement

Unit groups

Showing off the Unit class

We worked on supporting game-specific units, and how to store the properties of a **Unit**, back in Chapter 7. But Gary wants more than a class diagram before he's convinced you're getting any work done.

Unit

type: String properties: Map setType(String) getType(): String

setProperty(String, Object) getProperty(String): Object This may be what you need to start coding the Unit class, but it doesn't do anything to prove to Gary that you've got working units in the game system framework.

How about a test? Can't you come up with a way to show me the unit has properties, and can move around, and that you've got support for armies? I want to see your code actually running.



Your customers want to see something that makes sense to them

Your customers are used to seeing computer programs run on a computer. All those diagrams and lists may help you get on the same page with them in terms of requirements and what you're supposed to build, but you're going to need more than that before they think you've built anything useful.

You need to come up with some test scenarios that you can show to your customer, which will prove that your code works, and that it behaves like your customer expects it to.

Writing test scenarios

Test cases don't have to be very complex; they just provide a way to show your customer that the functionality in your classes is working correctly.

For the properties of a unit, we can start out with a simple test scenario that creates a new **Unit**, and adds a property to the unit. We could just show our customer a running program that displays output like this: Be careful... this "scenario" isn't the same as the "scenario" we've been talking about in a use case scenario.

This test, although simple, lets your customer "see" that the code you're writing really works.

We start out by creating the Unit...

...then we set some properties...

...and finally get the properties and make sure the values match up with what we set *File Edit Window Help NiWorks

*java UnitTester
Testing the Unit class...
...Created a new unit
...Set "type" to "infantry"
...Set "hitPoints" to 25
...Getting unit type: "infantry"
...Getting unit hitPoints: 25

Test complete.

Write the output you want Gary to see in these blanks.

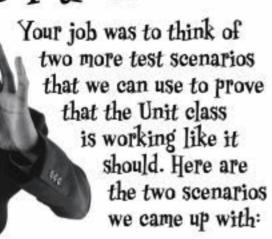
BE the Customer

We've already got one test scenario. It's your job to play Gary, and think of two more test scenarios that we can use to prove that the Unit class is working like it should. Write the output of each scenario in the code windows on the right.

File Edit Window Help Scenario2	\
%java UnitTester Testing the Unit class	=7 $)$
Test complete.	

File Edit Window Help Scenario3	
%java UnitTester Testing the Unit class	
Test complete.	-

BE the Customer Solutions



**File Edit Window Help ItWorks

**java UnitTester
Testing the Unit class...
...Created a new unit
...Set "type" to "infantry"
...Set "hitPoints" to 25
...Getting unit type: "infantry"
...Getting unit hitPoints: 25

Test complete.

Here's the first test scenario, which tests setting and getting property values.

Scenario #2: Changing property values

We decided to test setting, and then changing, the value of a property. If the **hitPoints** property is set, for example, and then set again, getting the value of **hitPoints** should return the most recent value for that property: This is pretty similar-looking to the first scenario, above, but it tests changing a property value, rather than just setting and retreiving a property.

We always begin by creating a new Unit, so we can test things out

Next we set the value of hitPoints, and then reset it to a new value.

Finally, we make sure hitPoints has the most current value, and not the original value of 25. %java UnitTester
Testing the Unit class...
....Created a new unit
....Set "hitPoints" to 25
....Set "hitPoints" to 15
....Getting unit hitPoints: 15

Test complete.

Scenario #3: Getting non-existent property values

For our third scenario, we decided to test what would happen when you tried to retrieve the value of a property that had never been set. Error conditions like this crop up all the time, and we don't want our program crashing every time a game designer makes a small typo or mistake in their code. Here's what we did to test this:

This test shows the customer that you're not just dealing with happy paths... you're thinking about how to deal with uses of the software that are outside of the norm.

Start out by creating a new Unit again.

Next, we set a hitPoints property, which is the normal Unit usage.

Now let's try and access a property that has no value.

Finally, make sure the Unit still behaves when you ask for a property that does

have a value.

File Edit Window Help Scenario3

% java UnitTester
Testing the Unit class...
...Created a new unit
...Set "hitPoints" to 25
...Getting unit strength: [no value]
...Getting unit hitPoints: 25

Test complete.

You should test your software for <u>every</u> possible usage you can think of. Be <u>creative!</u>

Don't forget to test for <u>incorrect usage</u> of the software, too. You'll <u>catch errors early</u>, and make your customers very happy.

Dumb Questions

Q: We don't have any code written yet. Aren't we doing things a bit backwards by worrying about tests right now?

A: Not at all. In fact, if you know what tests you're going to use before you write your code, it's easy to figure out what code you're going to need to pass those tests. With the three test scenarios we just developed, it should be pretty simple to write the Unit class, and the tests tell us exactly how our code should behave.

Q: Isn't this just test driven development?

A: For the most part, yes. Formally, test driven development focuses on automated tests, and usually involves a testing framework like JUnit. But the idea of writing test cases, and then writing the code that will pass the test, is the core idea behind test driven development.

Q: So are we using test driven development or feature driven development? I'm confused...

A: Both. In fact, most good software analysis and design mixes lots of different approaches. You might start with a use case (use case driven development), and then choose just a small feature in that use case to start working on (which is really a form of feature driven development). Finally, you might use tests to figure out how to implement that feature (feature driven development).

Q: Why are the tests so simple? I expected something a little fancier.

A: You want to keep your tests simple, and have them test just a small piece of functionality at a time. If you start testing multiple things at once, it's hard to tell what might have caused a particular test to fail. You may need a lot more tests, but keep each one focused on a very specific piece of functionality.

Q: And each test makes sure a single method in the class works correctly, right?

A: No, each test really focuses on a single piece of functionality. That might involve one method, or several methods. For example, you can't test setting a property's value (which uses setProperty()) without getting that property's value as well (using getProperty()). So it's one piece of functionality—setting a property—but it takes two methods.

Can you explain why you tested getting a property that you didn't set? Isn't that testing the wrong way to use the Unit class?

A: Testing incorrect usage of your software is usually at least as important as testing it when it's used properly. Game designers could easily mistype a property name, or write code that expects some other piece of a game to set a property and asks for a property that doesn't exist. It's your job to know what will happen in these situations.

Q: Now that we've got our tests planned out, we can finally start coding the Unit class, right?

A: Well, there's one more bit of design we need to think about first...

Test driven development focuses on getting the behavior of your classes right.

Guys, I've been looking
at our class diagram for Unit,
and I'm not sure that this is the best
way to handle things. I think our
commonality analysis might have
been a little off.



0

Unit

type: String properties: Map

setType(String) getType(): String

setProperty(String, Object) getProperty(String): Object

Here's the current class diagram for Unit that Frank, Jill, and Joe are discussing. **Joe:** What do you mean? We figured out that all properties in a Unit have a name and a value. So we decided to use a Map to store them all.

Frank: And game designers can add any new properties they want by just creating new property names, and sticking name/value pairs in the Map with the setProperty() method.

Jill: Right. But then, we also added a type property, since all units will have a type. And that's something common for all units...

Joe: Sure. See, we did do the commonality analysis right.

Jill: ...but we also now know that units can be assembled into groups, like armies or fleets or whatever. So what happens if we have two units of the same type in the same group... how can we tell the difference between them?

Frank: You think we need some sort of ID, don't you?

Jill: Yeah, maybe. Or at least a name... but even then, you can't really prevent duplication with a name property, can you?

Joe: OK, but that still doesn't mean we need to change our design. We can just add the ID property into our property Map. So we've got a nice, uniform way to access all those properties, using the getProperty() method.

Frank: He's right, Jill. And since we encapsulate away the details about property names into the properties Map, we could even change from using an ID to a name, or something totally different, and code using the Unit class wouldn't have to change much... you'd just need to use the new property name in getProperty(). That's a pretty slick design!

Jill: But what about commonality? If ID is really common to all types of Unit, shouldn't it be moved out of the Map, sort of like we did with the type property?

Joe: Whoa... encapsulation or commonality. That's tough... it seems like we can't do one without screwing up the other.

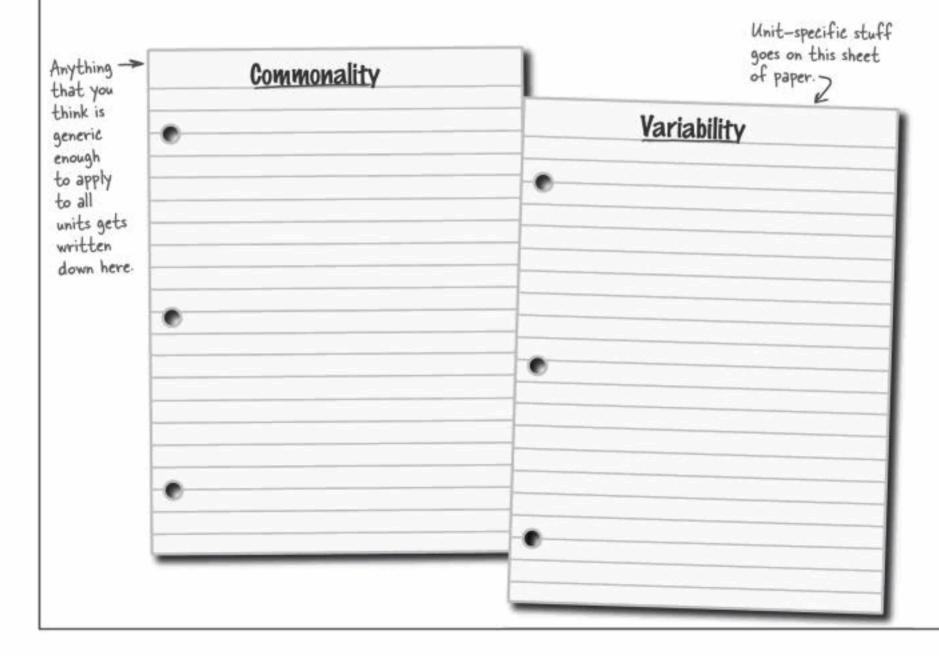
Sharpen your pencil

Refine your commonality analysis.

Before we close the book on dealing with Unit properties, there are a few things you still need to think through. Below are several properties that different units might have, and two sheets of paper. Write down on the Commonality sheet the properties that you think all units, regardless of their type, would have; on the Variability sheet, write down properties you think only specific types of units might have.

Potential Unit Properties

name	weapon	allegiance	gear
type	hitPoints	wingspan	lastName
strength	weight	landSpeed	id
speed	intelligence	experience	groundSpeed
stamina	firstName	weapons	hunger



Now update the Unit class diagram.

With the details from your revised commonality analysis on page 442, you (might) need to update the Unit class diagram, shown below. Make any changes that might improve the design of the Unit class below, and add notes to remind yourself what the purpose of any additions you've made are going to be used for.

Unit

You can cross out or modify the existing properties of Unit, in addition to adding new stuff.

type: String

properties: Map

setType(String) getType(): String setProperty(String, Object) getProperty(String): Object

Change and add to the methods in Unit to match what you figured out in the commonality and variability analysis on the last page.

Add any new properties you think Unit needs here.



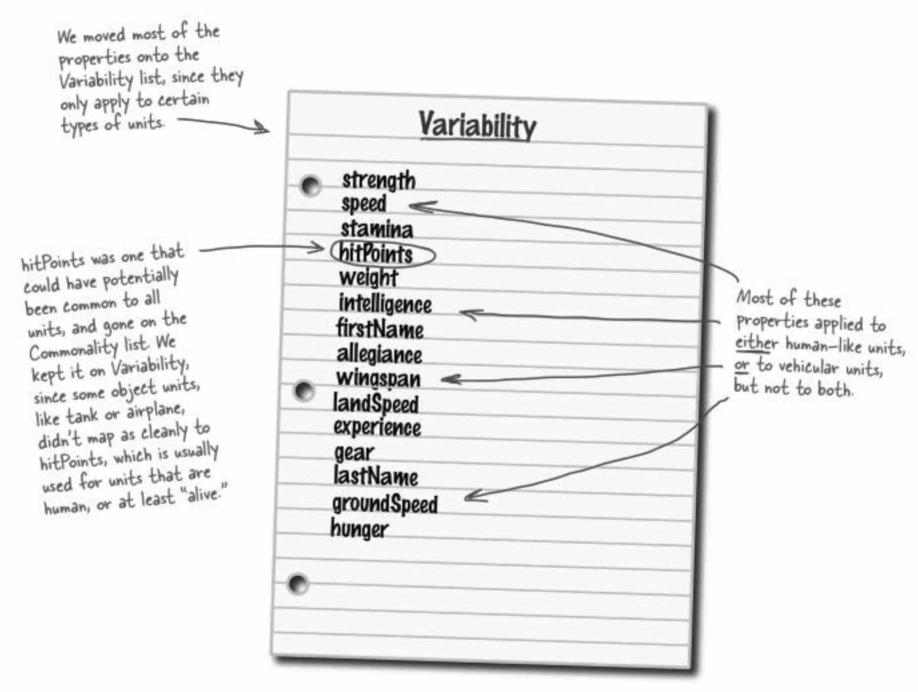
Refine your commonality analysis.

On page 442, we showed you several properties that different units might have. Your job was to write down on the Commonality sheet the properties that you think all units, regardless of their type, would have; on the Variability sheet, you should have written down properties you think only specific types of units might have.

We didn't find a lot of properties that You should definitely could apply to any have written down "type", type of unit, so our since we figured out Commonality commonality page is that was common to all pretty thin. units back in Chapter 7. type "name" and "id" are pretty basic, and we weapons thought that all units would probably have "weapons" might be a bit of a both properties. controversial decision. We figured that since these are war games, all units would have at least one weapon, but that some might have more than one. So a generic "weapons" property seemed a good fit for all unit types. We also decided that we would never need just a single "weapon" property ... units with one weapon would have just a single weapon in the "weapons" property. So we ditched this property.

You may have a different idea about what makes a good game.

You might have played different games than we have, and come up with different common properties. That's OK—just focus on how and why you made your own decisions. We're going to use our choices in the rest of the chapter, so you should be comfortable with how we made our choices, too.



Dumb Questions

Q: I didn't have anything on the Commonality list except for "type". Where did I go wrong?

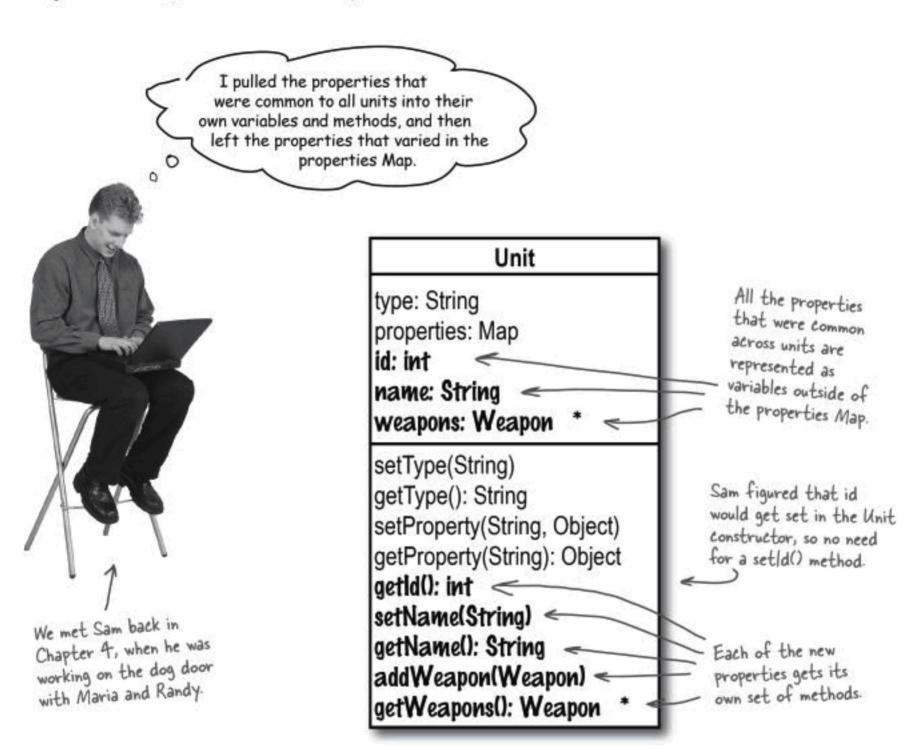
A: You didn't go wrong at all. Analysis and design are all about making choices, and sometimes you're going to make a different choice than another programmer. There's nothing wrong with that, as long as you have good, well thought out reasons for the decision you made.

Q: But won't different choices at least result in different code and design implementations?

A: Yes, they sure will. But OOA&D, and software development, aren't about making a particular decision, since many times there isn't an exactly "right" or exactly "wrong" choice. They're about writing well-designed software, and that can happen in a lot of different ways.

In fact, even if two programmers made the same decision about commonality and variability in this exercise, it can lead to totally different design decisions when it comes to actually writing your classes. Let's assume for a moment that two developers both came up with the answers for commonality and variability shown here, and then tried to revise the Unit class to reflect what they figured out...

Solution #1: Emphasizing Commonality



In this solution, all game designers can directly access the id, name, and weapons properties, instead of having to use getProperty() and work through the more generic properties Map.

The emphasis is on keeping the **common** properties of a **Unit outside** of the **properties Map**, and leaving properties that **vary inside** the **properties Map**.

You defintely found some commonality between different unit types, but what about good encapsulation?
That Unit class doesn't seem very resistant to change, if you ask me.

Design decisions are always a tradeoff

Sam chose to emphasize the things that are common across all types of **Unit**s. But there are some negatives to Sam's design, too:

We're repeating ourselves

Now there are two different ways to access properties: through the getId(), getName(), and property-specific methods, and the getProperty() method. Two ways

to access properties is almost certainly going to mean duplicate code somewhere.

Maintenance is a problem

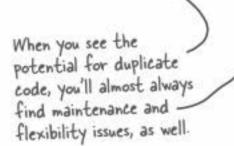
Now you've got property names, like id and name, hard-coded into the Unit class.

If a game designer doesn't want to use those, or wants to change them, it's going to be a

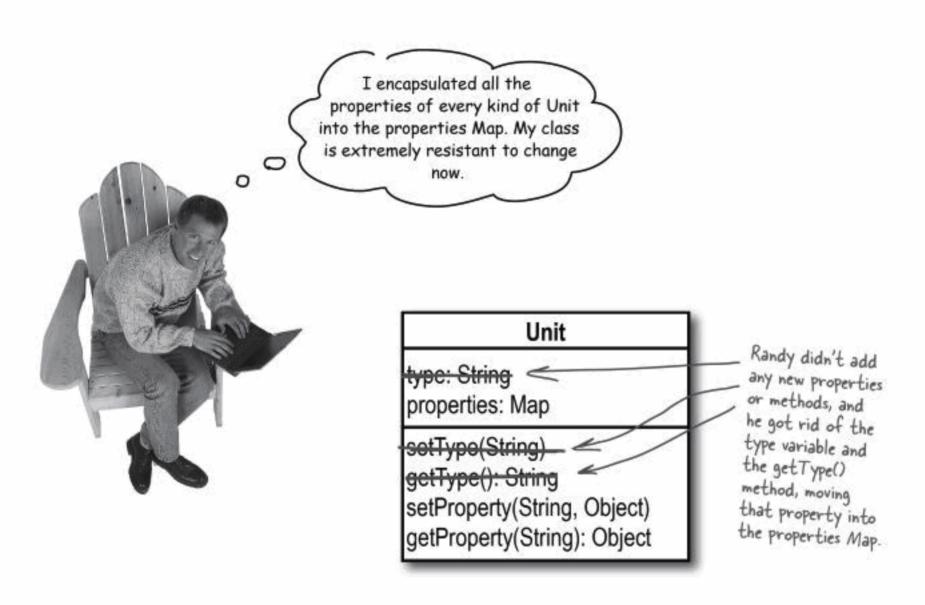
real hassle, and require changes to the **Unit** class. This is usually where encapsulation would help, and that leads us to Randy's design choice...



Randy's learned a lot about 00 design since we saw him last in Chapter 4.



Solution #2: Emphasizing Encapsulation



This solution focuses on encapsulating <u>all</u> the properties for a **Unit** into the **properties Map**, and providing a standard interface—the **getProperty()** method—for accessing all properties. Even properties that apply to all units, like **type** and **id**, are accessed through the **properties Map** in this solution.

The emphasis is on **encapsulation**, and a **flexible design**. Even if the names of common properties change, the **Unit** class can stay the same, since no property names are hardcoded into the class itself. But you're totally ignoring what's common across Units. And how are game designers going to know that we intended name, type, id, and weapons to be standard properties?

Tradeoffs with this decision, too...

Randy's solution is more resistant to changes, and uses a lot more encapsulation, but there are tradeoffs with this design, as well. Here are a few of the downsides to Randy's design:

We're ignoring commonality

Randy encapsulated all of the properties into the properties

Map, but now there's nothing to indicate that type, name, id, and weapons are intended to be properties common to all Unit types.



Lots of work at runtime

getProperty() returns an Object, and you're going to have to cast that into the right value type for each different property, all at runtime. That's a lot of casting, and a lot of extra work that your code has to do at runtime, even for the properties that are common to all Unit types.



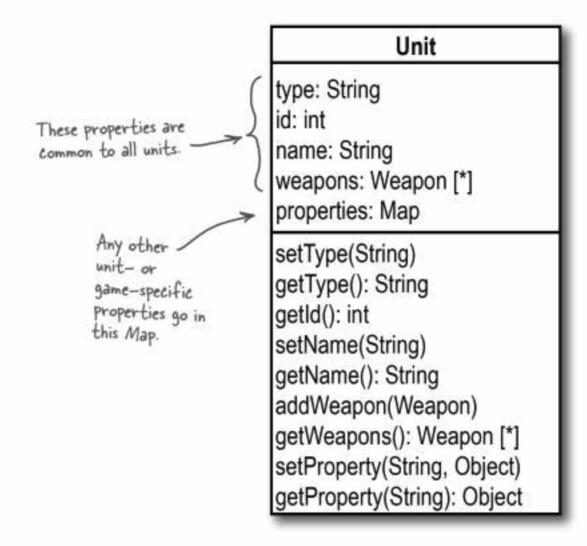


Which developer's solution do you think is best? Are there times where you think one solution might be the best choice, and other times where the other might work better?

Let's go with the commonality-focused solution

For Gary's game system framework, let's use Sam's solution, which pulls the common properties of a **Unit** out into their own properties and methods, and leaves unit-specific properties in a separate **Map**. Unit properties Unit movement Unit groups

This is all still part
of dealing with the
properties of a unit



Dumb Questions

Q: I thought the other design, that focused on encapsulation, was better. Is that OK?

A: Absolutely. Both design choices have positives, and either one might work well. The only thing you cannot do is be unwilling to change your design—whichever one you start with—if it turns out to not work well down the line. At each stage of iterating through your app, you need to reevaluate your design decisions, and make sure they're still solid.

Q: So how do I know when I need to change my design? My code won't just stop working, so what should I look out for?

A: Iteration is really the key point here. Lots of design decisions look great at one stage of your development, but then turn out to be a problem as you get deeper into a particular part of your app. So once you make a decision, stick with it, and iterate deeper into your application. As long as your design is working, and you're able to use good OO principles and apply design patterns, you're in good shape. If you start running into trouble with a decision, though, don't ever be afraid to change designs and rework things.

Q: What happens when I can't decide between a couple of good design choices?

A: You always have to make a choice, even if you're not 100% sure if it's the right one. It's always better to take your best guess, and see how things work out, rather than spend endless hours debating one choice or another. That's called analysis paralysis, and it's a sure way to not get anything done. It's much better to start down one path, even if you're not totally sure it's the right one, and get some work done, than to not make a choice at all.

Good software is built iteratively. Analyze, design, and then iterate again, working on smaller and smaller parts of your app.

Each time you iterate, reevaluate your design decisions, and don't be afraid to CHANGE something if it makes sense for your design.

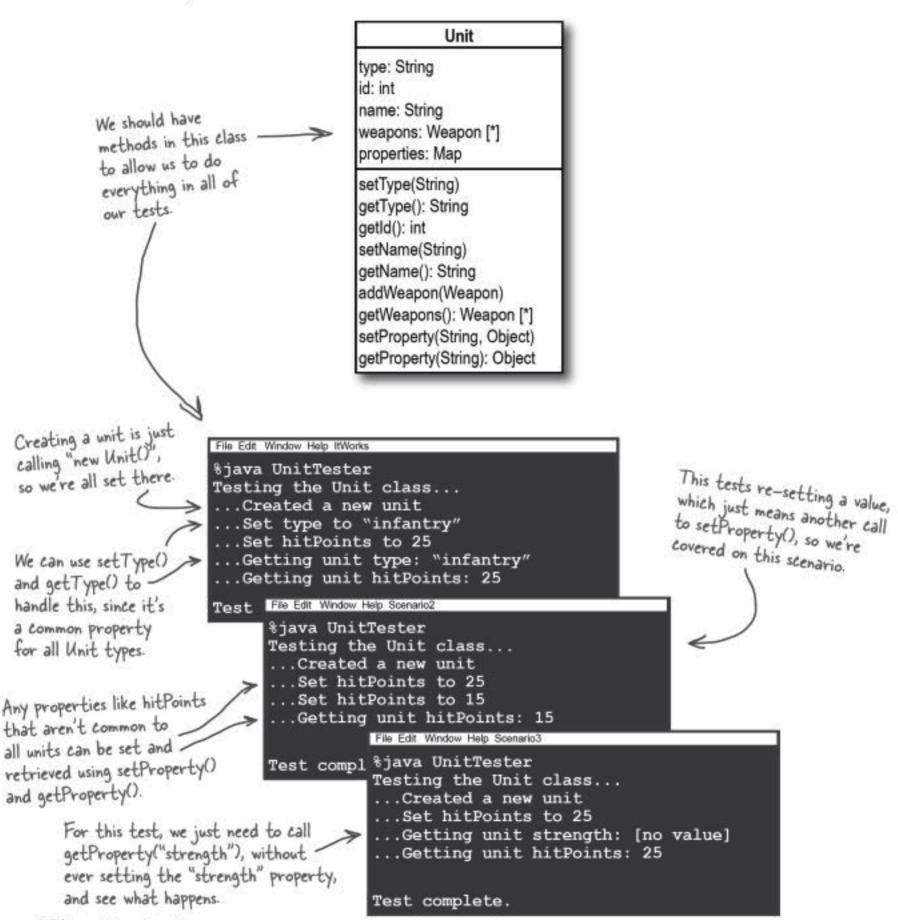
Unit properties

Unit movement

Unit groups

Match your tests to your design

We've got test scenarios we want to show Gary, and a design for the **Unit** class. The last thing we need to do before coding is to make sure our design for **Unit** will allow us to code a solution that passes all the tests.



Let's write the Unit class

It's been two chapters in coming, but we're finally ready to write the code for the Unit class. Here's how we did it:



```
package headfirst.gsf.unit;
public class Unit (
  private String type;
  private int id:
  private String name;
  private List weapons;
  private Map properties;
                              We take the ID of the Unit
                              in through the constructor ...
  public Unit(int id) (
    this.id = id;
                             ... so we only need a getld(),
                              and not a set(d() as well.
  public int getId()
    return id;
                                                  We didn't list the code for
                                                  these simple getters and
                                                  setters to save a little space.
  // getName() and setName() methods
  // getType() and setType() methods
                                                                          You'll need a simple Weapon
                                                                           class to make this code
  public void addWeapon(Weapon) weapon)
                                                                           compile. We created an
    if (weapons == null) {
                                                                           empty Weapon java, with no
                                               We wait until there's a
      weapons = new LinkedList();
                                               need for a weapons list to
                                                                           methods, for testing.
                                               instantiate a new List That
    weapons.add(weapon);
                                              saves a little bit of memory,
                                              especially when there may be
  public List getWeapons() {
                                              thousands of units.
    return weapons;
  public void setProperty(String property, Object value) {
    if (properties == null) {
                                                          Just like the weapons List, we
      properties = new HashMap(); <
                                                           don't create a HashMap for
                                                           properties until it's needed.
    properties.put(property, value);
  public Object getProperty(String property) {
    if (properties == null) {
       return null;
                                                    Since properties might not be
                                                   initialized, there's an extra
    return properties.get (property); __
                                                   check here before looking up a
                                                   property's value.
```



Test cases dissected...

We've talked a lot about test cases, but so far, you haven't seen how to actually write one. Let's examine a test case up close, and see exactly what makes up a good test.

Each test case should have an ID and a name.

The names of your test cases should describe what is being tested. Test names with nothing but a number at the end aren't nearly as helpful as names like testProperty() or testCreation(). You should also use a numeric ID, so you can easily list your tests cases out (something we'll do on the next page).

Each test case should have one specific thing that it tests.

> Each of your test cases should be atomic: each should test only one piece of functionality at time. This allows you to isolate exactly what piece of functionality might not be working in your application.

Each test case should have an input you supply. You're going to give the test case a value, or a set of values,

Each test case should have an output that you expect.

> Given your input, what should the program, class, or method output? You'll compare the actual output of the program with your expected output, and if they match, then you've got a successful test, and your software works.

that it uses as the test data. This data is usually then used to execute some specific piece of functionality or behavior.

> This is what you want the program to output. So if you set type to "infantry", and then call getType(), your exepcted output is "infantry".

Most test cases have a starting state.

Do you need to open a database connection, or create a certain object, or set some values before running your test? If so, that's all part of the starting state of the test case, and needs to be handled before you run the actual test.

There's not much starting state for the Unit class. We do need to create a new Unit, but that's about it.

One piece of functionality may involve one method, two methods, or even multiple classes ... but to start with,

focus on very simple pieces of

functionality, one at a time.

Try not to refer to

Use descriptive names

whenever possible.

tests as testl, test2, etc.

If you're setting hitPoints to 15, then "15" becomes the input you supply to your test case.

Sharpen your pencil

Design your test cases.

Below is a table with 5 columns, one for each of the 5 important parts of a test case. Your job is to fill in the table with information for the test cases we've laid out in this chapter already. We've even done the first one to help get you started, and filled in a few empty spots on the rest of the tests.

This test sets the "type" property to a value of "infantry."

Remember, there's a difference between a common property like type, and unit-specific properties.

ID	What we're testing	Input	Expected Output	Starting State
1	Setting/Getting the type property	"type", "infantry"	"type", "infantry"	Existing Unit object
		"hitPoints", 25		
		2 6 3		Existing Unit object with hitPoints set to 25
4		10.10		

There are actually 4 individual things being tested in these three scenarios.

File Edit Window Help ItWorks

The first

Set hitPoints to 25

Getting unit type: "infant

Getting unit hitPoints: 25

Test complete.

Test complete.

File Edit W

% java

"type" property,
as shown here.

Testing...Cre

```
%java UnitTester
Testing the Unit class... File Edit Window Help Scenario2
...Created a new unit
...Set type to "infantry" Testing the Unit
...Set hitPoints to 25
```

...Set type to "infantry" Testing the Unit class...
...Set hitPoints to 25 ...Created a new unit
...Getting unit type: "infantry ...Set hitPoints to 25
...Getting unit hitPoints: 25 ...Set hitPoints to 15

... Getting unit hitPoints: 15

File Edit Window Help Scenario3

%java UnitTester
Testing the Unit class...
...Created a new unit
...Set hitPoints to 25

...Getting unit strength: [no value]

...Getting unit hitPoints: 25

Test complete.



Design your test cases.

Below is a table with 5 columns, one for each of the 5 important parts of a test case. Your job was to fill in the table with information for the test cases we've laid out in this chapter already.

In most of our tests, we want as output exactly what we supplied as input

You should have --one test case
for working
with common
properties, and
one for working
with unit—
specific ones.

ID	What we're testing	Input	Expected Output	Starting State
Ę	Setting/Getting a common property	"type", "infantry"	"type", "infantry"	Existing Unit object
2	Setting/Getting a unit- specific property	"hitPoints", 25	"hitPoints", 25	Existing Unit object
3	Changing an existing property's value	"hitPoints", 15	"hitPoints", 15	Existing Unit object with hitPoints set to 25
4	Getting a non-existent property's value	N/A	"strength", no value	Existing Unit object without strength value

The entire point of this test is to not supply a value for a property, and then try and retrieve that property's value.

Did you figure out that you needed to make sure there was no property with a previous value for this test case?

Dumb Questions

How did our three test scenarios turn into four test cases?

A: Because the first test case really tested two things: setting and retrieving a common property, which has its own variable and access method (like getType()), and setting a retrieving a unit- or game-specific property, which is accessed through getProperty() (like hitPoints). That's two pieces of functionality, so two different test cases are required.

Q: And all these tests will let us know that our software works like it should, right?

A: It's a good start on that, yes, but remember, we started out writing the tests so that we could prove to the customer that the software we've been writing actually will work. Our test cases let the customer see some code actually running, as well as help us find bugs in our code before we get too far along in our development cycle.



Now that you know what test cases are, and have several written up in table form, you're ready to code a test class to show your customer that your software works, and prove to yourself that there aren't any bugs in the code that you've written.

The problem:

Gary wants to know that you're making progress on supporting units in his game system framework, and you want to be sure that the code you've written for **Unit.java** works properly.

Your task:

- Oreate a new class called UnitTester.java, and import the Unit class and any related classes into it.
- Add a new method for each test case you figured out from the table on page 456. Be sure to use descriptive names for the test methods.
- Each test method should take in an instance of Unit with any starting state already set, and any other parameters you think you'll need to run the test and compare an input value with an expected output value.
- The test method should set the supplied property name and property value on the provided Unit, and then retrieve the expected output property value using the expected output property name.
- 6 If the provided input value and expected output value match, the method should print out "Test passed"; if they don't match, the method should print "Test failed", along with the mismatched values.
- Write a main () method that sets up the starting state for each test, and then runs each test.

Bonus Credit:

- There are several things in Unit.java that are not being tested by the scenarios on page 456. Identify what each of these are, and create a test method for each.
- Run these tests from your main () method as well.

UnitTester.java



public class UnitTester {

Test Puzzle Solutions

Here's the class we wrote to test the Unit class.

```
public void testType(Unit unit, String type, String expectedOutputType) {
               System.out.println("\nTesting setting/getting the type property.");
               unit.setType(type);
               String outputType = unit.getType();
                                                                 Most tests end with a
Each test
               if (expectedOutputType.equals(outputType))
                                                                 comparison of the expected
method has
                 System.out.println("Test passed");
                                                                 output and the actual output
different
               } else {
parameters, since
                 System.out.println("Test failed: " + outputType + " didn't match " +
each method is
                   expectedOutputType);
                                                                            Properties stored in the Map
testing different ;
                                                                           take Objects as input and
things in the
Unit class.
    public void testUnitSpecificProperty(Unit unit, String propertyName,
                                Object inputValue, Object expectedOutputValue) { <
               System.out.println("\nTesting setting/getting a unit-specific property.");
               unit.setProperty(propertyName, inputValue);
               Object outputValue = unit.getProperty(propertyName);
               if (expectedOutputValue.equals(outputValue)) {
                 System.out.println("Test passed");
               | else {
                 System.out.println("Test failed: " + outputValue + " didn't match " +
                   expectedOutputValue);
                                                                This test is almost identical to test2(),
                                                                because the starting state takes care of
                                                               - pre-setting the property to another value.
            public void testChangeProperty(Unit unit, String propertyName,
                                Object inputValue, Object expectedOutputValue) {
  This test
               System.out.println("\nTesting changing an existing property's value.");
  assumes
               unit.setProperty(propertyName, inputValue);
  you've set
               Object outputValue = unit.getProperty(propertyName);
  the starting
               if (expectedOutputValue.equals(outputValue)) {
   state
                 System.out.println("Test passed");
   correctly...
   otherwise, it
                 System.out.println("Test failed: " + outputValue + " didn't match " +
   will ALWAYS
                   expectedOutputValue);
   fail.
                                                                                         Unit-
```

```
This last test doesn't need an input value,
                                                                                      iterating and testing
                        because that's what is being tested for: a
                        property without a preset value.
                 public void testNonExistentProperty(Unit unit, String propertyName) {
                   System.out.println("\nTesting getting a non-existent property's value.");
                   Object outputValue = unit.getProperty(propertyName);
                   if (outputValue == null) {
                     System.out.println("Test passed");
                   | else {
                     System.out.println("Test failed with value of " + outputValue);
                                                                            hitPoints is set to 25 in
                                                                            testUnitSpecificProperty(), so
                 public static void main(String args[]) {
                                                                            we can call testChangeProperty()
                   UnitTester tester = new UnitTester();
All our main()
                                                                            knowing that the value will be reset
                   Unit unit = new Unit(1000);
method needs to
                                                                            in that test case. =
do is create a new
                   tester.testType(unit, "infantry", "infantry");
Unit, and then run
                   tester.testUnitSpecificProperty(unit, "hitPoints",
through the tests
                                                     new Integer (25), new Integer (25));
                   tester.testChangeProperty(unit, "hitPoints",
                                                new Integer (15), new Integer (15));
                   tester.testNonExistentProperty(unit, "strength");
```

And now for some bonus credit...

We added three new test cases to our table, to handle the three properties common to all units that aren't tested in UnitTester. You should be able to write three additional test methods based on this table. Did you figure these out on your own?

This test case doesn't test <u>all</u> common properties; it just tests the type property. We need to test all three of the other common properties, since each uses its own specific methods.	ID	What we're testing	Input	Expected Output	Starting State
	1	Setting/Getting the type property	"type", "infantry"	"type", "infantry"	Existing Unit object
	2	Setting/Getting a unit- specific property	"hitPoints", 25	"hitPoints", 25	Existing Unit object
	3	Changing an existing property's value	"hitPoints", 15	"hitPoints", 15	Existing Unit object with hitPoints set to 25
	4	Getting a non-existent property's value	N/A	"strength", no value	Existing Unit object without strength value
	5	Getting the id property	N/A	1000	Existing Unit object with an id of 1000
	Ь	Setting/getting the name property	"name", "Damon"	"name", "Damon"	Existing Unit object
	7	Adding/getting weapons	Axe object	Axe object	Existing Unit object

Prove yourself to the customer

With a **Unit** class and a set of test cases, you're ready to show Gary some working code, and prove that you're on the right track to building his game system framework just the way he wants it. Let's show him the test class running:

Test classes aren't supposed to be exciting or sexy... they just need to prove that your software does what it's supposed to do.

File Edit Window Help ProveToMe

%java UnitTester

Testing setting/getting the type property. Test passed

Testing setting/getting a unit-specific property.

Test passed

Testing changing an existing property's value.

Test passed

Testing getting a non-existent property's value.

Test passed

This is great! You really do know what you're doing. I'll put a check in the mail, and you just keep on with the Unit class. Do you have units moving around the board yet?

Customers that see <u>running</u> <u>code</u> tend to get happy, and keep paying you. Customers that only see diagrams get impatient and frustrated, so don't expect much support or cash.



It's not perfect for me—I don't need your framework returning null all the time, and my guys having to check for it. We'll write our code correctly, so if your framework gets asked for a property that doesn't exist, just throw an exception, OK?

Let's change the programming contract for the game system

When you're writing software, you're also creating a contract between that software and the people that use it. The contract details how the software will work when certain actions are taken—like requesting a non-existent property on a unit.

If the customer wants an action to result in different behavior, then you're changing the contract. So if Gary's framework should throw an exception when a non-existent property is queried, that's fine; it just means that the contract between game designers and the framework has changed.



Meet Sue. She manages a team of top-notch game developers, and they're interested in using Gary's game framework.

When you program by contract, you and your software's users are agreeing that your software will behave in a certain way.

Want to know more about what this means? Turn the page to find out more...

We've been programming by contract so far

You probably didn't notice, but we've been doing something called **programming by contract** in the **Unit** class so far. In the **Unit** class, if someone asks for a property that doesn't exist, we've just returned null. We've been doing the same thing in **getWeapons()**; if the **weapons** list isn't initialized, we just return null there, too:

The decisions we're making now affect the Unit class and how we handle non-existent properties, so we're still on this first bit of Unit functionality.

Unit movement

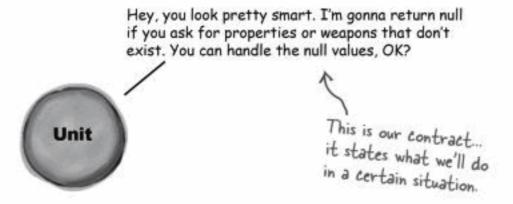
Unit groups

Unit properties



This is the contract for Unit

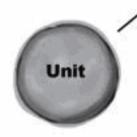
The Unit class assumes that people using it are competent programmers, and that they can handle null return values. So our contract states something like this:



Programming by contract is really all about trust

When you return null, you're **trusting** programmers to be able to deal with null return values. Programmers are basically saying that they've coded things well enough that they won't ask for non-existent properties or weapons, so their code just doesn't worry about getting null values back from the **Unit** class:

Hey, you look pretty smart. I'm gonna return null if you ask for properties or weapons that don't exist. You can handle the null values, OK?



Look, we know what we're doing. Our code will only ask you for properties that exist. So just return null... trust us to do the right thing, OK?

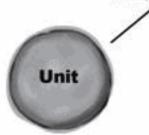
And we can always change the contract if we need to...

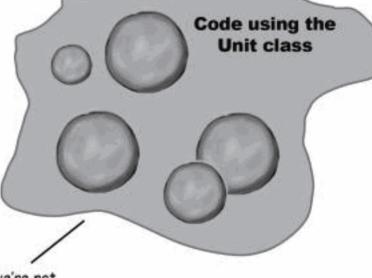
Back on page 461, we were asked to stop returning null, and throw an exception instead. This really isn't a big change to the contract; it just means that now game designers are going to have big problems if they ask for non-existent properties or weapons.



You know what? We're really confident we're not going to ask you for non-existent properties. In fact, if we do, just throw an exception, and it will crash the program, and we'll hunt down the bug. Trust us... throwing an exception is no problem.

Sure. As long as you know I'm going to start throwing an Exception, we're good to go. I'll just change my code, and we'll start using this new contract.





But if you don't trust your users...

But what happens if you don't think your code will be used correctly? Or if you think that certain actions are such a bad idea that you don't want to let users deal with them in their own way? In these cases, you may want to consider **defensive programming**.

Suppose you were really worried that game designers using the Unit class, and asking for non-existent properties, were getting null values and not handling them properly. You might rewrite the **getProperty()** method like this:

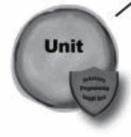


```
public Object getProperty(String property)
                 throws IllegalAccessException
                 if (properties == null) (
                  return null:
                   throw new IllegalAccessException(
We don't
                     "What are you doing? No properties!");
return null
anymore... we
                -return properties.get (property) /
make a BIG
                 Object value = properties.get(property);
deal about
                 if (value == null) {
asking for a
                 throw new IllegalAccessException(
non-existent
                     "You're screwing up! No property value.");
 property.
                 } else (
                   return value;
                                                           Unit.java
```

This version of getProperty() can throw a <u>CHECKED</u> exception, so code using Unit will have to catch this exception.

This is a <u>defensive</u> version of Unit.java.

I'm sure you're great code and all, but I just don't trust you. I could send you null, and you could totally blow up. So let's just be safe, and I'll send you a checked exception that you'll have to catch, to make sure you don't get a null value back and do something stupid with it.



Defensive programming assumes the worst, and tries to protect itself (and you) against misuse or bad data.

-or if they don't trust you...

Of course, when programmers use your code, they might not trust you either... they can program defensively as well. What if they don't believe that you'll only return non-null values from getProperty()? Then they're going to protect their code, and use defensive programming, as well:

```
Here's a sample of code that uses the Unit class.
```

```
// Some method goes out and gets a unit
Unit unit = getUnit();

// Now let's use the unit...
String name = unit.getName();
if ((name != null) && (name.length() > 0)) {
    System.out.println("Unit name: " + name);
}
Object value = unit.getProperty("hitPoints");
if (value != null) {
    try {
        Integer hitPoints = (Integer) value;
        ) catch (ClassCastException e) {
            // Handle the potential error
        }
}
// etc...
```

Dumb Questions

You said on page 463 that we could change the contract to throw an exception, but then you said here that throwing an exception is defensive programming. I'm confused...

A: It's really not that important what kind of exception is thrown. What's important is how your customers and clients are involved in that decision. In programming by contract, you work with the client to agree on how you're going to handle problems; in defensive programming, you make that decision in a way that ensures your code doesn't crash, regardless of what the client wants to have happen.

When we decided to switch from returning null to throwing an exception, we did that by listening to the client, and agreeing on that particular action as a response to a request for non-existent properties. And we made the exception a RuntimeException, again because the client didn't want to add lots of try/catch blocks to their code. They could have just as easily asked for a checked exception, and we could have agreed—and still been programming by contract.

Compare that to defensive programming, where we're not really that interested in what the client wants. In defensive programming, we're making sure that we aren't responsible for crashing a program, and we even go out of our way to try and prevent the client from crashing their program.



Tonight's talk: Programming by Contract and Defensive Programming duke it out over trust issues with programmers.

Programming by Contract

It's nice to sit down with you and meet face to face, we really don't see each other like this very often.

What do you mean?

Well, sure, I guess... but you can't live your whole life in fear of bad code. At some point, you have to just commit to how you're going to behave, and trust other programmers to use you right.

Boy, it sounds like you have trust issues.

No. I trust programmers understand the contract that I provide them.

Defensive Programming

Yeah, I really don't like to get out much. There's just so much that can go wrong.

Well, I could be crossing the street, and slip on some Banana.peel() that hadn't been garbage collected, or some for loop without a good termination condition could come screaming through the intersection... there's a lot of bad code out there, you know?

Are you kidding me? Have you met most of the programmers writing the code you're talking about trusting? They're too busy watching Lost to worry about checking for bugs in their software. If they'd stop gawking at that Kate and her freckles, maybe I wouldn't have to double-check their work so much.

And you don't?

Contract? Oh, you still think that if you explain what you'll do in a certain situation, that a "good" programmer will use you correctly? Boy, what naivete!

Programming by Contract

Look, my contract explicitly states what I have to do, and what people that use me have to do.

Look, if programmers and users don't keep their end of the bargain, I can't be held responsible for that. If they violate the contract, they deserve what they get. I can't be held liable.

With tons of extra code, little "if (value == null)" checks everywhere? What a beating. Sounds like you slow things down more than anything.

Superman? You did not just say that...

But that's the point! I may not be great for lazy programmers, but I'm terrific for programmers who do check their work. They get a performance bump, and their code is shorter when they use me.

And that's what I provide, just without all the trust issues and baggage you bring along...

...transmission ended... Veuillez nous aider! ... 4 8 15 ...

I'll show you safe code, you little...

Defensive Programming

Haven't you heard? Over 50% of contracts today end in divorce... or maybe that was a different stat, I'm not sure... anyway, do you really think programmers are paying attention to your little contract?

Sounds pretty callous to me. I try and help my users, and even protect them from themselves.

Sure, sometimes I'm not the best performer, but I sure keep everyone safe from disaster. I often like to think of myself... a bit like Superman.

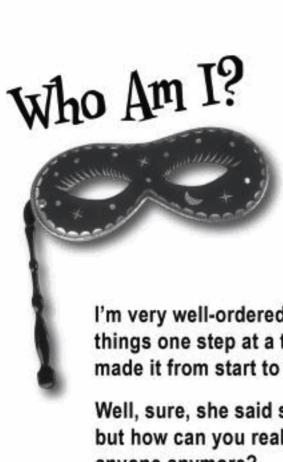
It's true! Besides, how many times has your code gone up in smoke because of a lazy programmer who ignored your contract?

Short code, humph. I'd much rather have good code. Code that keeps programmers and users safe.

Hey, I've got a trust issue for you right here...

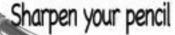
you are here >

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Feature Driven Development, Use Case Driven Development, Programming by Contract, and Defensive Programming have all showed up for a masquerade party, but none of them bothered to wear name tags. They're all a chatty bunch, though, so it's up to you to listen to what they're saying, and try and figure out who's behind the masks. Be careful.... sometimes more than one masked guest could be saying the same thing.

→ Figure out who is who on page 481.



Change the programming contract for Unit.

Gary's clients want Unit to assume they're using it correctly. That means that if a non-existent property is being queried, then something has truly gone wrong in the game, and an exception needs to be thrown. Your job is to:

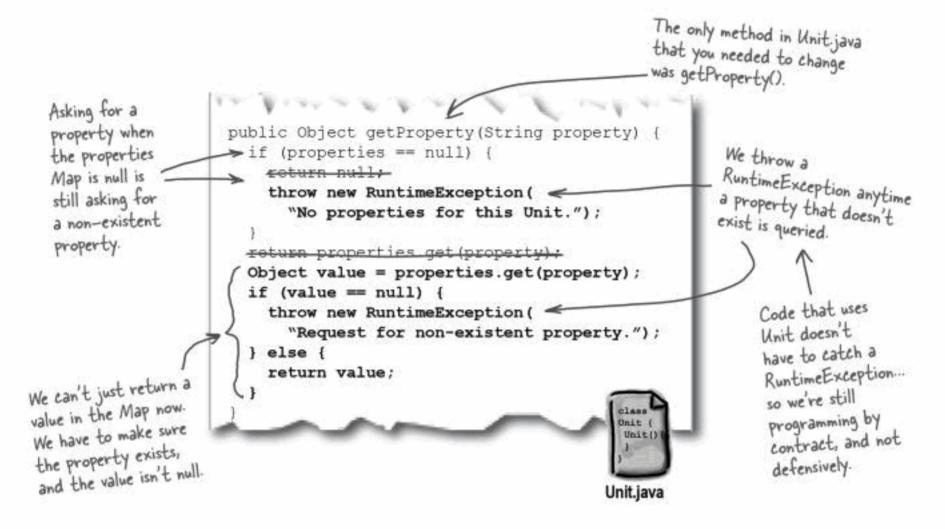
- Update Unit.java so that requests for a non-existent property result in an exception being thrown. Figuring out the type of exception to use is up to you.
- Update UnitTester and the test cases that this contract change affects to reflect this new contract.
- 3. Re-run UnitTester and make sure Unit.java still passes all of the tests.

Our answers are on the next page



Change the programming contract for Unit.

Gary's clients want Unit to assume they're using it correctly. That means that if a non-existent property is being queried, then something has truly gone wrong in the game, and an exception needs to be thrown.



Dumb Questions

Why are you throwing a RuntimeException, and not a checked exception, like IllegalAccessException?

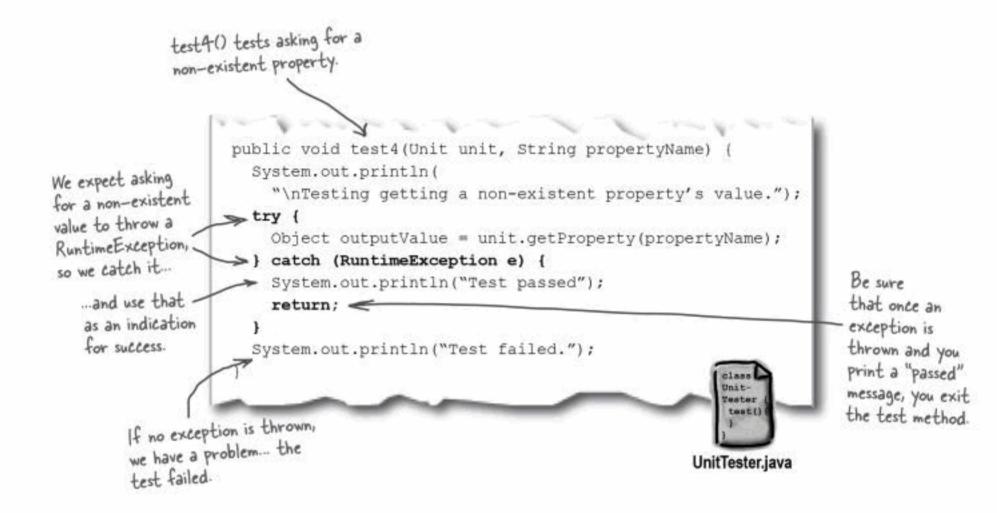
A: If you used a checked exception, code that calls getProperty() would have to check for that exception, in try/catch blocks. That's not what the client wanted; we agreed to a contract that would let them code without having to catch for any exceptions. So by using a RuntimeException, no extra worked is required for their client code to use the Unit class.

What about the get methods for other properties, like weapons, name, and id?

A: id and name are an int and String, respectively, so those aren't a problem (id is reuired to create a new Unit, and name will either be null or a String with a value). The weapons property is a List, so if you call getWeapons () when there aren't any it's going to result in a null list being returned. You could change that method to throw an exception if the weapons list was empty, although that wasn't specifically asked for by the clients.

When you are programming by contract, you're working with client code to agree on how you'll handle problem situations.

When you're programming defensively, you're making sure the client gets a "safe" response, no matter what the client wants to have happen.



Q: You said that programming by contract resulted in less code, but it seems like we just added a lot of code to Unit.java.

A: That's because instead of directly returning null, we throw a new RuntimeException. But that's more of a special case here than the rule. Most of the time, you'll not have much extra code on the service side, because you're simply returning objects and values without checking to see if they're non-null, or within a particular data range.

Q: I still don't see why we're switching to programming by contract here. Why is it so much better?

A: It's not a matter of being better or worse; it's a matter of what your customer wants. In fact, you'll rarely decide on your own if you want to do programming by contract or defensive programming. That's something that's usually determined by what your customer wants, and the types of users that will be using the software that you're writing.

Unit properties

Unit movement Unit groups

Moving units

We've finally finished up unit properties, and can move on to the next item on our list:

It took a while, but we're finally on to the next piece of functionality in the Unit class.



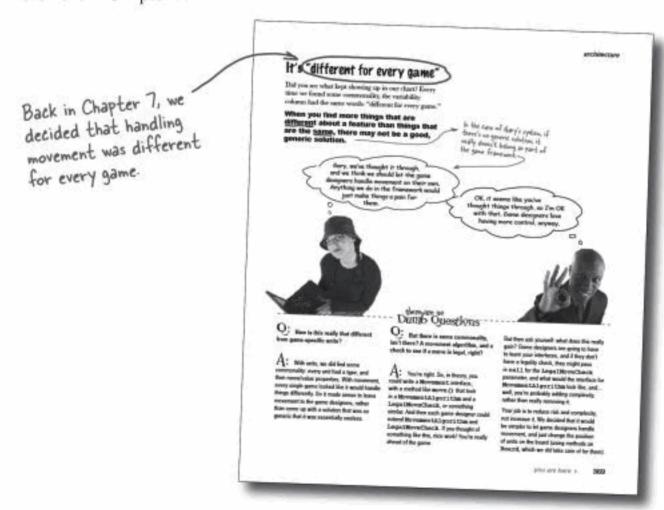
Each unit should have properties, and game designers can add new properties to unit types in their own games.

We're on to dealing with movement, now. Units have to be able to move from one tile on a board to another.

Units can be grouped together into armies.

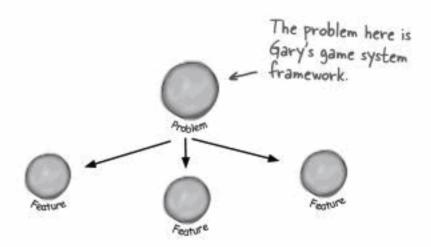
Haven't we been here before?

This should sound pretty familiar... we already dealt with movement in Chapter 7:



Break your apps up into smaller chunks of functionality

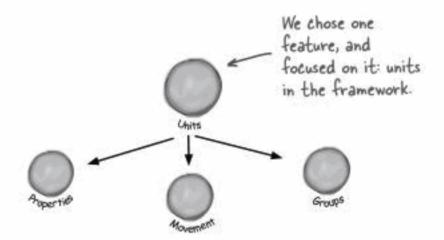
We've been talking a lot about iterating deeper into your application, and at each stage, doing more analysis and design. So you're taking each problem, and then breaking it up (either into use cases or features), and then solving a part of the problem, over and over. This is what we've been doing in this chapter: taking a single feature, and working on that feature until it's complete.



But you can still break things up further...

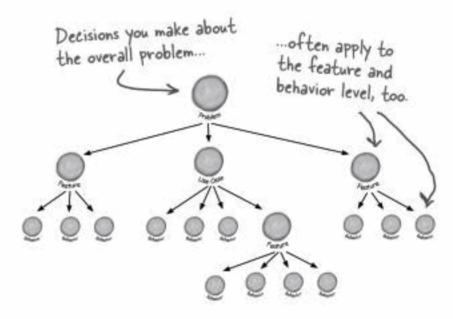
But once you choose a single feature or use case, you can usually break that feature up into even smaller pieces of behavior. For example, a unit has properties and we have to deal with unit movement. And we also need to support groupings of units. So each of these individual pieces of behavior has to be dealt with.

Just like when you broke your app up and began to iterate, you'll have to do more analysis and design at each step. Always make sure your earlier decisions make sense, and change or rework those decisions if they don't.



Your decisions can iterate down, too

Lots of times you'll find that decisions you made earlier save you work down the line. In Gary's system, we decided that game designers would deal with movement on their own. So now that we're talking about how to handle unit movement, we can take that decision we made earlier, and apply it here. Since it still seems sensible—there's no reason to change that decision—we can have game designers worry about handling unit movement, and move on to the next piece of behavior.



Just add a note to your does for the game designers that movement is up to them.

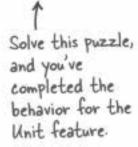
Units have to be able to move from one tile on a board to another.

 We can check off this next bit of behavior in the Unit class.



Feature Puzzle

By now, you should have feature driven development, iteration, analysis, and design down pretty solid. We're going to leave it up to you to handle the last bit of behavior and finish off the Unit feature of Gary's game system framework.



The problem:

Gary's framework needs to support groups of units.

Your task:

- Create a new class that can group units together, and both add and remove units to the group.
- Fill out the table below with test case scenarios that will test your software, and prove to Gary that the grouping of units works.
- Add methods to UnitTester to implement the test scenarios in the table, and make sure all your tests pass.

A
(
There's no
guarantee that you'll use all these rows or that
you won't need
more rows.
7

ID	What we're testing	Input	Expected Output	Starting State
89		111		
- 09		÷		
53				
	*	5	1	
+			 	
2		4.		

See how we solved the puzzle on page 476.



- The first step in writing good software is to make sure your application works like the customer expects and wants it to.
- Customers don't usually care about diagrams and lists; they want to see your software actually do something.
- Use case driven development focuses on one scenario in a use case in your application at a time.
- In use case driven development, you focus on a single scenario at a time, but you also usually code all the scenarios in a single use case before moving on to any other scenarios, in other use cases.
- Feature driven development allows you to code a complete feature before moving on to anything else.
- You can choose to work on either big or small features in feature-driven development, as long as you take each feature one at a time.
- Software development is always iterative.
 You look at the big picture, and then iterate down to smaller pieces of functionality.
- You have to do analysis and design at each step of your development cycle, including when you start working on a new feature or use case.

- Tests allow you to make sure your software doesn't have any bugs, and let you prove to your customer that your software works.
- A good test case only tests one specific piece of functionality.
- Test cases may involve only one, or several, methods in a single class, or may involve multiple classes.
- Test driven development is based on the idea that you write your tests first, and then develop software that passes those tests. The result is fully functional, working software.
- Programming by contract assumes both sides in a transaction understand what actions generate what behavior, and will abide by that contract.
- Methods usually return null or unchecked exceptions when errors occur in programming by contract environments.
- Defensive programming looks for things to go wrong, and tests extensively to avoid problem situations.
- Methods usually return "empty" objects or throw checked exceptions in defensive programming environments.

worth having units stored by ID.



Feature Puzzle Solutions

Gary's framework needs to support groups of units, and should also allow groups of those groups (in as many nestings as the game designer wants to allow).

```
You create a new UnitGroup by
                     public class UnitGroup {
                                                                    passing in a List of the units to add
We decided to use a
                     private Map units;
                                                                    to the group initially.
Map, storing the ID
of a unit as the key,
                       public UnitGroup (List unitList) {
and the Unit object
                          units = new HashMap();
itself as the value of
                          for (Iterator i = unitList.iterator(); i.hasNext(); ) {
an entry.
                            Unit unit = (Unit)i.next();
                                                                       The constructor just adds all the units
                            units.put(unit.getId(), unit);
                                                                        to its units Map, setting the key of
                                                                        each entry to the ID of each unit.
                       public UnitGroup() {
                                                                     Here's the class diagram for
                          this (new LinkedList());
                                                                     UnitGroup, to give you an overview
                                                                     of what we did.
                       public void addUnit (Unit unit) {
                                                                                             UnitGroup
                          units.put(unit.getId(), unit);
                                                                                     units: Map
                                                                                     addUnit(Unit)
                       public void removeUnit(int id) {
                                                                                     removeUnit(int)
                          units.remove(id);
   By using a Map
                                                                                     removeUnit(Unit)
   of units, we can
                                                                                     getUnit(int): Unit
                       public void removeUnit(Unit unit) {
   retrieve and
                                                                                     getUnits(): Unit [*]
                          removeUnit(unit.getId());
   remove units by
   their ID, which
   is a nice bit of
                     public Unit getUnit(int id) {
   functionality.
                          return (Unit)units.get(id);
                       public List getUnits() {
                          List unitList = new LinkedList();
                          for (Iterator i = units.entrySet().iterator(); i.hasNext(); )
                            Unit unit = (Unit)i.next();
                            unitList.add(unit);
                                                                There's a little bit of work
                                                                   in returning a list of all units,
                          return unitList;
                                                                   since we store the units in a
                                                                   Map, but we thought it was
```

And now for the test cases:

We started the IDs higher, so they wouldn't conflict with the IDs of the test cases we already have.

- 1	/
/	
(
-	-
	_

ID	What we're testing	Input	Expected Output	Starting State
10	Creating a new UnitGroup from a list of units	List of units	Same list of units	No existing instance of UnitGroup
11	Adding a unit to a group	Unit with ID of 100	Unit with ID of 100	UnitGroup with no entries
12	Getting a unit by its ID	100	Unit with ID of 100	UnitGroup with no entries
13	Getting all the units in a group	N/A	List of units that matches initial list	UnitGroup with a known list of units
14	Removing a unit by the ID of the unit	100	List of units (none with ID of 100)	UnitGroup with no entries
15	Removing a unit by the Unit instance	Unit with 1D of 100	List of units (none with ID of 100)	UnitGroup with no entries

1

Here are the test cases for UnitGroup that we came up with. Did you think of any others? We like to start with an empty UnitGroup, to make sure the units we're working with don't already appear in the MunitGroup.



You should be able to write the code for UnitTester using the test case table shown here. If you want to see how your code compares with ours, visit http://www.headfirstlabs.com, click on Head First OOA&D, and look for "UnitGroup Test Cases."

Tools for your OOA&D Toolbox

We learned about several approaches to iterating through your project, and even a bit about two common programming practices in this chapter. Add all these to your toolbox:

Requirements Analysis and Design

Good requirems works like your

Well-designed software is easy to char and extend.

Make sure your

00 Principles

Encapsulate what varies.

Code to an interface rather than an implementation.

Each class in your application should have only one reason to change.

Classes Programming Practices

Classe: for me

Avoid that a locatio

Every single v

should respons

Subclas classes Programming by contract sets up an agreement about how your software behaves that you and users of your software agree to abide by.

Defensive programming doesn't trust other software, and does extensive error and data checking to ensure the other software doesn't give you bad or unsafe information.

Solving Big Problems

Listen to the customer, and figure out what they want you to build.

Put together a feature list, in language the customer understands.

Make sure your features are what the customer actually wants.

then CHA

ke encapsula

your softwe

Create blueprints of the system using use

Development Approaches

Use case driven development takes a single use case in your system, and focuses on completing the code to implement that entire use case, including all of its scenarios, before moving on to anything else in the application.

Feature driven development focuses on a single feature, and codes all the behavior of that feature, before moving on to anything else in the application.

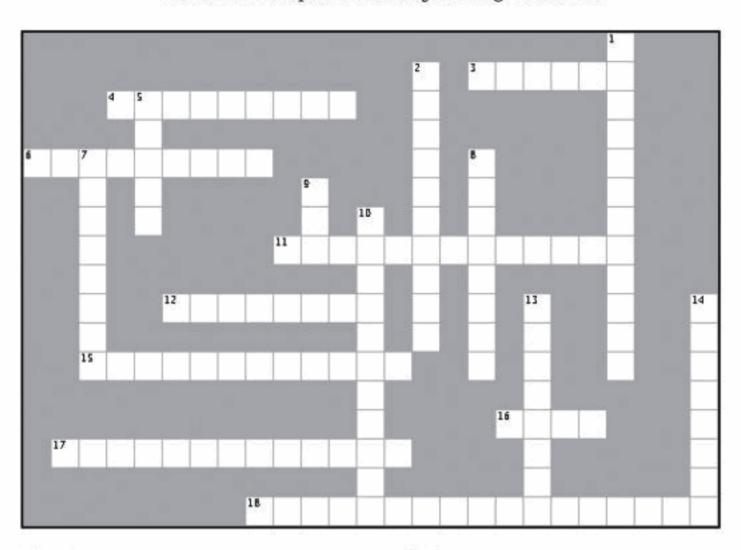
Test driven development writes test scenarios for a piece of functionality before writing the code for that functionality. Then you write software to pass all the tests.

Good software development usually incorporates <u>all</u> of these development models at different stages of the development cycle.



OOA&D Cross

Lots of new terms in this chapter, so lots of little square boxes to fill in for this chapter's crossword. Review the chapter and see if you can get them all!



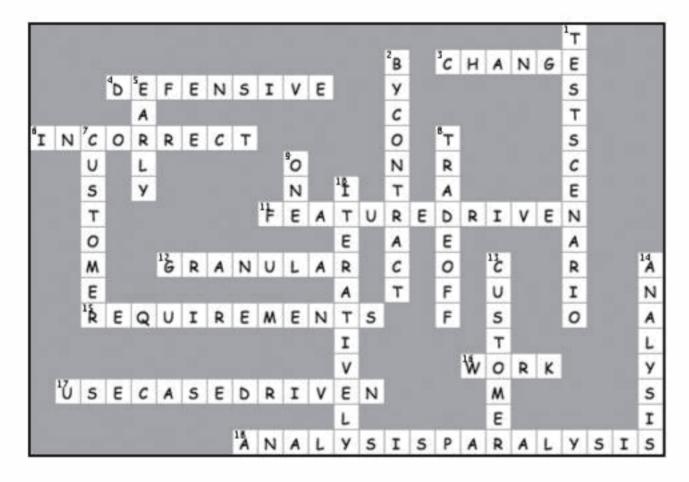
Across

- Never be afraid to do this in design.
- 4. This type of programming protects you and focuses on preventing errors and invalid data.
- You should test your software for this kind of usage.
- Iterating your development based on specific pieces of functionality.
- 12. Feature driven development is very
- 15. Good development is driven by these.
- 16. Customers just want their software to do
- Developing your software based on scenarios through a system.
- Getting stuck trying to decide on one design decision or another.

Down

- This is what you use to prove to the customer that your software works.
- Program this way when you trust your users, and they trust you.
- 5. Testing weird and strange usages of your code will help you catch errors _____.
- 7. Use case diagrams and feature lists don't make sense to the ______
- 8. Design decisions are always a _____
- A single test case can focus on this many pieces of functionality.
- 10. Great software is written like this.
- 13. You write software for the _____
- Once you choose a feature or use case, you need to do this again.







Feature Driven Development, Use Case Driven Development, Programming by Contract, and Defensive Programming have all showed up for a masquerade party, but none of them bothered to wear name tags. They're all a chatty bunch, though, so it's up to you to listen to what they're saying, and try and figure out who's behind the masks. Be careful.... sometimes more than one masked guest could be saying the same thing.

I'm very well-ordered. I prefer to take things one step at a time, until I've made it from start to finish.

Well, sure, she said she would call, but how can you really believe anyone anymore?

Oh, absolutely, requirements really get me motivated.

I'm very well-behaved. In fact, I've been focusing on all of my own behavior before moving on to anything else.

Really, it's all about my customer. I just want to satisfy them, after all.

Hey, you're a big boy. You can deal with that on your own... it's really not my problem anymore, is it?

As long as you're good with it, so am I. Who am I to tell you what to do, so long as you know what you can expect from me.

Use Case Priven Development

Pefensive Programming

Feature Priven Pevelopment, Use Case Priven Pevelopment You might have added Programming by Contract here, since a contract is really a form of requirements.

Feature Driven Development

All of them!

Programming by Contract

All of these techniques and tools are really about getting the customer the software that they want.

Programming by Contract

10 the ooa&d lifecycle

Putting It

All Together

Honey, I think you're a great programmer, but I just don't see how you're going to combine all those little bits and pieces into anything that makes sense.

You may not see it yet, Walter, but I'm going to take all these pieces and turn them into one big beautiful cake of OO goodness.

Just you wait and see...



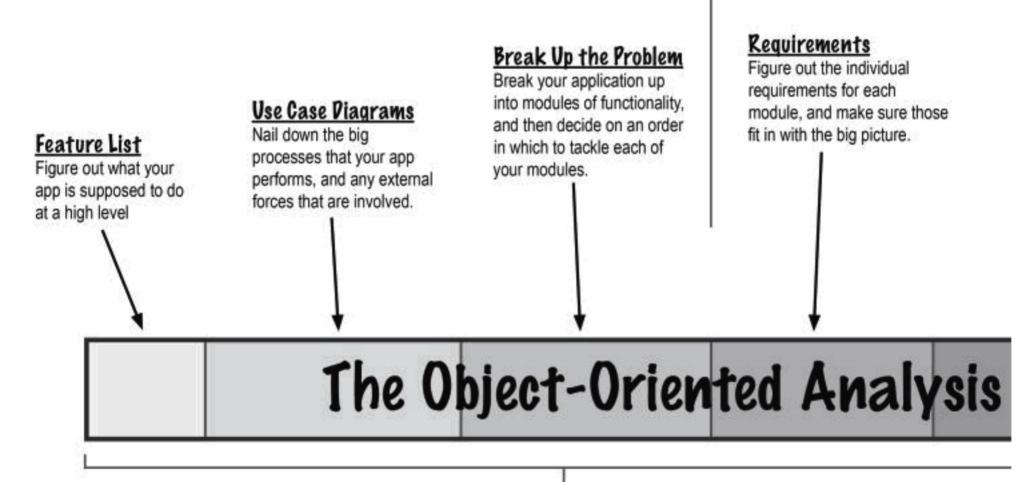
Are we there yet? We've been working on lots of individual ways to improve your software, but now it's time to put it all together. This is it, what you've been waiting for: we're going to take everything you've been learning, and show you how it's all really part of a single process that you can use over and over again to write great software.

Developing software, OOA&D style

You've got a lot of new tools, techniques, and ideas about how to develop great software by now... but we still haven't really put it all together.

That's what this chapter is all about: taking all the individual things you know how to do—like figuring out requirements, writing up use cases, and applying design patterns—and turning it into a reusable process that you can use to tackle even your trickiest software problems, over and over again.

So what does that process look like?



1. Make sure your software does what the customer wants it to do

Does it seem like you spend a LOT of time worrying about functionality? That's because you do... if the customer isn't happy with what your software does, you won't succeed.

This entire section applies to each smaller problem... so you'll solve a problem using these phases, iterate to another problem, and use these phases again.

Iterative Development

Pomain Analysis

Figure out how your use cases map to objects in your app, and make sure your customer is on the same page as you are.

Preliminary Design

Fill in details about your objects, define relationships between the objects, and apply principles and patterns.

<u>Implementation</u>

Write code, test it, and make sure it works. Do this for each behavior, each feature, each use case, each problem, until you're done.

Delivery

You're done! Release your software, submit your invoices, and get paid.

& Design Project Lifecycle

2. Apply basic 00 principles to add flexibility.

1

}

These may seem like small parts of the process, but you'll spend most of your development time in the design and implementation phases.

3. Strive for a maintainable, reusable design.

Look, I love your pretty arrows
and all those labels, but I'm not
convinced. We've used parts of that
process, but how am I supposed to
know using all those steps together
like that really works?

Let's build a software project, from start to finish, using this process.

We've used all of the different parts of this process to work on software projects throughout the book, but we haven't yet really put it all together. But that's all about to change... we're going to let you build a pretty complex piece of software in this chapter, from feature list to implementation and delivery.

Along the way, you'll see for yourself how all the things you've been learning really do help you build great software. Get ready, this will be your final test.



OOA&D GENERAL'S WARNING: Answers to this exercise do NOT appear on the next page. Go ahead and work through this chapter, and we'll come back to these answers at the end of the chapter.



00A&D Magnets

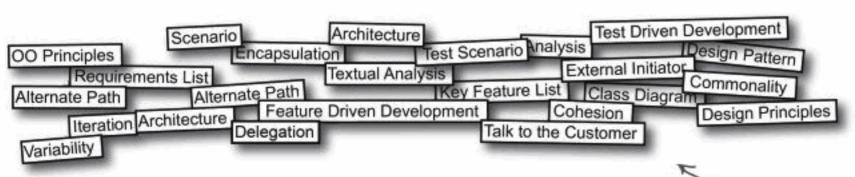
Before we dive into the problem we're going to be solving in this chapter, you need to make sure you see where all the things you've been learning fit in the big OOA&D Project Lifecycle. At the bottom of this page are OOA&D magnets for lots of the things you've learned about already; your job is to try and put those magnets on the right phase of the OOA&D lifecycle, shown again below.

You can put more than one magnet on each phase, and there are some magnets you may want to use more than once, so take your time, and good luck.

Feature Use Case Break Up the Requirements Pomain Preliminary Implementation Pelivery

List Diagrams Problem Requirements List

Textual Analysis



You can use each of these magnets as many times as you like.

The problem

Here's the project we're going to work through in this chapter, from beginning to end:



Objectville Travel, Inc. 210 Tourist Ave. Objectville, HF 90210

Statement of Work

Congratulations! Based on your amazing work for Rick's Stringed Instruments and Doug's Dog Doors, we'd like to commission you to program our brand new Objectville Travel RouteFinder.

With the recent increase in travel to Objectville, we want to provide tourists an easy way to see the wonderful sights that make Objectville so unique. The RouteFinder should be able to store Objectville's complete network of subway lines, as well as all the stations along each line. Objectville's subways are state-of-the-art, and can go backwards and forwards between stations, so you don't need to worry about the direction of any of the lines.

The RouteFinder should also be able to take a starting station, and a destination station, and figure out a route to travel. Our travel agents should be able to print out the route, indicating which lines to take, which stations are passed on a line, and when travelers may need to get off one line and get on another at a connecting station.

We pride ourselves on flexibility and extensibility in Objectville, so we expect the RouteFinder to be easy to extend as we come up with new ways to provide our tourists the best experience around in object-based travel.

We look forward to seeing your design and a working RouteFinder soon. We're all counting on you!

Orb Tralate

Orbin Traveloctic, CEO

P.S. To help you get started, we've provided a map of Objectville's subway lines, and a file with all of the stations and lines. This page left intentionally blank, so you can cut out the cool Objectville Map on the next page and hang it up on your cubicle wall.

Inote from marketing: What are you thinking? Can't we sell the poster as an add-on and charge extra?]

Objectville Subway Map

Legend

- O Local train station
- Interchange with other lines

•••••••

Booch Line

Gamma Line

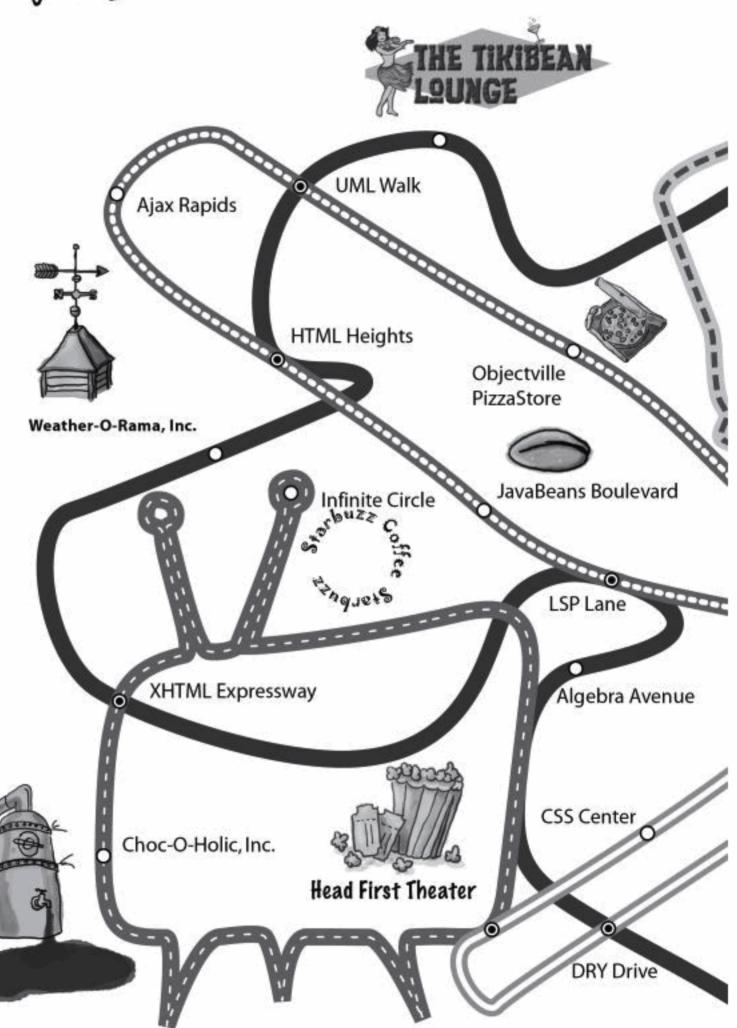
Jacobson Line

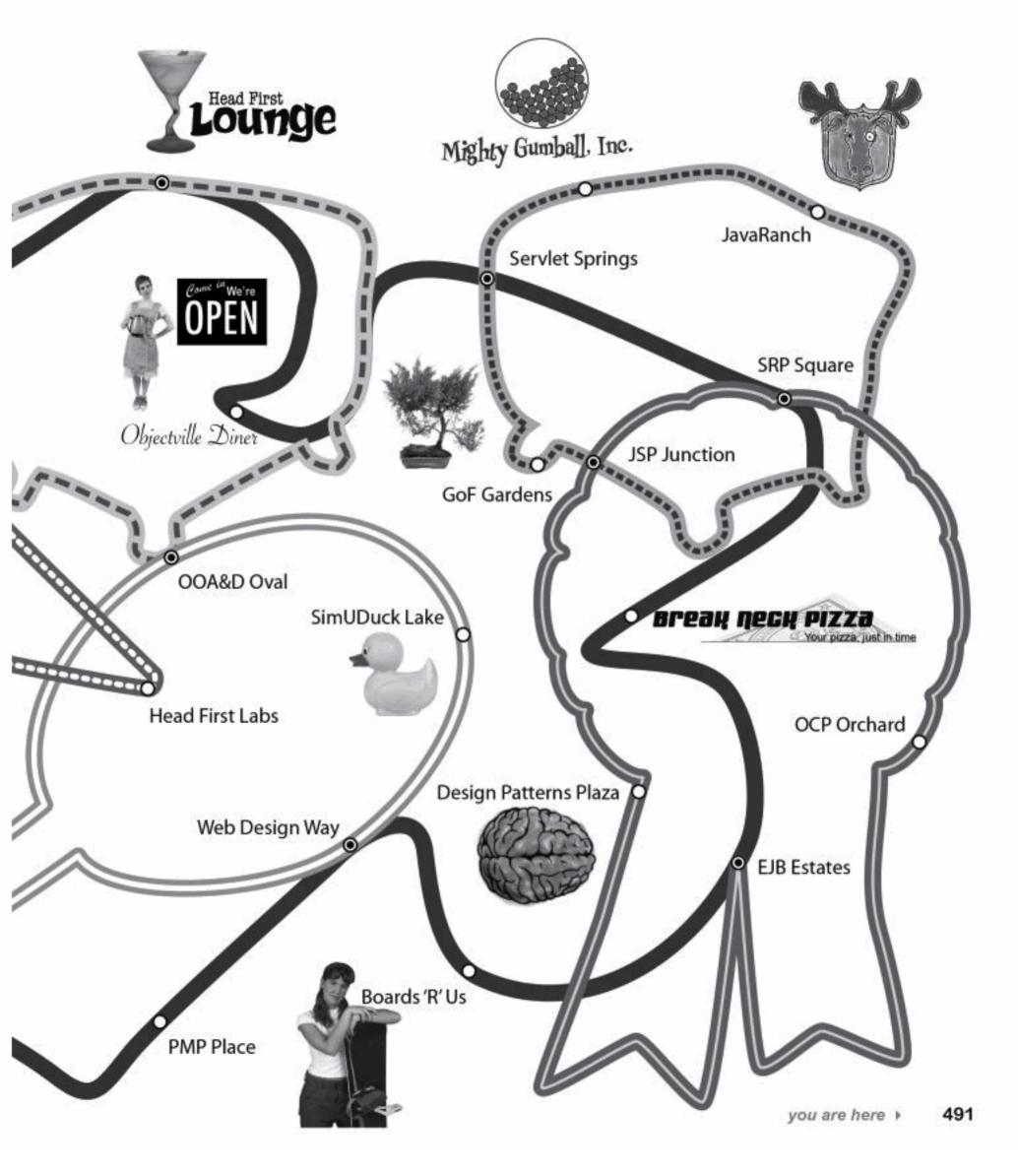
Liskov Line

Meyer Line

Rumbaugh Line

Wirfs-Brock Line

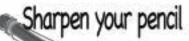




scratch paper

This page left intentionally blank, so you can cut out the cool Objectville

Map on the previous page and hang it up on your cubicle wall.



Write the feature list for the RouteFinder app.

We're throwing you right into things. Your job is to take the Statement of Work on page 488, and use it to develop a feature list. You can refer back to Chapter 6 if you need help on what features are, and what a typical feature list looks like.

	Objectville RouteFinder Feature List
1	
2	
3	
4	
 5	
6	
7	
-	

You don't have to use all of these blanks if you don't think you need them all.

You are HERE.

Feature List	Use Case Piagrams	Break Up the Problem	Requirements	Pomain Analysis	Preliminary Pesign	Implementation	Pelivery
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Write the feature list for the RouteFinder app.

Your job was to take the Statement of Work on page 488, and use it to develop a feature list for the RouteFinder we're going to build.

Here's what we came up with.
Your answers may not match
ours exactly, but they should
be pretty close, and cover
these same basic four features.

A "valid route" might be all on one line, or involve

several different line

Objectville RouteFinder Feature List

- We have to be able to represent a subway line, and the stations along that line.
- We must be able to load multiple subway lines into the program, including overlapping lines.
- 3. We need to be able to figure out a valid path between any two stations on any lines.
- 4. We need to be able to print out a route between two stations as a set of directions.

Lines overlap when they both share the same station.

Printing is a separate feature... be sure you have this in your feature list.

Dumb Questions

Q: Why aren't we gathering requirements? I'm still not clear on how a feature is really that different from a requirement, anyway.

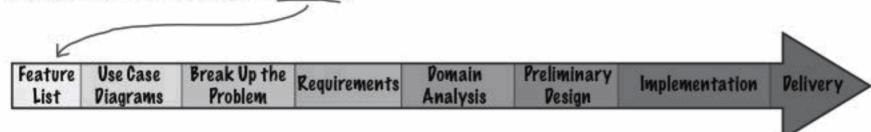
A: Features and requirements are often used almost interchangeably. Most of the time, though, people say "feature" when they're talking about BIG things that an application needs to do. So it might take several requirements to satisfy one feature. And since features are usually a little bigger-picture than requirements, it's a good idea to start any new project by writing out a feature list, like we've done with the RouteFinder.

Q: Why did you list printing out the route as a separate feature? That's pretty easy once you've got a valid route between two stations, isn't it?

A: It probably will be, yes. But the feature list isn't just a list of hard problems you have to solve—it's a list of all the things your application has to be able to do. So even if a feature seems easy or trivial, put it on your feature list anyway.

Now you should really know what you're supposed to do

At this point, you've finished up that first phase.



With a feature list in hand, you should have a good understanding of the things that your app needs to do. You probably even can begin to think about the structure of your application, although we'll spend a lot more time on that in just a bit,

Once you've got your feature list down, you should move on to use case diagrams. Those will help you connect what your app *does* to how it will be *used* and that's what customers really are interested in.

Your feature lists are all about understanding what your software is supposed to <u>do</u>.

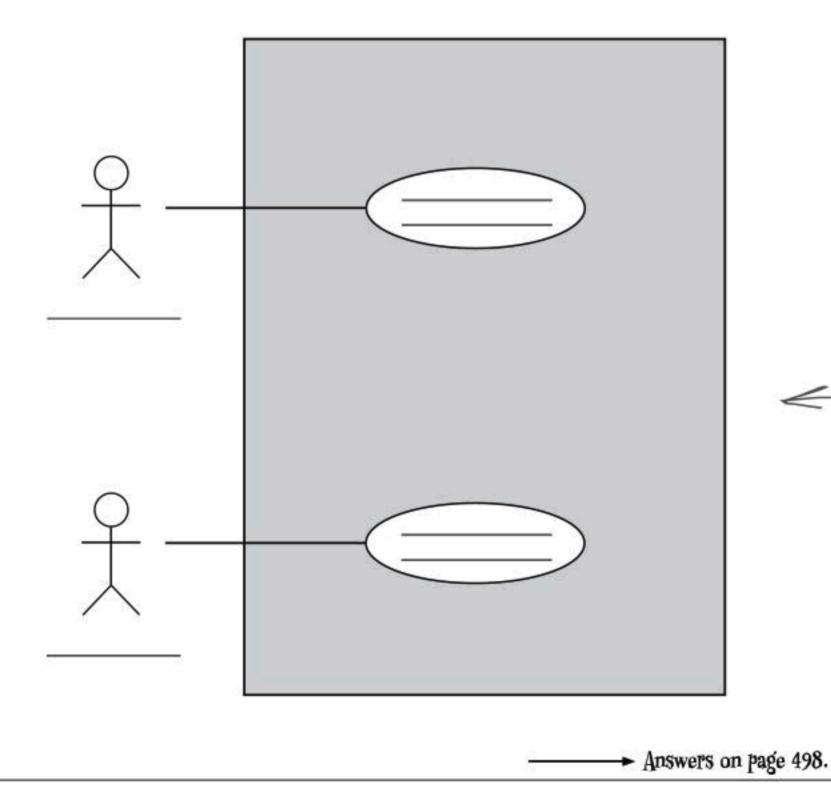
Your use case diagrams let you start thinking about how your software will be <u>used</u>, without getting into a bunch of unnecessary details.

Sharpen your pencil

Decide on the structure for the RouteFinder code.

With feature lists in hand, let's look at how our app is going to be used. Below, we've started a use case diagram for the RouteFinder app. For this project, there are two actors, and just two use cases (sounds sort of simple, doesn't it?).

It's up to you to figure out who (or what) the two actors are, and to label the two use cases. If you need help, refer back to Chapter 6 for more on use case diagrams.





Feature Magnets

Once you've got your use case diagrams figured out, you need to make sure that your use cases match up with the features you have to deliver to the customer. Below is the feature list for RouteFinder, as well as magnets for each feature. Place each magnet below on one of the use cases you filled in on page 496. Make sure you have each feature covered before turning the page.

Objectville RouteFinder Feature List

Represent subway lines, and stations along each line.

- We have to be able to represent a subway line, and the stations along that line.
- 2. We must be able to load multiple subway lin lines into the program, including overlapping lines.
- 3. We need to be able to figure out a valid pat Figure out a valid route between any two stations on any lines. between two stops.
- 4. We need to be able to print out a route between two stations as a set of directions.

Print directions for a particular route.

Each one of these magnets should go on one of the use cases over here.

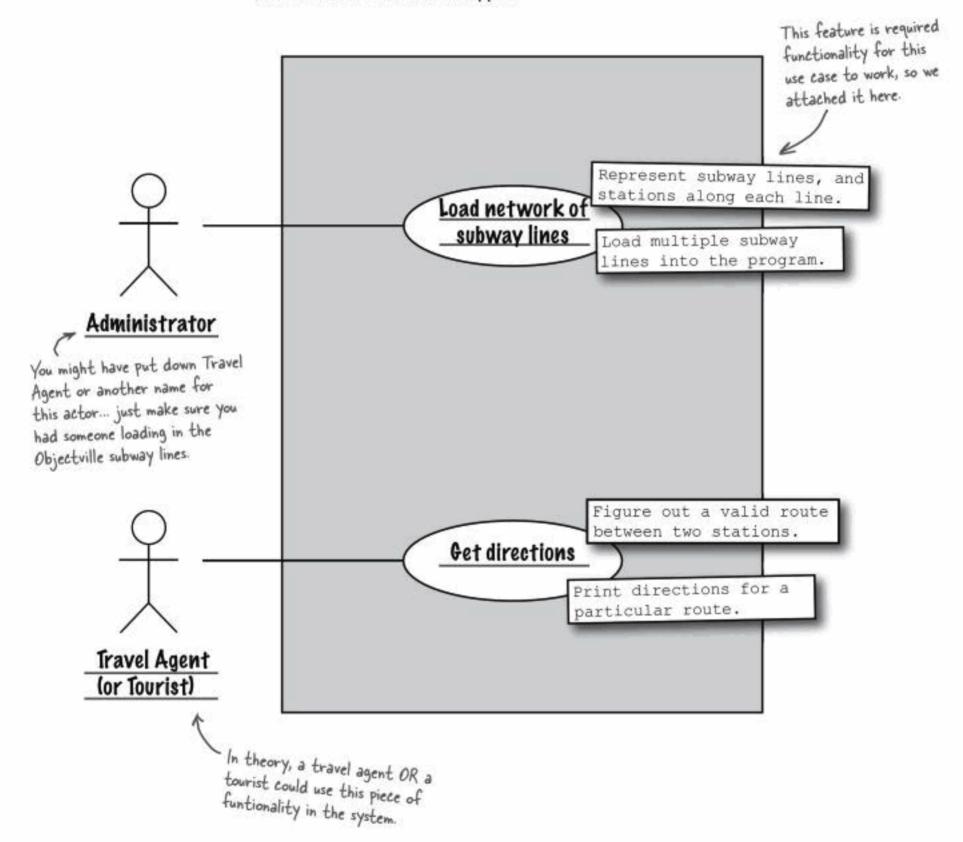
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A CONTRACTOR OF THE PARTY OF TH	Use Case Diagrams	Problem	Requirements	Vomain Analysis	Preliminary Design	Implementation	Pelivery
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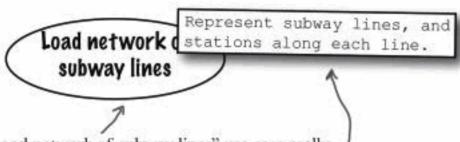
Decide on the structure for the RouteFinder code, and map your use cases back to your feature list.

You had a Sharpen Your Pencil, and a Feature Magnets to solve. You were supposed to figure out the actors and use cases for your system, and then make sure those use cases covered all the features we decided RouteFinder had to support.



Use cases reflect <u>usage</u>, features reflect <u>functionality</u>

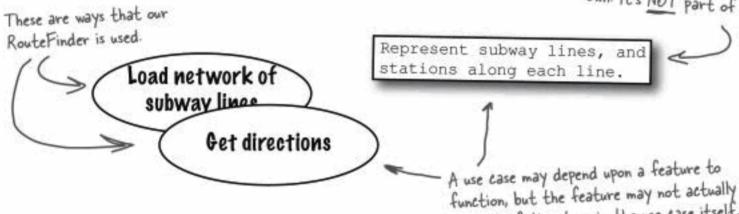
Let's look more closely at one of the feature-use case matches we showed you on the last page:



The "Load network of subway lines" use case really does not directly use our feature that deals with representing the subway. Obviously, we have to be able to represent the subway for this use case to work, but it's a stretch to tie the two together like this.

That's not a mistake, though; when we're writing use cases, we're dealing with just the **interactions** between actors and a system. We're just talking about the ways that your system is **used** (which is where the term "use case" came from).

This is something the RouteFinder must do for a use case to work, but it's not actually an interaction on its own. It's NOT part of any use case.



The features in your system reflect your system's functionality. Your system must do those things in order for the use cases to actually work, even though the functionality isn't always an explicit part of any particular use case.

function, but the feature may not actually be part of the steps in the use case itself. "Load network of subway lines" depends on a representation of the subway, but only uses that feature indirectly.

You	are (still) HE	RE.					
Feature List	Use Case Piagrams	Break Up the Problem	Requirements	Pomain Analysis	Preliminary Design	Implementation	Pelivery
	- 50			77			

Dumb Questions

Q: Didn't you say that I should be able to match up every feature to a use case in my system?

A: Yes, and that's still true. Every feature in your system will be at least a part of addressing one or more uses cases in your use case diagram. But that doesn't mean that the use case has to actually directly use that feature. Lots of times, a feature makes it possible for a use case to function without being directly used by the use case itself.

In our RouteFinder, there would be no way to load a network of subway lines into the system (one of our use cases) without having a representation of a subway in the first place (one of our features). But the "Load Network" use case doesn't have any steps that match up directly with that feature... the steps in the use case just assume that a representation of the subway exists. So the use case indirectly uses the feature, without explicitly referring to it.

Q: So is a use case a requirement, or is a feature a requirement?

A: Both! Use cases are requirements for how people and things (actors) interact with your system, and features are requirements about things that your system must do. They're related, but they are not the same. Still, to implement a system's use cases, you're going to need the functionality in the system's features. That's why you should always be able to map your features to the use cases that they enable and are used by.

What happens if I find a feature that I can't match up to a use case, even indirectly?

A: You should take a hard look at the feature, and make sure it really is a required part of your system. Your customer—and her customers—only interact with your system through the use cases. So if a feature doesn't at least indirectly make a use case possible, you're customer really isn't going to see a benefit. If you think you've got a feature that doesn't really affect how your system is used or performs, talk it over with the customer, but don't be afraid to cut something if it's not going to improve your system.

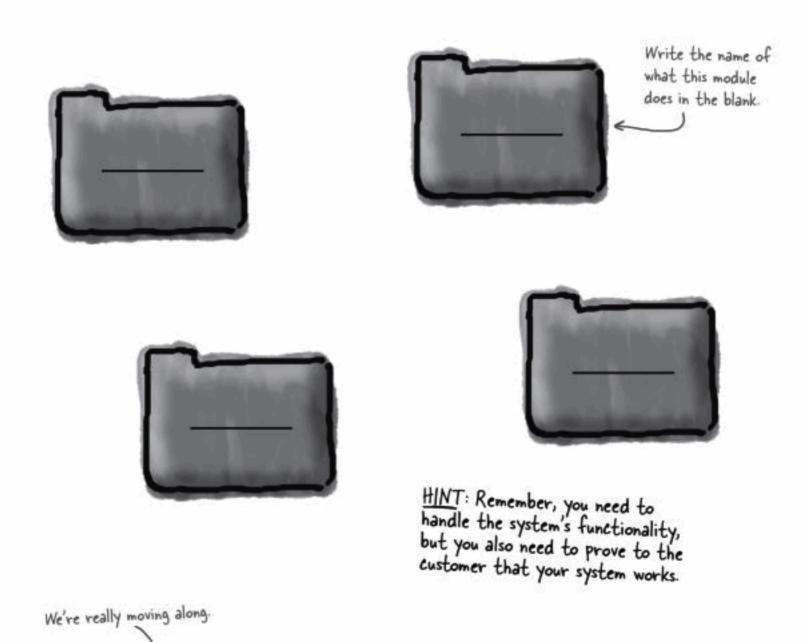
The features in your system are what the system does, and are not always reflected in your use cases, which show how the system is used.

Features and use cases work together, but they are not the same thing.

The Big Break-Up

We're starting to pick up some steam. With use case diagrams in place, you're ready to break this problem up into some smaller pieces of functionality. There are several ways to do this in any application, but our goal here is to keep the RouteFinder system very modular. That means keeping different pieces of functionality separate—each module should have a single responsibility.

Go ahead and break up the RouteFinder system into four different "modules". Think carefully about the best way to break up your system... it isn't necessarily going to line up with your four features (although it might!).



Feature List	Use Case Diagrams	Break Up the Problem	Requirements	Pomain Analysis	Preliminary Design	Implementation	Pelivery
	0 7.35	10,	700	55.2			

The Big Break-Up, Solved

We're starting to pick up some steam. With use case diagrams in place, you're ready to break this problem up into some smaller pieces of functionality.

These three modules make up the system... they form a "black box" that is used by tourists and travel agents to get directions.

Subway Loader Printer Loader Printer

We added a Testing module, because we need some code that actually proves to our customer that the system works... not only in our "perfect world", but also in the real world.

Test T

The Subway module has all the code that represents stations, connections between those stations, and the entire subway system itself. It also knows how to get directions from one station to another on its connections and lines.

We could have several different ways to load a subway: from a file, or with user input, or even from a database. Loading is really separate from the subway representation itself, so it gets its own module.

Printing is a lot like loading: it's separate from the subway system itself. This module handles printing the subway to any device or format that we might need.

Liskov Substitution Principle

Test is outside the system... it interacts with the system, but isn't part of the system itself.

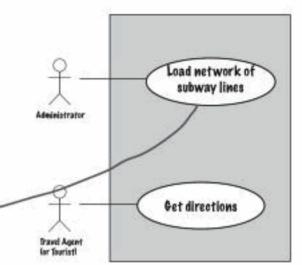
Sharpen your pencil Which OO principles are we using? Check the box next to the OO principles you think we're using to break up the RouteFinder functionality in this manner. Single Responsibility Principle Delegation Page 504

Encapsulation

Now start to iterate

Once you've broken up your software into several individual pieces of functionality, you're ready to start iterating over each piece of functionality, until the application is complete.

At this point, we need to take our big-picture view of the system, from our use case diagram, and refine that into requirements that we can begin to tackle, one by one. For this first iteration, let's take the "Load network of subway lines" use case, and turn that into a set of requirements that isn't so big-picture. Then we can take care of that use case, and iterate again, working on the next use case.



We're taking the first use case from our diagram, and starting with it

Sharpen your pencil

What approach to development are we using?

Sharpen your pencil

Write the use case for loading subway lines.

Turn that little oval into a full-blown use case. Write the steps that RouteFinder needs to take to implement the "Load network of subway lines" use case.

	Load network of subway lines
	Use Case
_	

You can use more room, or more steps, if you need them.

Not too sure about this use case? It's OK ... turn the page for some help...

How am I supposed to write this use case? I'm not totally sure I know what a subway line even is yet. And what about that file that Objectville travel said they were going to send over to us? Won't that affect how we write our use case?

0

You'll often have to do some extra work between breaking up the problem and writing your use cases.

You've just uncovered a "secret step" in our process for writing software the OOA&D way:

Understand

the Problem

Here's the "extra step" that we sometimes need to take.

We really don't understand our problem well enough to write better requirements yet.

Break Up the Requirements Use Case Feature Preliminary Implementation **Piagrams** Problem Analysis

If you get stuck writing a use case, there's nothing wrong with taking a step back, and examining the problem you're trying to solve a bit. Then, you can go back to your use case, and have a better chance of getting it written correctly.

By breaking up printing, loading, and representing the subway into three modules, we're making sure each module has only one reason to change.

We've encapsulated printing and loading, which might vary, away from the subway, which should stay the same.

Sharpen your pencil Which OO principles are we using? answers Check the box next to the OO principles you think we used to break up the

RouteFinder functionality into separate modules.

Single Responsibility Principle

Delegation '

Don't Repeat Yourself

Polymorphism

Encapsulation

Liskov Substitution Principle

It's not clear if we're using delegation yet, although with SRP and encapsulation, we probably will at some point

Pelivery

A closer look at representing a subway

Before we can figure out how to load a subway line, there are two things we need to get a good grasp of:

- Understanding the basics of what a subway system is.
- Understanding the information an administrator would have when they're loading a set of subway stations and lines.

We're on Iteration I, trying to handle the first use case: loading a network of subway lines.

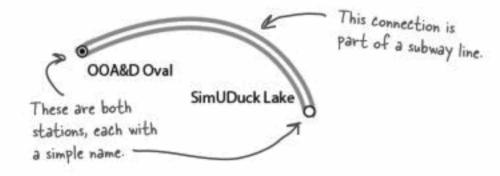
What is a station?

A subway system has stations, and connections between those stations, and lines that are groups of connections. So let's begin by figuring out exactly what a station is.



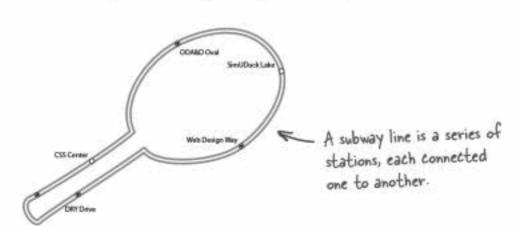
And a connection between two stations?

As soon as you start adding several stations, you've got to deal with the connections between those stations:



Then a line is just a series of connections...

If you put several connections together, then you've got a subway line.



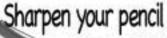


Let's take a look at that subway file

We've got a basic idea now of what a subway is, so let's see what kind of data we've got to work with. Remember, Objectville Travel said they would send us a file with all the stations and lines, so this should give us an idea of what an administrator will use to load the lines into the subway system.



			We're HERE.				
Feature List	Use Case Piagrams	Break Up the Problem	Requirements	Pomain Analysis	Preliminary Design	Implementation	Pelivery
-	0 070	Ç.	7/-				



Write the use case for loading subway lines.

You should have enough understanding of what a subway system is, and the format of the Objectville Subway input file, to write this use case now.

	Load network of subway lines
	Use Case
_	
_	
! _	
3	
)	

You can use more room, or more steps, if you need them.



Write the use case for loading subway lines.

You should have enough understanding of what a subway system is, and the format of the Objectville Subway input file, to write this use case now.

The first step is the start condition: the loader gets a new file to load from.

Did you get this step?

We really don't want our

system to have duplicate

stations... that could be

a real problem later on.

Here's another step

input, to make sure the

connection is valid for

the current subway.

where we validate

Load network of subway lines Use Case

- _ 1. The administrator supplies a file of stations and lines.
- 2. The system reads in the name of a station.
- 3. The system validates that the station doesn't already exist.
- 4. The system adds the new station to the subway.
- 5. The system repeats steps 2-4 until all stations are added.
- 6. The system reads in the name of a line to add.
- 7. The system reads in two stations that are connected.
- 8. The system validates that the stations exist.
- The system creates a new connection between the two stations, going in both directions, on the current line.
- 10. The system repeats steps 7-9 until the line is complete.
- 11. The system repeats steps 6-10 until all lines are entered.

This is really only one possible way to write the use case. Instead of creating a "SubwayLine" object, we decided to just give the subway each connection, and associate the connection with a particular subway line.

You didn't have to write this down, but we thought it was important to remember that subways in Objectville can go in EITHER direction.

Steps like this, which — indicate repeating other steps, help make your use cases a little more readable and concise.

Dumb Questions

Q: My use case looks totally different. Is your use case the only solution to the puzzle?

A: No, not at all. By now you realize that there are lots of decisions you have to make to solve any problem, and our use case simply reflects the decisions we made. We're going to work with this particular use case throughout the rest of this chapter, so make sure you understand our reasoning behind it, but it's perfectly OK if you came up with your own use case that solves the same problem of loading a network of subway stations and lines.

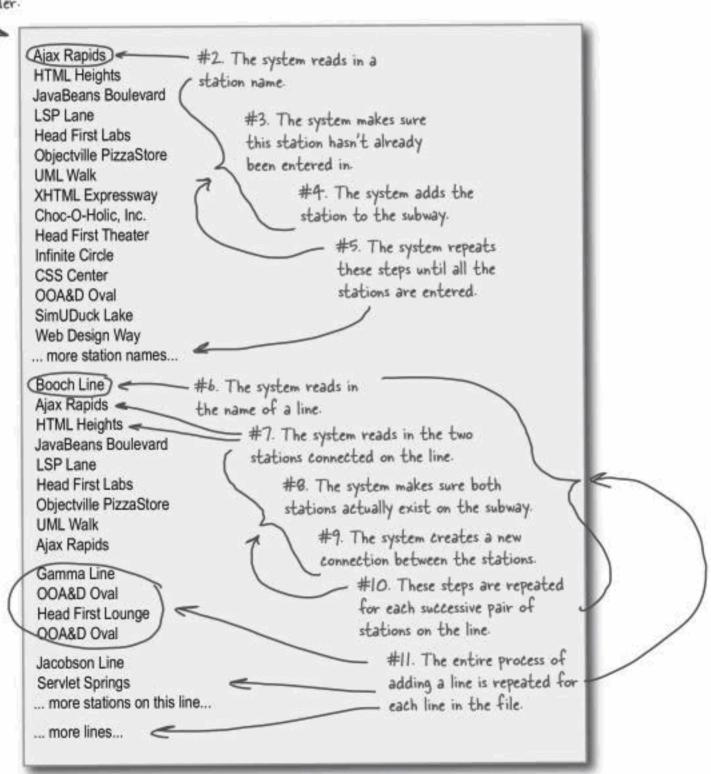
I didn't add any steps about validation to my use case. Is that OK?

A: Validation is something that you should add to your use case if you left it out. Making sure the stations for a connection actually exist is a lot like not having a dog door automatically close. It seems innocent enough, until the real world creeps in, and someone mispells a station name. Suddenly, you have the equivalent of software rodents: a connection that goes to a non-existent station. So if you left out validation, be sure to add it in to your own use case.

Let's see if our use case works

The use case for loading a network is a little tricky, and has several groups of steps that repeat. Let's check the flow of things against our text file before we go on to analyzing the use case, and starting to design the classes in our system.

#1. The administrator supplies a file like this to the system loader.





Analysis and Design Puzzle

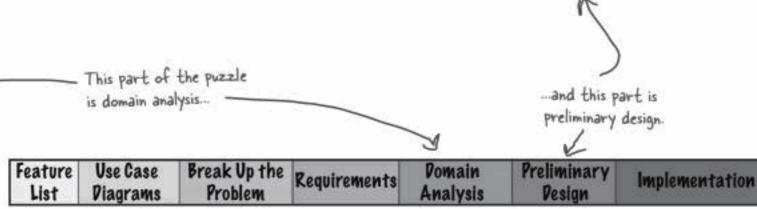
This time, it's your job to take on two phases of the OOA&D process at once. First, you need to perform textual analysis on the use case below, and figure out the nouns that are candidate classes, and the verbs that are candidate operations. Write the nouns and verbs in the blanks provided below the use case.

Load network of subway lines Use Case

- 1. The administrator supplies a file of stations and lines.
- 2. The system reads in the name of a station.
- 3. The system validates that the station doesn't already exist.
- 4. The system adds the new station to the subway.
- 5. The system repeats steps 2-4 until all stations are added.
- 6. The system reads in the name of a line to add.
- 7. The system reads in two stations that are connected.
- 8. The system validates that the stations exist.
- 9. The system creates a new connection between the two stations, going in both directions, on the current line.
- 10. The system repeats steps 7-9 until the line is complete.
- 11. The system repeats steps 6-10 until all lines are entered.

Nouns (candidate classes):		
erbs (candidate operations):	<u> </u>	
		-

It's on to preliminary design. Using the candidate nouns and verbs you got from the use case, draw a class diagram below of what you think the subway system might look like modeled in code. Use associations and any other UML notation you think will help make your design clear and understandable.



Pelivery



Analysis and Design Puzzle Solutions

Load network of subway lines Use Case

- 1. The administrator supplies a file of stations and lines.
- 2. The system reads in the name of a station.
- 3. The system validates that the station doesn't already exist.
- 4. The system adds the new station to the subway.
- 5. The system repeats steps 2-4 until all stations are added.
- 6. The system reads in the name of a line to add.
- 7. The system reads in two stations that are connected.
- 8. The system validates that the stations exist.
- 9. The system creates a new connection between the two stations, going in both directions, on the current line.
- 10. The system repeats steps 7-9 until the line is complete.
- 11. The system repeats steps 6-10 until all lines are entered.

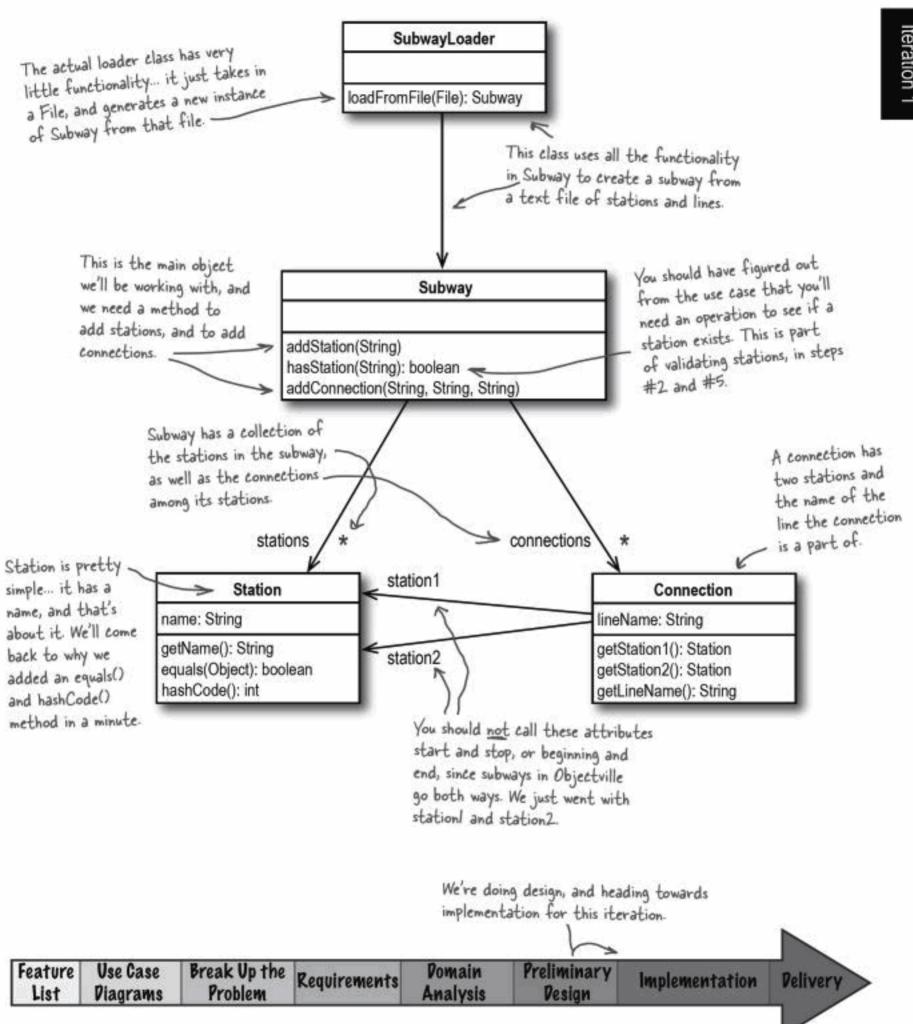
These are easy... they all Nouns (candidate classes): appear on our class diagram. We know administrator > line system that actors file connection station are outside This is an input to our the system, so no class We decided not to create system, not something needed here. a Line class ... more on that we model in our system. when you turn the page.

Verbs (candidate operations):

supplies a file validates station < repeats We can use Java's -reads in adds a station ≤ 1/0 operations to handle this.

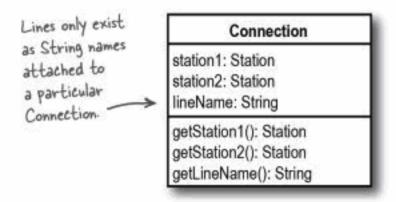
adds a connection

Most of these directly map to methods on our classes.



To use a Line class or not to use a Line class... that is the question

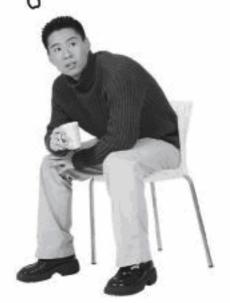
It was pretty easy to look at our use case and figure out that we need a **Station**, **Connection**, and **Subway** class—those are fundamental to our system. But then we decided to **not** create a **Line** class. Instead, we just assigned a line name to each connection:



We made this decision based on one thing: we know how the system is going to be used. In the original Statement of Work (back on page 488) from Objectville Travel, we were told we needed to represent a subway, and get directions between one station and another. Once we have those directions, we can simply ask each connection for its line; there doesn't seem to be a need for an actual Line class.

Your design decisions should be based on how your system will be used, as well as good 00 principles.

Even if it turns out we need to add a Line class later, that's no big deal. This is a **preliminary** design, and we can change it if we need to once we start writing our code.



Dumb Questions

Lifound the "validates that a station exists" verb, but where does that operation appear on any of the classes in your design?

A: We modeled that operation as hasStation()
on the Subway class. You could have called that operation
validate() or validateStation(), but those aren't
as descriptive as hasStation(), and you should always try
and make your code as readable as possible.

Could you talk a little more about how you showed those repeated steps in the use case?

A: Lots of times a use case has a set of steps that need to be repeated, but there's not a standard way to show that in use cases. So we just made one up! The point of a use case is to provide you with a clear set of steps that detail what your system should do, and we thought the clearest way to show those repeated steps was to write down "Repeat Steps 7-9."

l've been thinking about that subway representation, and it looks a lot like a graph data structure to me. Why aren't we using a graph?

A: Wow, you must have taken a data structures or algorithms class recently! Yes, you can use a graph to represent the subway. In that case, each station would be a node, and each connection would be a labeled edge.

Q: So then why aren't we using a graph structure in this example?

A: We think it's really overkill in this situation. If you already know about graphs and nodes and edges, and you happen to have code for that sort of data structure lying around, then go ahead and use them. But from our point of view, we'd do more work adapting a graph to our needs than just coming up with a few simple classes for Station and Connection. Like almost everything else in the design stage, there are several ways to solve a problem, and you need to choose a solution that works well for you.

You lost me on the whole graph thing... what's all this about edges and nodes?

A: It's OK; you don't need to know about graphs in order to understand and solve this particular problem. It's nothing to worry about, at least until we come up with a Head First Data Structures book (anyone? anyone?).

Feature Use Case Break Up the List Piagrams Problem Requirements Analysis Pesign Implementation Pelivery

Code the Station class

We've got requirements in the form of a use case, a class diagram, and we know the **Station** class will fit into our **Subway** model. Now we're ready to start writing code:

If you want, you —
can put Station
in a package like
objectville subway.
It's up to you if you
want to break up your
modules by package.

```
equals(Object): boolean
                                                                hashCode(): int
public class Station (
  private String name;
                                                                     This is our class diagram for
  public Station(String name) {
                                                                     Station, from page 513.
     this.name = name;
                                       - A Station is basically
                                       just a named object
  public String getName() {
     return name;
                                                                   This ensures, for example, that a
                                                                   station named "AJAX RAPIDS" is
                                                                   considered the same as a station
  public boolean equals(Object obj) {
                                                                   named "Ajax Rapids".
    if (obj instanceof Station) {
       Station otherStation = (Station)obj;
       if (otherStation.getName().equalsIgnoreCase(name)) {
          return true;
                                        We figured there's going to be a lot
                                        of comparisons between stations, so we
     return false:
                                        made sure we defined equals(). In this
                                        version, two Station objects are equal
                                        if they have the same name.
  public int hashCode() {
     return name.toLowerCase().hashCode();
```

We base the hash code of a Station on the same property that comparisons are based on: the name of the station.

For a lot more on equals() and hashCode(), check out Chapter 16 of Head First Java.



When you override equals() in Java, you should usually also override hashCode() to ensure correct comparisons.

We came up with the Subway module back on

Page 502.

Station

name: String

getName(): String

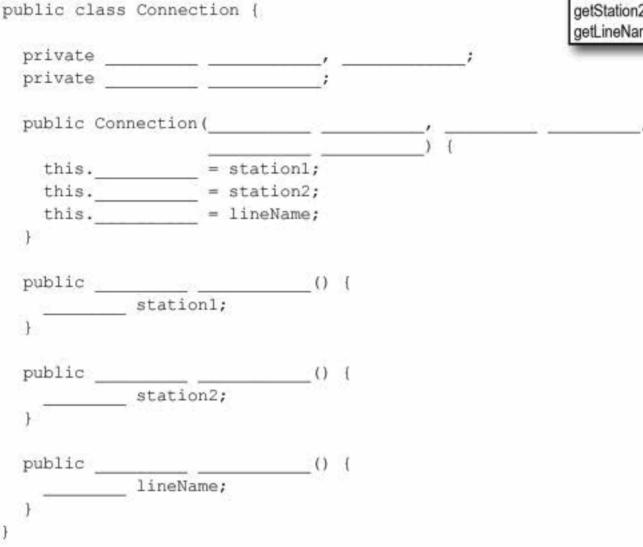
Subway

The Java specification recommends that if two objects are equal, they should have the same hash code. So if you're deciding on equality based on a property, it's a good idea to also override hashCode() and return a hash code based on that same property. This is particularly important if you're using your object in a Hashtable or HashMap, which both make heavy use of the hashCode() method.

Sharpen your pencil

Write the Connection class.

Using the class diagram on the right, complete the Connection class by filling in the blanks with the correct lines of code. Be sure your class will compile before you turn the page and see our answers.



Connection
station1: Station
station2: Station
lineName: String
getStation1(): Station
getStation2(): Station
getLineName(): String

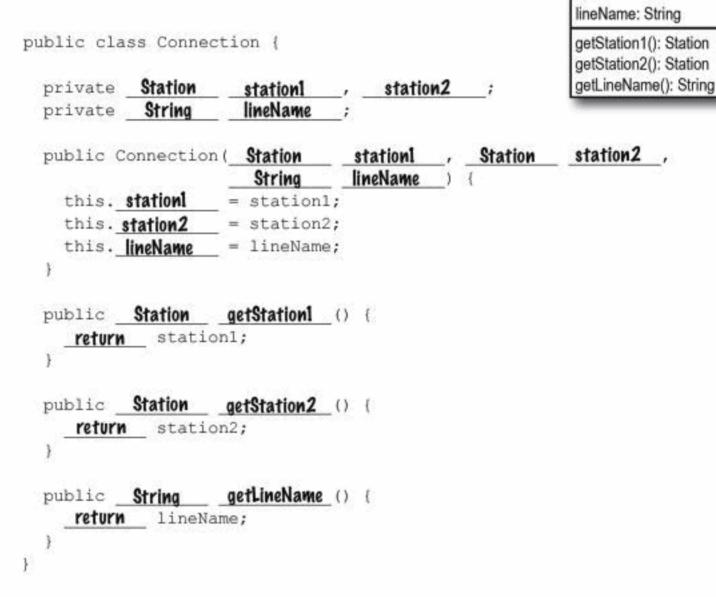
We're well into the implementation phase of our first iteration, now.

Feature Liet	Use Case	Break Up the	Requirements	Pomain Analysis	Preliminary Pesign	Implementation	Pelivery
PIST	Flagi arits	Troplem		Analysis	resign		7/

Sharpen your pencil answers

Write the Connection class.

Using the class diagram on the right, your job was to fill in the blanks and complete the Connection class.



You are HERE.

Subway

station1: Station station2: Station

Connection

Feature Use Case Break Up the List Diagrams Problem Requirements Analysis Design Implementation Delivery

Code the Subway class

}

Next up is the Subway class itself. With Station and Connection done, and a good class diagram, nothing here should be a surprise:

```
stations: Station [*]
                                                       connections: Connection [*]
public class Subway (
                                                       addStation(String): Station
                                                       hasStation(String): boolean
  private List stations;
                                                       addConnection(String, String, String): Connection
  private List connections;
  public Subway() {
                                                        These will store all the
    this.stations = new LinkedList();
                                                        stations, and the connections
    this.connections = new LinkedList();
                                                        between those stations.
  public void addStation(String stationName) {

    First, we validate the name, and make

    if (!this.hasStation(station)) {
                                                              sure we don't already have this station.
       Station station = new Station(stationName);
       stations.add(station);_
                                                      _ If not, we create a new
                                                        Station instance, and add it
                                                        to the subway.
                                                                   This method checks to see
  public boolean hasStation(String stationName) {
                                                                       if a station is already in the
     return stations.contains(new Station(stationName));
                                                                        subway's stations List
  public void addConnection(String station1Name, String station2Name,
                                  String lineName) {
                                                                    Like addStation(), we begin
    if ((this.hasStation(station1Name)) && -
                                                                   - with some validation: this
          (this.hasStation(station2Name))) {
                                                                     time, we make sure both
       Station station1 = new Station(station1Name);
                                                                    stations exist in the subway.
       Station station2 = new Station(station2Name);
       Connection connection = new Connection(station1, station2, lineName);
       connections.add(connection);
       connections.add(new Connection(station2, station1, <
                                             connection.getLineName()))
     ) else (
                                                                         This is VERY important. Since
       throw new RuntimeException ("Invalid connection!");
                                                                         Objectville subways run in
                                                                          both directions, we add two
                                                                          connections: one connection
            This is pretty rough in terms of error
            handling ... see if you can come up with a better
                                                                          for both directions.
            way to handle the case where one of the
            stations in the connection doesn't exist.
```

Subway

Subway

Points of interest on the Objectville Subway (class)

We threw a couple of new things into the **Subway** class; first, you'll see this line of code quite a bit:

```
Station station = new Station(stationName);
```

For example, when we create a new **Connection**, we have code like this:

```
Station station1 = new Station(station1Name);
Station station2 = new Station(station2Name);
Connection connection =
  new Connection(station1, station2, lineName);
```

Lots of programmers would take station1Name, and iterate through the list of stations in the Subway class to find the Station object that has a name of station1Name. But that takes a lot of time, and there's a better way. Remember how we defined an equals() and hashCode() method on our Station class?

Station

name: String

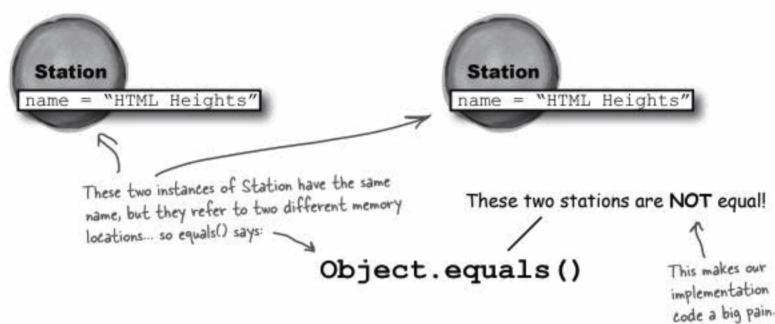
getName(): String equals(Object): boolean hashCode(): int

These methods allowed us to tell Java that when it compares two **Station** objects, just see if their name is the same. If the names are equal, even if the objects don't refer to the same location in memory, they should be treated as the same. So instead of looking for a particular Station object in the Subway class's list of station, it's much easier to just create a new Station and use it.

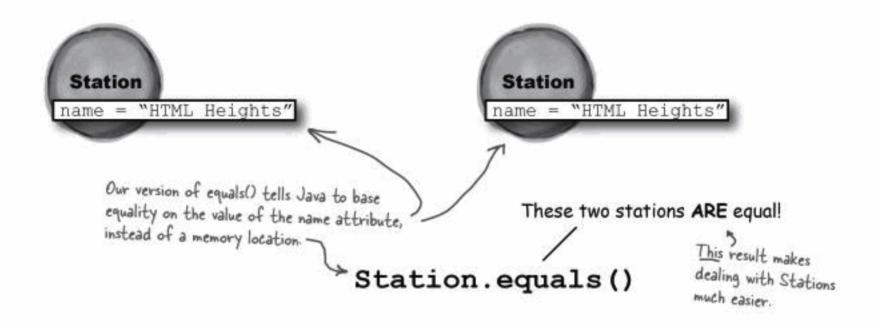
Because we overrode equals() and hashCode(), we can save search time and complexity in our code. Your design decisions should always make your implementation better, not more complicated or harder to understand.

Normally, equals() in Java just checks to see if two objects actually are the <u>SAME</u> object... in other words, it looks to see if they are actually both references to the same place in memory. But that's <u>NOT</u> what we want to use for comparison of two Station objects.

What Java's default equals() implementation does...



What our equals() implementation does...



Dumb Questions

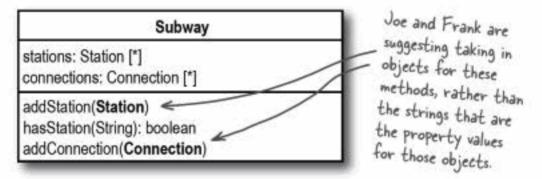
What does any of this have to do with OOA&D?

A: This is the very core of what makes OOA&D useful; because we understand our system, we realize that two stations should be considered identical if they have the same name. And, our design is improved by being able to compare stations based on their name, rather than their location in memory.

So the time we spent on requirements and getting a good grasp of our system made our design better, which in turn made implementing that design a lot simpler. That's the power of OOA&D: you can turn knowledge of your system into a flexible design, and even end up with cleaner code—all because you spent time up front listening to the customer and gathering requirements, rather than diving right into an IDE and typing in source code. Why aren't we just taking in a Station object in addStation(), and a Connection object in addConnection()? Wouldn't that make sense?



Frank: That's true. So we could change our Subway class to look more like this:



Jill: But then you're exposing the internals of your application!

Joe: Whoa... not sure what that means, but it sure doesn't sound like something I want to do. What are you talking about?

Jill: Well, look at our code right now. You don't have to work with a Station or Connection at all to load up the subway. You can just call methods on our new Subway class.

Frank: How is that any different from what we're suggesting?

Jill: If we went with your ideas, people that use the Subway class would have to also work with Station and Connection. In our version right now, they just work with Strings: the name of a station, and the name of a line.

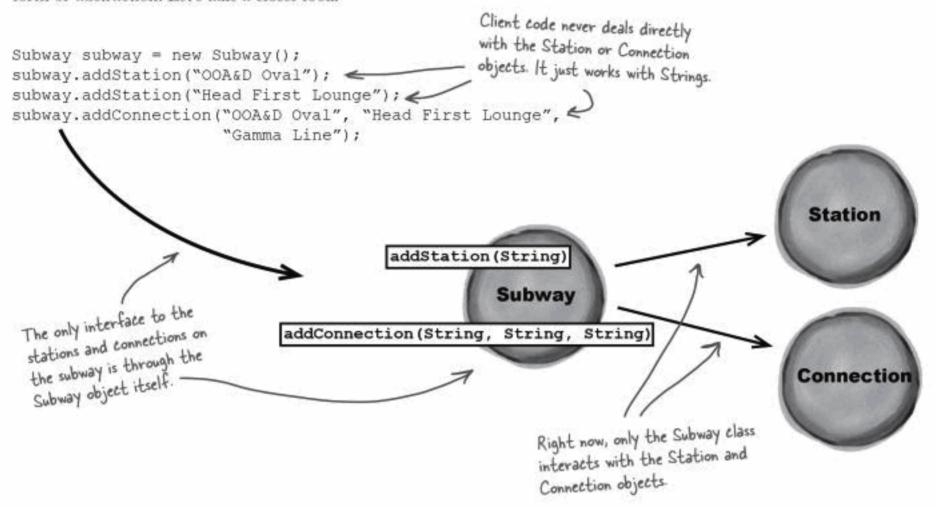
Joe: And that's bad because...

Frank: Wait, I think I get it. Their code is getting tied in to how we implement the Station and Connection classes, since they're having to work with those classes directly.

Jill: Exactly! But with our version, we could change up Connection or Station, and we'd only have to change our Subway class. Their code would stay the same, since they're abstracted away from our implementations of Connection and Station.

Protecting your classes (and your client's classes, too)

Frank, Joe, and Jill are really talking about just one more form of abstraction. Let's take a closer look:



You should only expose clients of your code to the classes that they <u>NEED</u> to interact with.

Classes that the clients don't interact with can be changed with minimal client code being affected.

In this application, we could change how Station and Connection work, and it wouldn't affect code that only uses our Subway object; they're protected from changes to our implementation.

The SubwayLoader class

We're almost done with our first iteration, and our first use case. All that's left is to code the class that loads a subway based on the test file we got from Objectville Travel, Inc.

```
public class SubwayLoader {
                                                                   loadFromFile(File): Subway
  private Subway subway;
  public SubwayLoader() (
    this.subway = new Subway();
  public Subway loadFromFile(File subwayFile) throws IOException (
    BufferedReader reader = new BufferedReader(
                                                       We start out by loading
      new FileReader(subwayFile));
                                                       all the stations.
    loadStations(subway, reader); <
    String lineName = reader.readLine();
    while ((lineName != null) && (lineName.length() > 0)) {
       loadLine(subway, reader, lineName);
                                                    Once we've got the stations, we need to
       lineName = reader.readLine();
                                                    get the next line, which should be a line
                                                    name, and add the stations underneath
                                                     that line into the subway.
    return subway;
  private void loadStations(Subway subway, BufferedReader reader)
    throws IOException {
                                                     Loading stations just involves reading a line, adding that line into the subway as
    String currentLine;
    currentLine = reader.readLine();
    while (currentLine.length() > 0) {
                                                     a new station name, and then repeating,
      subway.addStation(currentLine);
      currentLine = reader.readLine();
  private void loadLine (Subway subway, BufferedReader reader,
                           String lineName)
                                                     We read the first station, and the
    throws IOException {
    String station1Name, station2Name;
                                                    station after that...
    station1Name = reader.readLine(); 4
    station2Name = reader.readLine();
    while ((station2Name != null) && (station2Name.length() > 0)) {
       subway.addConnection(station1Name, station2Name, lineName);
       station1Name = station2Name;
                                                                       ...and then add a new connection
       station2Name = reader.readLine();
                                                                        using the current line name.
                                      We take the current second
                                      station, bump it up to the first,
                                      and then read another line to
                                       get the new second station.
```

We're working on the Loader module now

(see page 502).

SubwayLoader

Loader



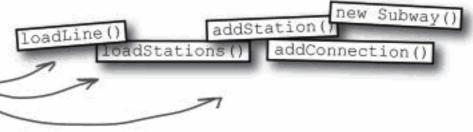
Method Magnets

Let's see exactly what happens when you call loadFromFile() in SubwayLoader, and give it the text file we got from Objectville Travel. Your job is to place the magnets from the bottom of this page—which match up to methods on the SubwayLoader and Subway classes—next to the lines in the text file where they'll be called.

wayLoader alled. ObjectvilleSubway.txt

Ajax Rapids HTML Heights JavaBeans Boulevard LSP Lane Head First Labs Objectville PizzaStore UML Walk XHTML Expressway Choc-O-Holic, Inc. Head First Theater Infinite Circle CSS Center OOA&D Oval SimUDuck Lake Web Design Way ... more station names... Booch Line Ajax Rapids HTML Heights JavaBeans Boulevard LSP Lane Head First Labs Objectville PizzaStore UML Walk Ajax Rapids Gamma Line OOA&D Oval Head First Lounge OOA&D Oval Jacobson Line Servlet Springs ... more stations on this line... ... more lines...

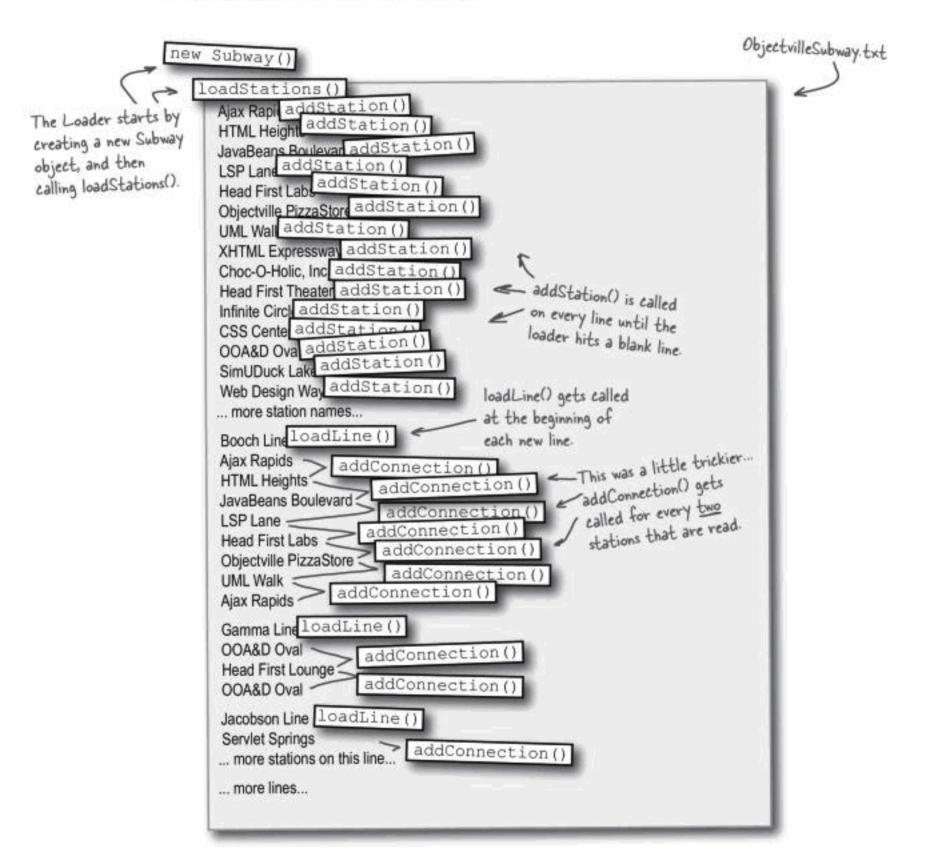
There are only 5 methods that are involved here, but you'll need to use most of these magnets = several times each.





Method Magnet Solutions

Let's see exactly what happens when you call loadFromFile() in SubwayLoader, and give it the text file we got from Objectville Travel. Your job was to place the magnets from the bottom of this page next to the lines in the text file where they'll be called.





You're almost done with the first use case, and our first iteration! All that's left is to test out our solution, and make sure it actually works.

The problem:

You need to test loading the **ObjectvilleSubway.txt** file, and make sure that **SubwayLoader** correctly loads in all stations and connections in the file.

Your task:

- Add a method to Subway to check if a particular connection exists, given the two station names and the line name for that connection.
- Write a test class, called LoadTester, with a main() method that loads the Objectville Subway system from the text file we got from Objectville Travel, Inc.
- Write code in LoadTester that checks a few of the stations and connections from the text file against the Subway object returned from SubwayLoader's loadFromFile() method. You should check to make sure that at least three stations and three connections on three different lines were all entered correctly.
- 4 Run your test program, and verify that we're really done with Iteration 1.

Here's the use case we're testing in this puzzle.

Load network of subway lines Use Case

- 1. The administrator supplies a file of stations and lines.
- 2. The system reads in the name of a station.
- 3. The system validates that the station doesn't already exist.
- 4. The system adds the new station to the subway.
- 5. The system repeats steps 2-4 until all stations are added.
- 6. The system reads in the name of a line to add.
- 7. The system reads in two stations that are connected.
- 8. The system validates that the stations exist.
- The system creates a new connection between the two stations, going in both directions, on the current line.
- 10. The system repeats steps 7-9 until the line is complete.
- 11. The system repeats steps 6-10 until all lines are entered.

Testing is really part of the implementation phase. Code isn't complete until it's tested.

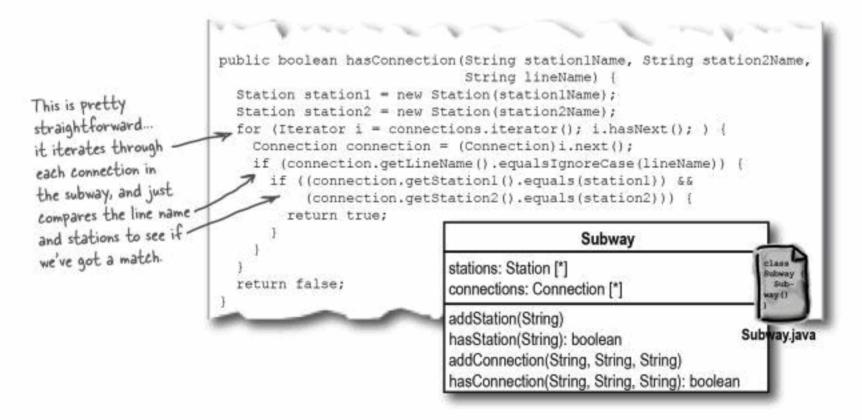
Feature List	Use Case Piagrams	Break Up the Problem	Requirements	Pomain Analysis	Preliminary Design	Implementation	Pelivery
1431	viagrams	Problem		Analysis	vesign		3



Test Puzzle Solution

Your job was to test the **SubwayLoader** and our subway representation to make sure you can load a subway system from a text file.

Add a method to Subway to check if a particular connection exists, given the two station names and the line name for that connection.



Dumb Questions

Wouldn't it be easier to write the hasConnection() method if we used a Line object, like we talked about a few pages ago?

A: It would. If we had a Line object, we could look up the line using the name passed into hasConnection(), and just iterate over the Connection objects for that line. So in most cases, hasConnection() would involve less iteration, and return a result faster, if we had a Line object.

We still decided not to use a Line object, though, because we've only added hasConnection () to help us test our classes. So adding a Line object just to make a test method return faster doesn't seem like a good idea. If we find that we need the hasConnection () method in other parts of our app, though, this might be something to come back and revisit later.

- Write a test class, called LoadTester, with a main() method that loads the Objectville Subway system from the text file we got from Objectville Travel, Inc.
- Write code in **LoadTester** that checks a few of the stations and connections from the text file against the **Subway** object returned from **SubwayLoader**'s **loadFromFile()** method. You should check to make sure that at least three stations and three connections on three different lines were all entered correctly.

This code simply passes in the text file, and then tests a few stations and connections to see if they got loaded.

```
public class LoadTester {
 public static void main(String[] args) {
    trv (
      SubwayLoader loader = new SubwayLoader();
      Subway objectville =
        loader.loadFromFile(new File("ObjectvilleSubway.txt"));
      System.out.println("Testing stations...");
      if (objectville.hasStation("DRY Drive") &&
          objectville.hasStation("Weather-O-Rama, Inc.") &&
          objectville.hasStation("Boards 'R' Us")) {
        System.out.println("...station test passed successfully.");
        System.out.println("...station test FAILED.");
        System.exit(-1);
                                                        You can use any
                                                         stations and
                                                         connections you
      System.out.println("\nTesting connections...");
                                                         like here.
      if (objectville.hasConnection("DRY Drive",
              "Head First Theater", "Meyer Line") &&
          objectville.hasConnection("Weather-O-Rama, Inc.",
                "XHTML Expressway", "Wirfs-Brock Line") &&
          objectville.hasConnection("Head First Theater",
                  "Infinite Circle", "Rumbaugh Line")) {
        System.out.println("...connections test passed successfully.");
      } else {
        System.out.println("...connections test FAILED.");
        System.exit(-1);
    } catch (Exception e) {
      e.printStackTrace(System.out);
```

LoadTester.java



Test Puzzle Solution (cont.)

Your job was to test the **SubwayLoader** and our subway representation to make sure you can load a subway system from a text file.

A Run your test program, and verify that we're really done with Iteration 1.

*File Edit Window Help NotVeryExciting

*java LoadTester
Testing stations...
...station test passed successfully.

Testing connections...
...connections test passed successfully.

Tests are usually not really exciting to run... until you realize that they prove your software is WORKING!

We're done here.



Try and write a test case that gets all the stations and connections in the Subway and prints them out, to verify your subway is loading the network correctly.

It's time to iterate again

Our test proves that we really have finished up our first iteration. The "Load network of subway lines" use case is complete, and that means it's time to iterate again. Now, we can take on our next use case—"Get directions"—and return to the Requirements phase and work through this use case.

Load network of subway lines

Feature Use Case Break Up the Requirements Pomain Preliminary Implementation Pelivery
List Piagrams Problem Requirements Analysis Pesign

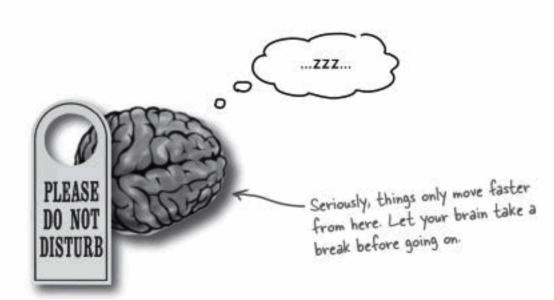
Once an iteration is complete, if there are more use cases or features to implement, you need to take your next feature or use case, and start again at the requirements phase.

But before we start Iteration 2 ...

It's been a <u>LONG</u> iteration, and you've done some great work. <u>STOP</u>, take a <u>BREAK</u>, and eat a bite or drink some water. Give your brain a chance to REST.

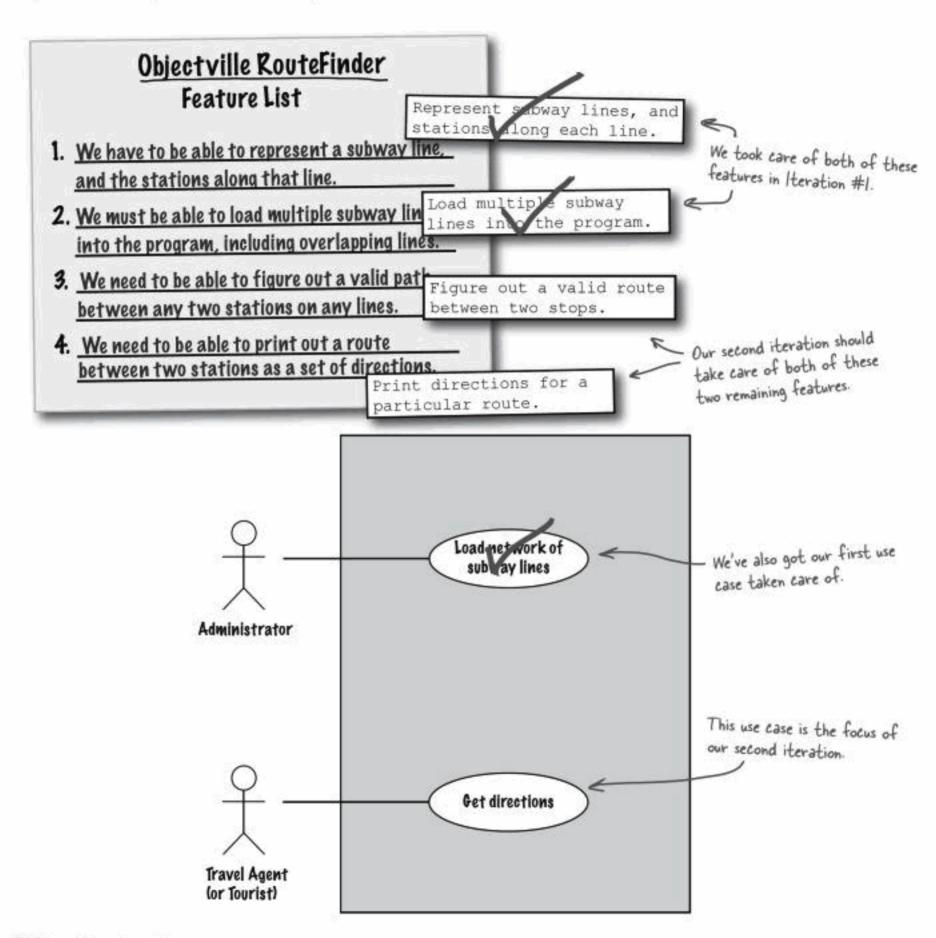
Then, once you've caught your breath, turn the page, and let's knock out that last use case. Are you ready? Then let's <u>iterate</u> <u>again</u>.





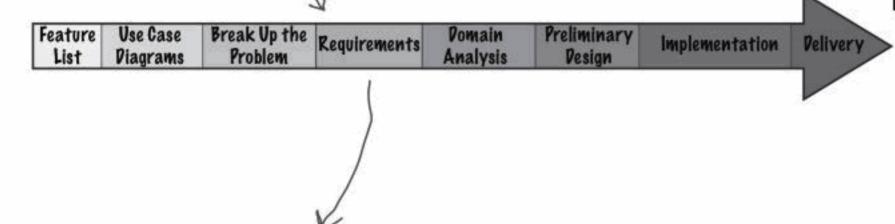
What's left to do?

We've made a lot of progress, on both our use cases, and our feature list. Below is the feature list and use case diagram we developed earlier in the chapter:



Back to the requirements phase...

Now that we're ready to take on the next use case, we have to go back to the requirements phase, and work through this use case the same way we did the first one. So we'll start by taking our use case title from our use case diagram, "Get directions," and developing that into a full-blown use case.

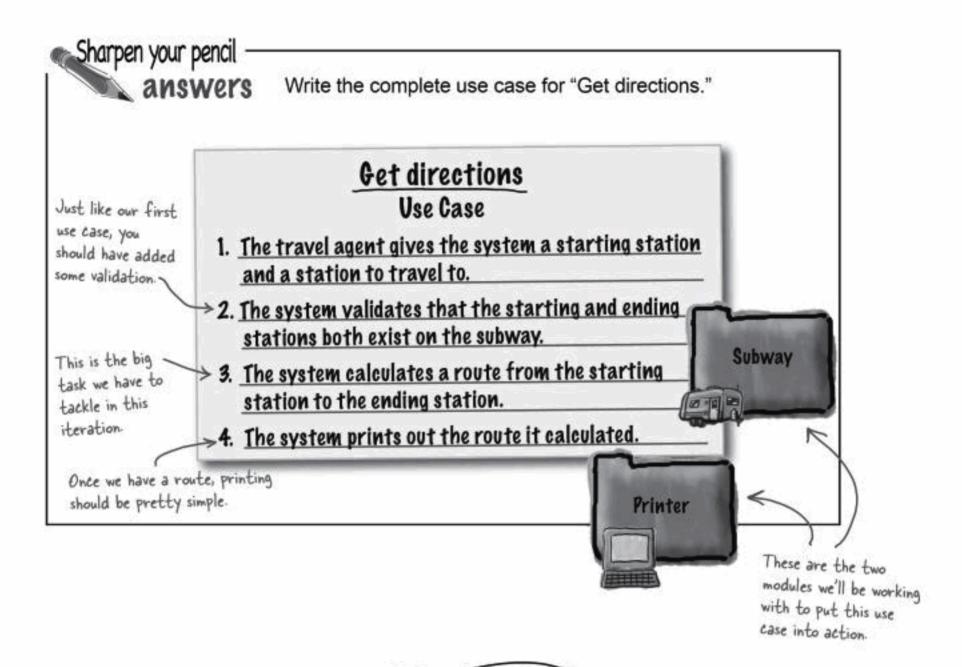


Sharpen your pencil

Write the complete use case for "Get directions."

We're back to writing use cases again. This time, your job is to write a use case that allows a travel agent to get directions from one station to another on the Objectville Subway.

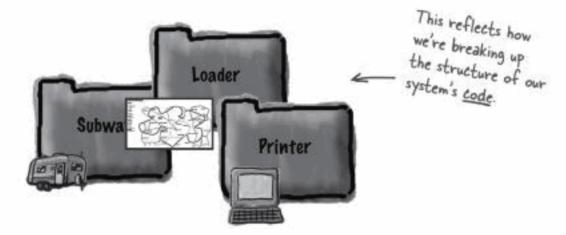
	Get directions Use Case
You shouldn't -> need as many steps to write this use case.	
	4.



I'm a little confused. We went to all that work to break our code up into modules, but our use cases involve code in more than one module. Why do we keep jumping back and forth between modules and use cases?

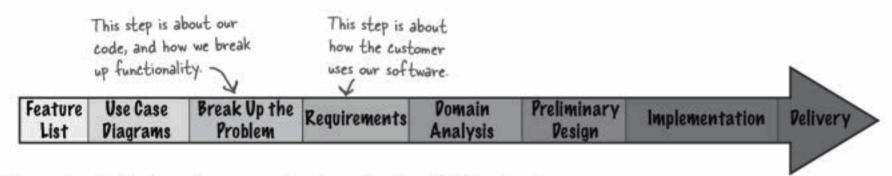
Focus on code, then focus on customers. Then focus on code, then focus on customers...

When we started breaking our application up into different modules way back on page 502, we were really talking about the structure of our application, and how we are going to break up our application. We have a **Subway** and **Station** class in the Subway module, and a **SubwayLoader** class in the Loader module, and so on. In other words, we're focusing on our **code**.



We've really been going back and forth between our code, and how our system is used, in both iterations.

But when we're working on use cases, we're focusing on how the customer <u>uses</u> the system—we looked at the format of an input file to load lines, and began to focus on the customer's interaction with your system. So we've really been going back and forth between our code (in the Break Up the Problem step) and our customer (in the Requirements step):



When you're developing software, there's going to be a lot of this back-andforth. You have to make sure your software does what it's supposed to, but it's your code that makes the software actually do something.

It's your job to balance making sure the customer gets the functionality they want with making sure your code stays flexible and well-designed.



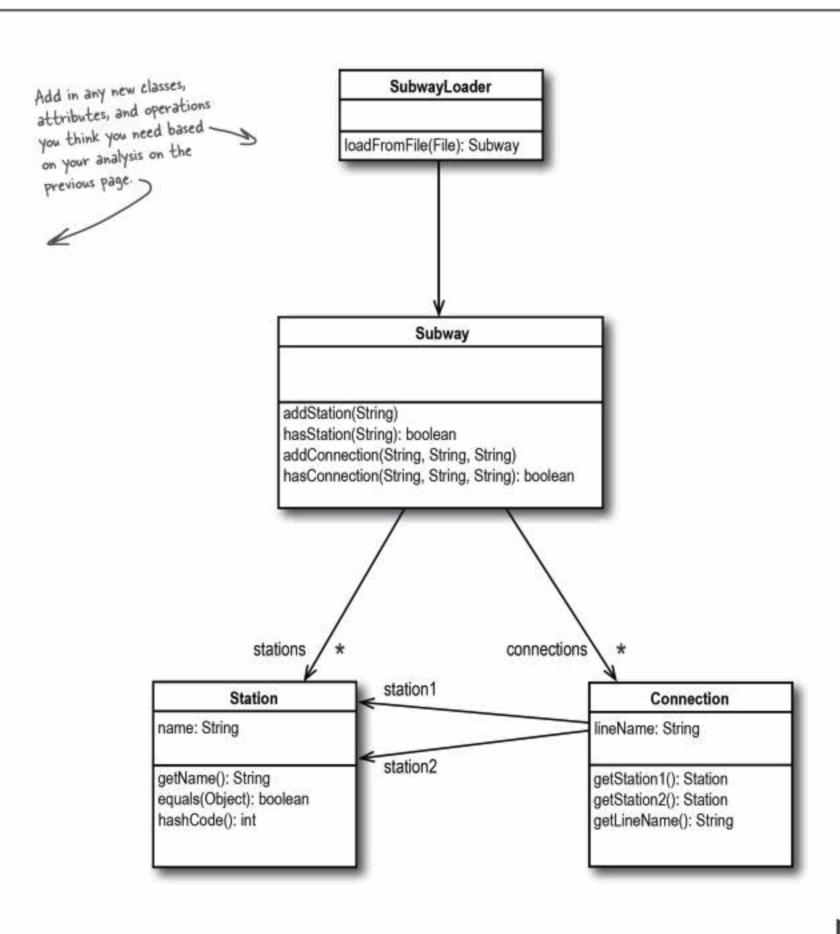
-Analysis and Design Puzzle

It's time to take on more domain analysis and design for your system. Take the use case below, figure out the candidate classes and candidate operations, and then update the class diagram on the right with any changes you think you need to make. - Do some of these exercises look familiar? You use the <u>same techniques</u> in each iteration of your development cycle.

Get directions Use Case

- The travel agent gives the system a starting station and a station to travel to.
- The system validates that the starting and ending stations both exist on the subway.
- 3. The system calculates a route from the starting station to the ending station.
- 4. The system prints out the route it calculated.

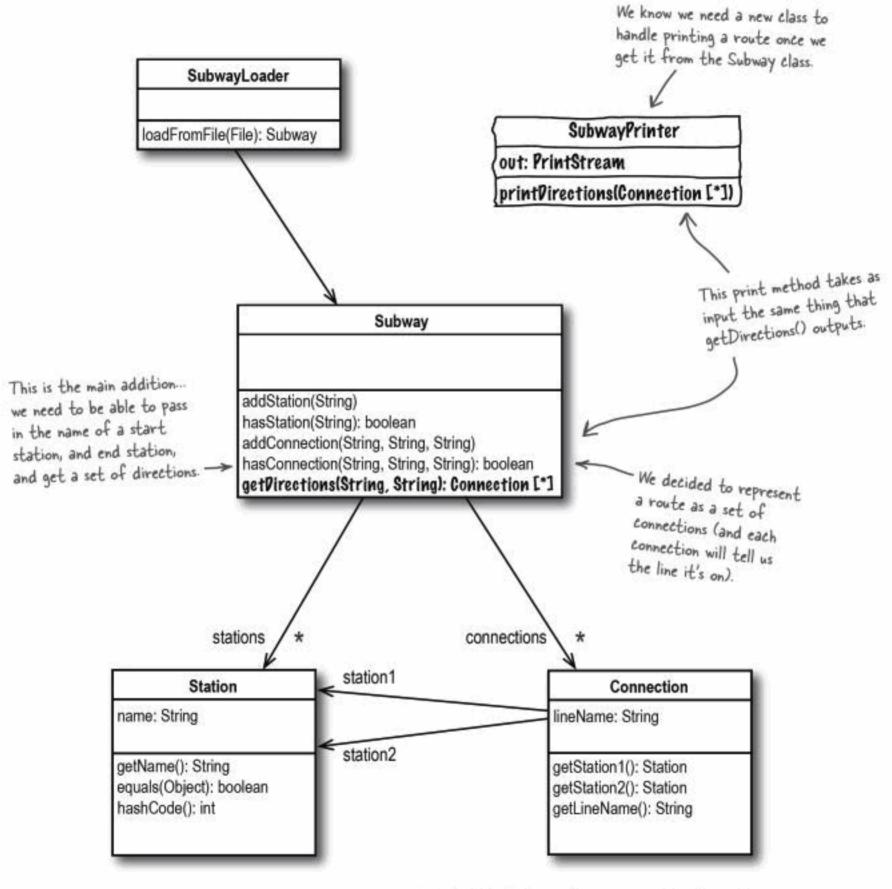
Nouns (candidate classes):	
	2 2 2
Verbs (candidate operations):	



Feature List	Use Case Diagrams	Break Up the Problem	Requirements	Pomain Analysis	Preliminary Design	Implementation	Pelivery
					-		200



Analysis and Design Puzzle Solutions



* We didn't show the nouns and verbs... by now, you should be comfortable with that step, and be able to translate them into the class diagram shown here.

Iteration makes problems easier

The class diagram on the last page really isn't that much different from our class diagram from the first iteration (flip back to page 513 to take a look at that earlier version). That's because we did a lot of work that applies to **all** our iterations during our **first** iteration.

Subway Test
Loader

We did a LOT of work in our first iteration... we worked on three modules, and completed an entire use case.

Load network of subway lines
Use Case

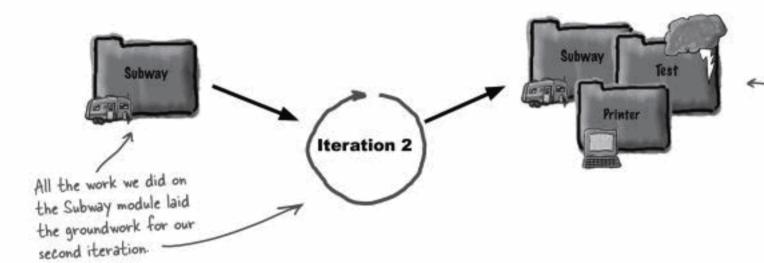
he administrator supplies a file of stations and lines, the system reads in the name of a station.

he system validates that the station doesn't aircady exist. he system adds the new station to the subway. he system repeats steps 2-4 until all stations are added.

- he system reads in the name of a line to add.
- 7. The system reads in two stations that are connected.

 8. The system validates that the stations exist.
- 9. The system creates a new connection between the two stations, going in both directions, on the current line.
- 10. The system repeats steps 7-9 until the line is complete.
- 1 L. The system repeats steps 6-10 until all lines are entered.

Once you've completed your first iteration, your successive iterations are often a lot easier, because so much of what you've already done makes those later iterations easier.



We still have plenty
of work to do, but
not nearly as much as
we did in the first
iteration. Most of the
Subway module is done,
and we've even got
some tests in place.

We're ready to move to the implementation phase... but this iteration is moving a lot faster, and there's less to do, than the first iteration.

Feature Use Case Break Up the List Piagrams Problem Requirements Analysis Pesign Implementation Pelivery

Implementation: Subway.java

Figuring out a route between two stations turns out to be a particularly tricky problem, and gets into some of that graph stuff we talked about briefly back on page 515. To help you out, we've included some Ready-bake Code that you can use to get a route between two stations.

```
public class Subway {
                                  We need a Map to store each
  private List stations;
                                 station, and a list of all the
  private List connections;
                                 stations that it connects to.
  private Map network; <
  public Subway() {
    this.stations = new LinkedList();
    this.connections = new LinkedList();
    this.network = new HashMap(); <
  // addStation(), hasStation(), and hasConnection() stay the same
  public Connection addConnection(String station1Name, String station2Name,
                                    String lineName) (
    if ((this.hasStation(station1Name)) &&
        (this.hasStation(station2Name))) {
      Station station1 = new Station(station1Name);
      Station station2 = new Station(station2Name);
      Connection connection = new Connection(station1, station2, lineName);
      connections.add(connection);
      connections.add(new Connection(station2, station1,
                                       connection.getLineName()));
      addToNetwork(station1, station2);
                                                            When we add connections, we need
      addToNetwork(station2, station1);
                                                            to update our Map of stations,
      return connection;
                                                            and how they're connected in the
    ) else (
      throw new RuntimeException ("Invalid connection!"); subway's network.
  private void addToNetwork(Station station1, Station station2) {
   if (network.keySet().contains(station1)) {
      List connectingStations = (List)network.get(station1);
      if (!connectingStations.contains(station2)) {
        connectingStations.add(station2); <
    } else {
      List connectingStations = new LinkedList();
      connectingStations.add(station2);
```

Ready-bake Code

Ready-bake code is code that we're already prepared for you. Just type it in as its shown here, or you can download a completed version of Subway java from the Head First Labs web site.

Our Map has as its keys each station. The value for that station is a List containing all the stations that it connects to (regardless of which line connects the stations).

down is new code.

```
network.put(station1, connectingStations);
                                                                                             teration 1 Iteration 2
  }
}
public List getDirections (String startStationName,
                             String endStationName) {
  if (!this.hasStation(startStationName) || <
                                                                - Here's the validation of the
      !this.hasStation(endStationName)) { <
                                                                  start and end stations that
    throw new RuntimeException (
                                                                  we referred to in our use
      "Stations entered do not exist on this subway.");
                                                                  case on page 534.
  Station start = new Station(startStationName);
  Station end = new Station(endStationName);
                                                                       This method is based on
  List route = new LinkedList();
                                                                       a well-known bit of code
  List reachableStations = new LinkedList();
                                                                       called Dijkstra's algorithm,
  Map previousStations = new HashMap();
                                                                       which figures out the
                                                                       shortest path between two
  List neighbors = (List)network.get(start);
                                                                        nodes on a graph.
  for (Iterator i = neighbors.iterator(); i.hasNext(); )
    Station station = (Station)i.next();
    if (station.equals(end)) {
      route.add(getConnection(start, end));
                                                                  This first part of the
      return route;
                                                                  code handles the case when
    | else {
                                                                  the end station is just one
      reachableStations.add(station);
                                                                  connection away from the
      previousStations.put(station, start);
                                                                 starting station.
  }
  List nextStations = new LinkedList();
  nextStations.addAll(neighbors);
                                                                         These loops begin to
  Station currentStation = start;
                                                                         iterate through each set
                                                                          of stations reachable by
  searchLoop:
  for (int i=1; i<stations.size(); i++) {
                                                                          the starting station, and
    List tmpNextStations = new LinkedList();
                                                                          tries to find the least
    for (Iterator j = nextStations.iterator(); j.hasNext(); ) {
                                                                          number of stations possible
      Station station = (Station) j.next();
                                                                          to connect the starting
      reachableStations.add(station);
                                                                           point and the destination.
      currentStation = station;
      List currentNeighbors = (List)network.get(currentStation);
      for (Iterator k = currentNeighbors.iterator(); k.hasNext(); ) {
         Station neighbor = (Station)k.next();
        if (neighbor.equals(end)) (
           reachableStations.add(neighbor);
           previousStations.put(neighbor, currentStation);
           break searchLoop;
```

```
} else if (!reachableStations.contains(neighbor)) {
           reachableStations.add(neighbor);
           tmpNextStations.add(neighbor);
          previousStations.put (neighbor, currentStation);
      1
    nextStations = tmpNextStations;
  }
  // We've found the path by now
  boolean keepLooping = true;
  Station keyStation = end;
  Station station;
  while (keepLooping) {
                                                               Once we've got a path, we
    station = (Station)previousStations.get(keyStation);
                                                               just "unwind" the path,
    route.add(0, getConnection(station, keyStation));
                                                               and create a List of
    if (start.equals(station)) {
                                                               connections to get from
      keepLooping = false;
                                                               the starting station to the
    keyStation = station;
                                                               destination station.
                            This is a utility method that takes two
                            stations, and looks for a connection
  return route;
                            between them (on any line).
                               V
private Connection getConnection(Station station1, Station station2) {
  for (Iterator i = connections.iterator(); i.hasNext(); ) {
    Connection connection = (Connection)i.next();
    Station one = connection.getStation1();
    Station two = connection.getStation2();
    if ((station1.equals(one)) && (station2.equals(two))) {
      return connection;
  return null;
```

}

Iteration 2

OK, this is just ridiculous. I spent 500 pages reading about how great OOA&D is so you can just give me the hardest code in the book? I thought I was supposed to be able write great software on my own by now.

Sometimes the best way to get the job done is find someone else who has already done the job for you.

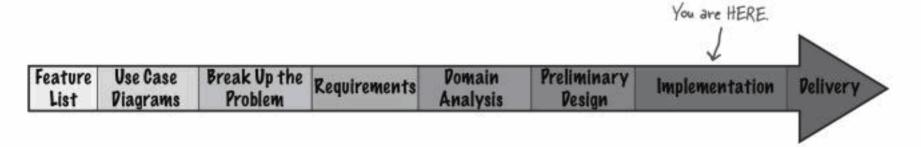
It might seem weird that at this stage, we're giving you the code for getting a route between two stations. But that's part of what makes a good developer; a willingness to look around for existing solutions to hard problems.

In fact, we had some help from a college student on implementing a version of Dijkstra's algorithm that would work with the subway (seriously!). Sure, you probably can come up with your own totally original solution to every problem, but why would you want to if someone

has already done the work for you?

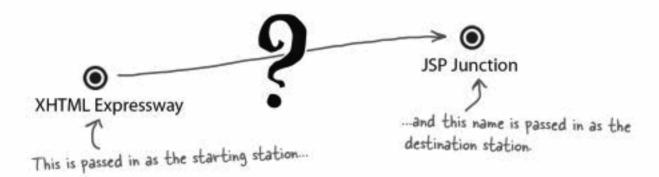
Thanks, Felix Geller, your code really saved the day

Sometimes the best code for a particular problem has already been written. Don't get hung up on writing code yourself if someone already has a working solution.

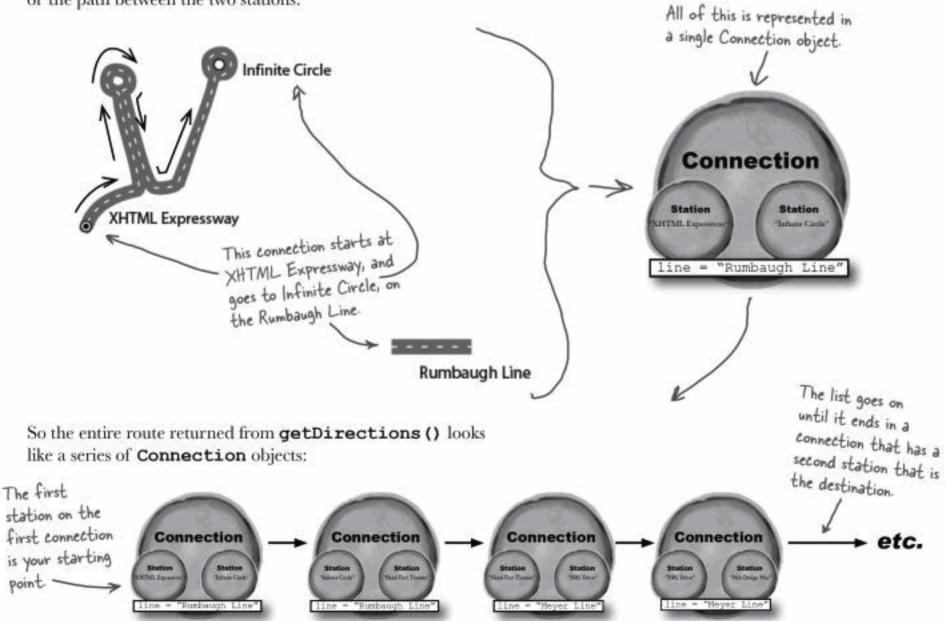


What does a route look like?

The **getDirections()** method we just added to **Subway** takes in two **Strings**: the name of the starting station, and the name of the station that a tourist is trying to get to:



getDirections () then returns a List, which is filled with Connection objects. Each Connection is one part of the path between the two stations:





Printing Puzzle

You're almost done! With a working getDirections () method in Subway, the last feature to implement is printing those directions out. Your job is to write a class called SubwayPrinter that takes the data structure returned from getDirections (), which is a list of Connection objects, and prints out the directions. The directions should be printed to an OutputStream, supplied to the constructor of the SubwayPrinter class when an instance of the printer class is created.

Here's the class diagram for **SubwayPrinter** that you should follow:

SubwayPrinter

out:PrintStream

printDirections(Connection [*])

Begin by printing out the starting station -

You can get the line for this -> Connection using getConnection. Print the line and which station to head towards.

Print out each station on a line that is passed.

Anytime the line changes, print out the line and station to get off of ...

... as well as the new line to get on. Your output should look similar to this:

BONUS CREDIT: Go ahead and write Subway Tester, too, a class to test out loading the Objectville subway system, and then printing out directions.

File Edit Window Help ShowMeTheWay

%java SubwayTester "XHTML Expressway" "JSP Junction" Start out at XHTML Expressway.

Get on the Rumbaugh Line heading towards Infinite Circle.

Continue past Infinite Circle...

When you get to Head First Theater, get off the Rumbaugh Line.

Switch over to the Meyer Line, heading towards DRY Drive.

Continue past DRY Drive ...

When you get to Web Design Way, get off the Meyer Line.

Switch over to the Wirfs-Brock Line, heading towards Boards 'R' Us.

Continue past Boards 'R' Us...

When you get to EJB Estates, get off the Wirfs-Brock Line.

Switch over to the Liskov Line, heading towards Design Patterns Plaza.

Continue past Design Patterns Plaza...

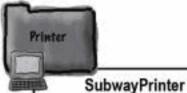
Get off at JSP Junction and enjoy yourself!

The last thing you should have is station as the stopping point

a Connection with the destination



Printing Puzzle Solution



Here's how we wrote the **SubwayPrinter** class. You might have come up with a slightly different approach to looping through the route **List**, but your output should match ours exactly for full credit.

out:PrintStream printDirections(Connection [*])

```
public class SubwayPrinter {
                                                      Rather than printing directly to System.out, our
  private PrintStream out;
                                                      class takes in an OutputStream at construction.
                                                      That allows directions to be output to any
  public SubwayPrinter(OutputStream out) {
                                                       output source, not just a console window on the
    this.out = new PrintStream(out);
                                                       user's screen.
  public void printDirections (List route) {
    Connection connection = (Connection) route.get(0);
    String currentLine = connection.getLineName();
                                                              We begin by printing the
    String previousLine = currentLine;
                                                            - starting station...
    out.println("Start out at " +
       connection.getStation1().getName() + ".");
    out.println("Get on the " + currentLine + " heading towards " +
       connection.getStation2().getName() + ".");
                                                             ...and the first line to get
    for (int i=1; i<route.size(); i++) {
                                                                  on, as well as the next
                                                                  station to travel towards.
       connection = (Connection)route.get(i);
       currentLine = connection.getLineName();
                                                                   This looks at the current
       if (currentLine.equals(previousLine)) ( <
                                                                   connection, and figures out
                                                                   if a line change is required.
         out.println(" Continue past " +
           connection.getStation1().getName() + "...");
                                                If it's the same line, just
       else (
         out.println("When you get to " +
                                                     print the station name.
                                                                               If the line
           connection.getStation1().getName() + ", get off the " +
                                                                               changes, print
                                                                               out how to
           previousLine + ".");
         out.println("Switch over to the " + currentLine + <
                                                                               change lines.
           ", heading towards " + connection.getStation2().getName() + ".");
         previousLine = currentLine;
    out.println("Get off at " + connection.getStation2().getName() +
       " and enjoy yourself!");

    Finally, we're through all
the connections... get off

                                                          the subway.
```

One last test class...

All that we need to do now is put everything together. Below is the **SubwayTester** class we wrote to load the Objectville. Subway system, take in two stations from the command line, and print out directions between those two stations using our new getDirections () method and printer class.



We can't prove our software works without some test cases and test classes.



Check out Objectville for yourself!

It's time to sit back and enjoy the fruits of your labor. Compile all your classes for the Objectville Subway application, and try out Subway Tester with a few different starting and stopping stations. Here's one of our favorites:

**Start out at Mighty Gumball, Inc." "Choc-O-Holic, Inc."

Start out at Mighty Gumball, Inc..

Get on the Jacobson Line heading towards Servlet Springs.

When you get to Servlet Springs, get off the Jacobson Line.

Switch over to the Wirfs-Brock Line, heading towards Objectville Diner.

Continue past Objectville Diner...

When you get to Head First Lounge, get off the Wirfs-Brock Line.

Switch over to the Gamma Line, heading towards OOA&D Oval.

When you get to OOA&D Oval, get off the Gamma Line.

Switch over to the Meyer Line, heading towards CSS Center.

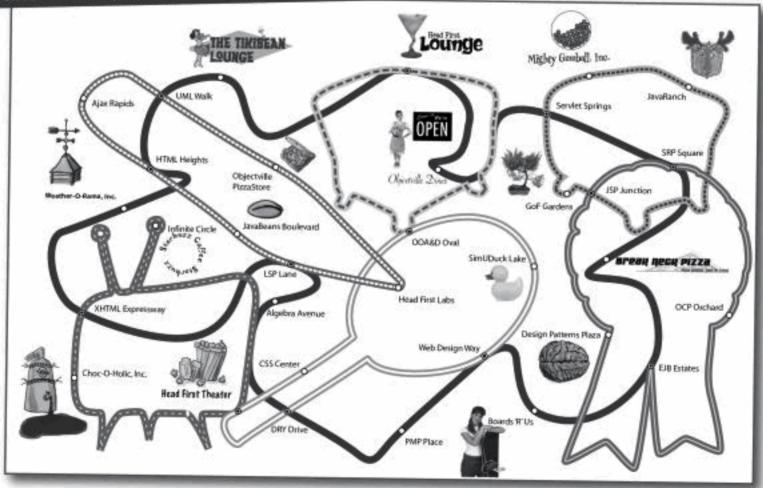
Continue past CSS Center...

When you get to Head First Theater, get off the Meyer Line.

Switch over to the Rumbaugh Line, heading towards Choc-O-Holic, Inc..

Get off at Choc-O-Holic, Inc. and enjoy yourself!

Where do YOU want to go in Objectville today?



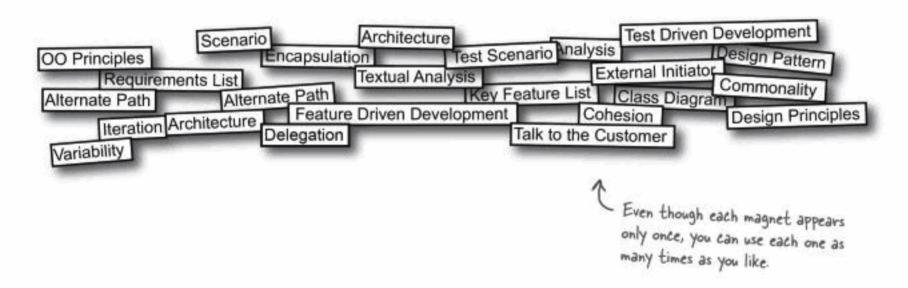


00A&D Magnets

Way back on page 487, we asked you to think about where lots of different things you've been learning about fit on the OOA&D lifecycle below. Now that you've written another piece of great software, you're ready to take this exercise on, and see how we answered it, too. Go ahead and work this exercise again; did you change where you put any of the magnets after working through this chapter?

Oh, and don't forget, you can put more than one magnet on each phase, and there are some magnets you may want to use more than once.

Feature List	Use Case Diagrams	Break Up the Problem	Requirements	Pomain Analysis	Preliminary Pesign	Implementation	Pelivery
-----------------	----------------------	-------------------------	--------------	--------------------	-----------------------	----------------	----------



— This time, answers are on the next page!



00A&D Magnet Solutions

Your job was to try and put the different magnets on the right phase of the OOA&D lifecycle, shown below. You could put more than one magnet on each phase; how do your answers compare with ours?



Dumb Questions

Q: It seems like I could put almost every magnet on each phase... but that can't be right, can it?

A: That's exactly right. Although there are definitely some basic phases in a good development cycle, you can use most of the things you've learned about OOA&D, OO principles, design, analysis, requirements, and everything else at almost every stage of development.

The most effective and successful way to write great software is to have as many tools as you can, and to be able to choose any one (or more) to use at each stage of your development cycle. The more tools you have, the more ways you'll have to look at and work on a problem... and that means less time being stuck or not knowing what to do next.

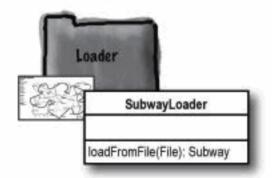
OOA&D is about having lots of options. There is never one right way to solve a problem, so the more options you have, the better chance you'll find a good solution to every problem.

Iteration #3, anyone?

No, we're not going to launch into any more design problems. But, you should realize that there is plenty more that you could do to improve the design of our RouteFinder application. We thought we'd give you just a few suggestions, in case you're dying to take another pass through the OOA&D lifecycle.

Make loading more extensible

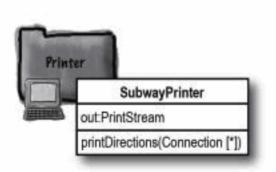
Right now, we've just got a single class that handles loading, and it only accepts a Java File as input. See if you can come up with a solution that allows you to load a subway from several types of input sources (try starting with a File and InputStream). Also make it easy to add new input sources, like a database. Remember, you want to minimize changes to existing code when you're adding new functionality, so you may end up with an interface or abstract base class before you're through.



OOA D and great software are ongoing projects... you can always add new functionality, or improve your design.

Allow different output sources (and formats!)

We can only print subway directions to a file, and the directions are formatted in a particular way. See if you can design a flexible Printing module that allows you to print a route to different output sources (like a File, OutputStream, and Writer), in different formats (perhaps a verbose form that matches what we've done already, a compact form that only indicates where to changes lines, and an XML form for other programs to use in web services).

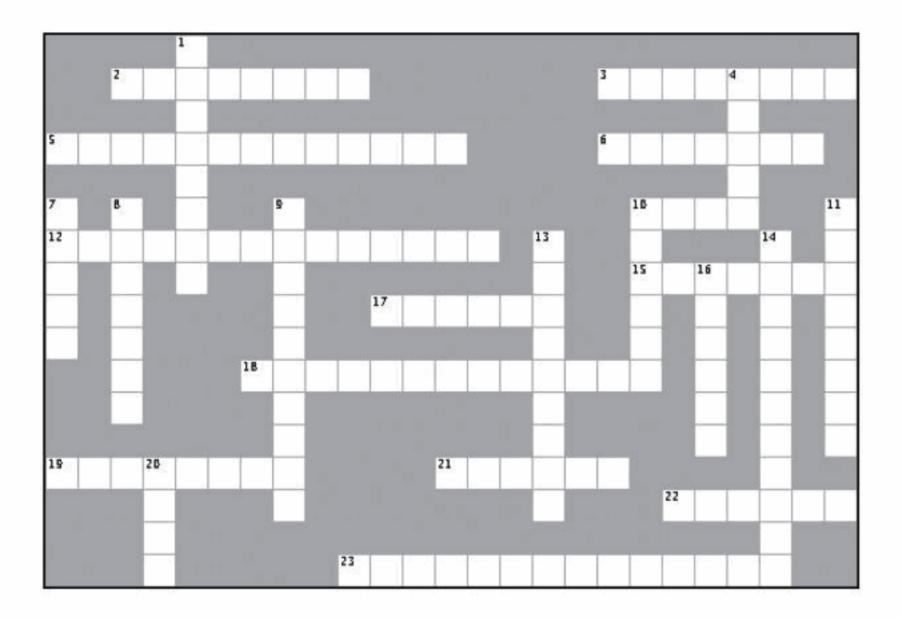


Here's a hint: check out the Strategy pattern in Head First Design Patterns for ideas on how you might make this work.



(the last) OOA&D Cross

Yes, it's a sad day: you're looking at the last crossword in the book. Take a deep breath, we've crammed this one full of terms to make it last a little longer. Enjoy!



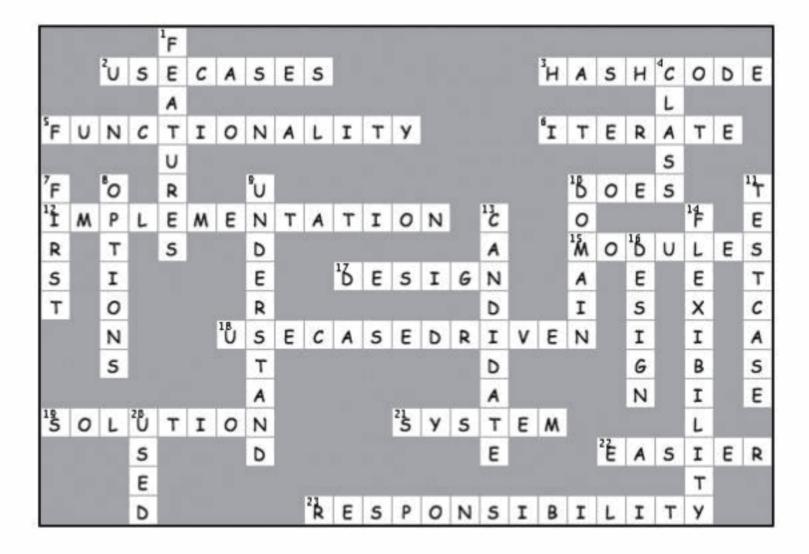
Across

- All of your features should map to these, at least indirectly.
- When you override equals() in Java, you should create a related implementation of this method.
- Your features reflect this in your application.
- You do this once you complete one feature or use case.
- A feature list focuses on what your software _____.
- When you complete this phase, you're either done or need to iterate again.
- Break your application up into these, based on your app's functionality.
- Understanding how a system is used should help you make better ______ decisions.
- The approach to development we used in this chapter (3 words).
- Never be afraid to use a ______ to a problem that someone else came up with.
- Your design decisions are based on how this is used as well as good OO principles.
- 22. Iteration makes problems _____
- Each module in your application should have a single ______.

Down

- Make a list of these to get your development started.
- You usually create this type of diagram based on your domain analysis.
- 7. This iteration is usually the toughest.
- 8. OOA&D is about giving you lots of these.
- You sometimes have to add a step to do this with your problem before writing use cases.
- The kind of analysis that involves speaking to the customer in language that they understand.
- This proves that your implementation is working.
- The nouns in your use case are these types of classes.
- 14. You have to balance what the customer wants with your software's _____.
- This is the stage where you apply good OO principles.
- Use case diagrams focus on how your software will be _____.





The journey's not over...



Now take OOA&D for a spin on your own projects!

We've loved having you here in Objectville, and we're sad to see you go. But there's nothing like taking what you've learned and putting it to use on your own development projects. So don't stop enjoying OOA&D just yet... you've still got a few more gems in the back of the book, an index to read through, and then it's time to take all these new ideas and put them into practice. We're dying to hear how things go, so drop us a line at the Head First Labs web site, http://www.headfirstlabs.com, and let us know how OOA&D is paying off for YOU.

appendix i: leftovers

The Top Ten Topics (we didn't cover)



Believe it or not, there's still more. Yes, with over 550 pages under your belt, there are still things we couldn't cram in. Even though these last ten topics don't deserve more than a mention, we didn't want to let you out of Objectville without a little more information on each one of them. But hey, now you've got just a little bit more to talk about during commercials of CATASTROPHE... and who doesn't love some stimulating OOA&D talk every now and then?

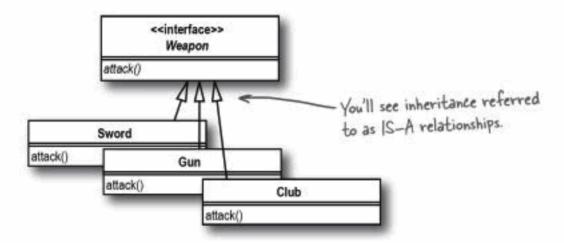
Besides, once you're done here, all that's left is another appendix... and the index... and maybe some ads... and then you're really done. We promise!

#1. IS-A and HAS-A

Lots of times in OO programming circles, you'll hear someone talk about the IS-A and HAS-A relationships.

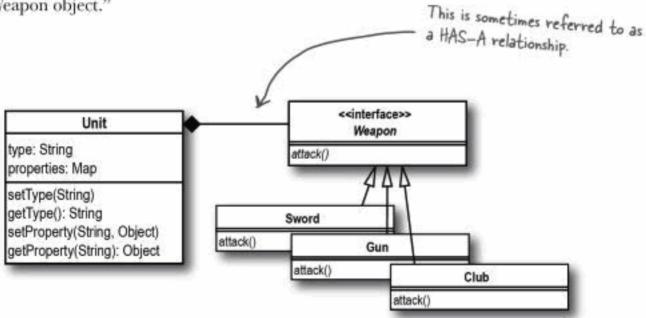
IS-A refers to inheritance

Usually, IS-A relates to inheritance, for example: "A Sword IS-A Weapon, so Sword should extend Weapon."



HAS-A refers to composition or aggregation.

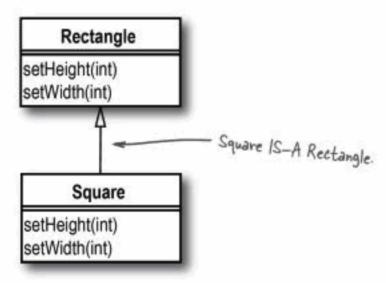
HAS-A refers to composition and aggregation, so you might hear, "A Unit HAS-A Weapon, so a Unit can be composed with a Weapon object."



The problem with IS-A and HAS-A

The reason we haven't covered IS-A and HAS-A much is that they tend to break down in certain situations. For example, consider the situation where you're modeling shapes, like **Circle**, **Rectangle**, and **Diamond**.

If you think about a **Square** object, you can apply the IS-A relationship: **Square** IS-A **Rectangle**. So you should make **Square** extend **Rectangle**, right?



But remember LSP, and that subtypes should be substitutable for their base types. So **Square** should be a direct substitute for **Rectangle**. But what happens with code like this:

```
Rectangle square = new Square();
square.setHeight(10);
square.setWidth(5);

System.out.println("Height is " + square.getHeight());

What does this method return? More importantly, what SHOULD it return?
```

The problem here is that when you set the width in **setWidth()** on **Square**, the square is going to have to set its height, too, since squares have equal width and height. So even though **Square** IS-A **Rectangle**, it doesn't *behave* like a rectangle. Calling **getHeight()** above will return 5, not 10, which means that squares behave differently than rectangles, and aren't substitutable for them—that's a violation of the LSP.

Use inheritance when one object behaves like another, rather than just when the IS-A relationship applies.

#2. Use case formats

Even though there's a pretty standard definition for what a use case is, there's not a standard way for writing use cases. Here are just a few of the different ways you can write up your use cases:

Todd and Gina's Pog Poor, version 2.0 What the Poor Poes

- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
 - 6.1 The door shuts automatically.
 - 6.2 Fido barks to be let back inside.
 - 6.3 Todd or Gina hears Fido barki
 - 6.4 Todd or Gina presses the butt remote control.
 - 6.5 The dog door opens (again).
- 7. Fido goes back inside.
- 8. The door shuts automatically.

Here's the format we've been using so far. It's a simple, step-based format that works well for most situations.

This use case is in a casual style. The steps that the system follows are written out in paragraph form.

Todd and Gina's Pog Poor, version 2.0 What the Poor Poes

Fido barks to be let outside. When Todd and Gina hear him barking, they press a button on their remote control. The button opens up the dog door, and Fido goes outside. Then Fido does his business, and returns inside. The dog door then shuts automatically.

If Fido stays outside too long, then the dog door will shut while he's still outside. Fido will bark to be let back inside, and Todd or Gina presses the button on the remote control again. This opens the dog door, and allows Fido to return back inside.



Any alternate paths are usually added to the end of the text in casual form, and presented in an "If-then" form.

Focusing on interaction

This format is a little more focused on separating out what is in a system, and how the actors outside of the system interact with your software. This format focuses on what is external to the system (the actors), and what the system itself does.

Todd and Gina's Pog Poor, version 2.0 What the Poor Poes Remember, System Actor actors are external to Fido barks to be let out. the system. They act on, Todd or Gina hears Fido or use, the barking. system-Todd or Gina presses the button on the remote control. The dog door opens. In Todd and Gina's dog door, the system Fido goes outside. is pretty simple, and usually is just Fido does his business. responding to the actions of Todd. Fido goes back inside. Gina, and Fido. The door shuts automatically. Extensions If Fido stays outside and the dog door shuts before he comes back in, he can bark to be let back in. Todd or Gina can press the button on the remote again, and he can return inside.

~

This format doesn't offer a very convenient way to handle alternate paths, so they're just added at the bottom of the use case.

A more formal use case

This is similar to the use case format we've been using, but adds some extra details.

Todd and Gina's Pog Poor, version 2.0 What the Poor Poes

The actors are external forces that affect the system.

Pre-conditions detail any assumptions that the system makes before things get started. Primary Actor: Fido

Secondary Actors: Todd and Gina

Pre-condition: Fido is inside, and needs to use the restroom.

Goal: Fido has used the bathroom and is back inside the house, without Todd or Gina having to get up and open or close the dog door.

Everything in the use case is geared towards accomplishing this goal.

Main Path

- 1. Fido barks to be let out.
- 2. Todd or Gina hears Fido barking.
- 3. Todd or Gina presses the button on the remote control.
- 4. The dog door opens.
- 5. Fido goes outside.
- 6. Fido does his business.
- 7. Fido goes back inside.
- 8. The door shuts automatically.

Extensions

- 6.1 The door shuts automatically.
- 6.2 Fido barks to be let back inside.
- 6.3 Todd or Gina hears Fido barking (again).
- 6.4 Todd or Gina presses the button on the remote control.
- 6.5 The dog door opens (again).

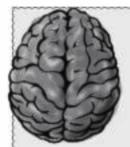
Alternate paths are also called extensions, and in this format, are listed below the main path steps.

These are the steps from the alternate path, but they're just listed separately.

All of these use cases say the same thing... it's up to you (and probably your boss) to decide which format works best for you.

#3. Anti patterns

We've talked a lot in this book about design patterns, and described them this way:



Design Patterns

Design patterns are proven solutions to particular types of problems, and help us structure our own applications in ways that are easier to understand, more maintainable, and more flexible.

But there's another type of pattern you should know about, called an anti-pattern:



Anti Patterns

Anti-patterns are the reverse of design patterns: they are common BAD solutions to problems. These dangerous pitfalls should be recognized and avoided.

Anti patterns turn up when you see the same problem get solved the same way, but the solution turns out to be a BAD one. For example, one common anti pattern is called "Gas Factory", and refers to designs that are overly complex, and therefore not very maintainable. So you want to work to avoid the Gas Factory in your own code.

> We're actually not making this up! At your next serious development meeting, be sure to mention trying to avoid the Gas Factory.

Design patterns
help you recognize
and implement
GOOD solutions to
common problems.

Anti patterns are about reconizing and avoiding BAD solutions to common problems.

#4. CRC cards

CRC stands for Class, Responsibility, Collaborator. These cards are used to take a class and figure out what its responsibility should be, and what other classes it collaborates with.

CRC cards are typically just 3x5 index cards, with each individual card representing a class. The card has two columns: one for the responsibilities of the class, and another for other classes that are collaborators, and used to fulfill those responsibilities.

Name

Responsibilities:

Open the door

Close the door

Name

Tell the door to open

Responsibilities:

This class is the class you're determining responsibilities for. Class: BarkRecognizer Pescription: This class is the interface to the bark recognition hardware. Collaborator If there are DogDoor other classes involved is this job, list them in this column. Class: DogDoor Description: Represents the physical dog door. This provides an interface to the hardware that actually controls the door. Collaborator There's no collaborator class for these.

List each

job this class

needs to do.

Be sure you write

down things that this class does on its own, as well as things

it collaborates with

other classes on.

CRC cards help implement the SRP

You can use CRC cards to make sure your classes follow the Single Responsibility Principle. These go hand in hand with your SRP Analysis, as well:

RP A	nalysis for	Automobile		
The .	Automobile	start[s]	_ itself.	
The .	Automobile	stop[s]	_ itself.	
The .	Automobile	changesTires	_ itself.	
The .	Automobile	drive[s]	_ itself.	
The .	Automobile	washEesJ	_ itself.	
The .	Automobile	check[s] oil	_ itself.	
The .	Automobile	get[s] oil	_ itself.	

If you've got a class that seems to violate the SRP, you can use a CRC card to sort out which classes should be doing what.

Any time you see "Gets", it's probably not the responsibility of this class to do a certain task.

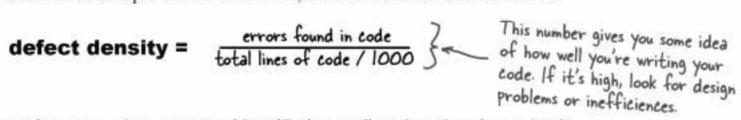
Class: Automobile Description: This class represents a car and its related functionality Responsibilities: Collaborator Name Starts itself. Stops itself. Mechanic, Tire Gets tires changed Gets driven Driver Gets washed CarWash, Attendant Mechanic Gets oil checked Reports on oil levels

Technically, you don't need to list responsibilities that AREN'T this class's, but doing things this way can help you find tasks that really shouldn't be on this class.

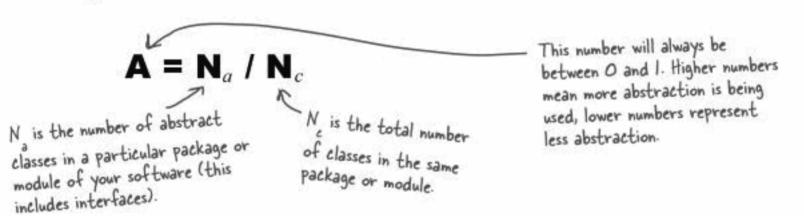
#5. Metrics

Sometimes it's hard to tell how solid your design really is, because design is such a subjective thing. That's where metrics can help out: while they don't provide a complete picture of your system, they can be helpful in pointing out strengths, weaknesses, and potential problems. You usually use software tools to take as input your class's source code, and those tools then generate metrics based on your code and its design.

These metrics are more than just numbers, though. For example, just counting the number of lines of code in your application is almost a total waste of time. It's nothing but a number, and has no context (and also depends on lot on how you're writing your code, something else we'll talk about in this appendix). But if you count the number of defects per 1000 lines of code, then that becomes a useful metric.

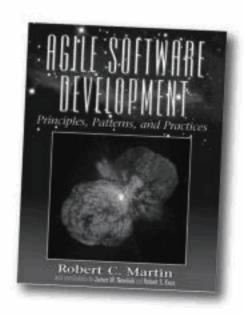


You can also use metric to measure things like how well you're using abstraction in your code. Good design will use abstract classes and interfaces, so that other classes can program to those interfaces rather than specific implementation classes. So abstraction keeps one part of your code independent from changes to other parts of your code, at least to the degree that it's possible in your system. You can use something called the **abstractness metric** to measure this:



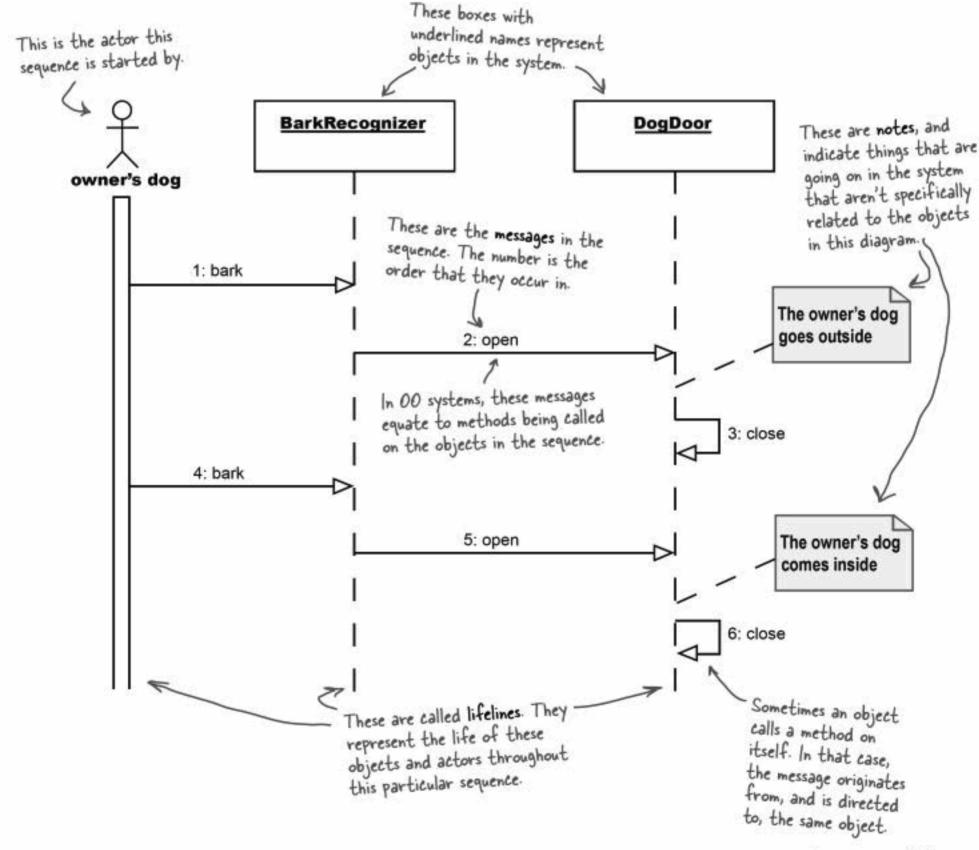
Packages that have lots of abstractions will have a higher value for A, and packages with less abstractions have a lower value for A. In general, you want to have each package in your software only depend on packages with a higher value for A. That means that your packages are always depending on packages that are more abstract; the result should be software that can easily respond to change.

Robert Martin's book called "Agile Software Development" has a lot more of these 00-related metrics.



#6. Sequence diagrams

When we were working on the dog door for Todd and Gina, we developed several alternate paths (and one alternate path actually had an alternate path itself). To really get a feel for how your system handles these different paths, it's helpful to use a UML **sequence diagram**. A sequence diagram is just what it sounds like: a visual way to show the things that happen in a particular interaction between an actor and your system.

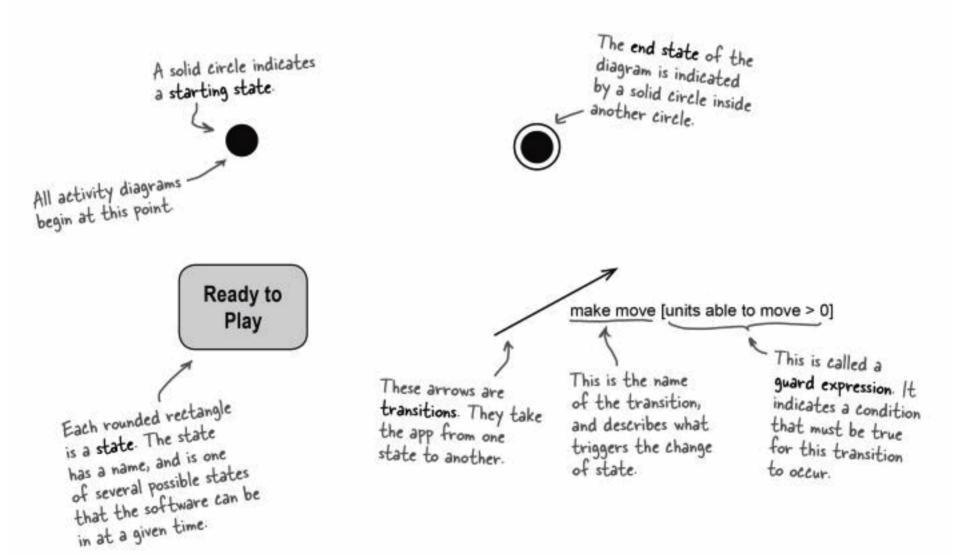


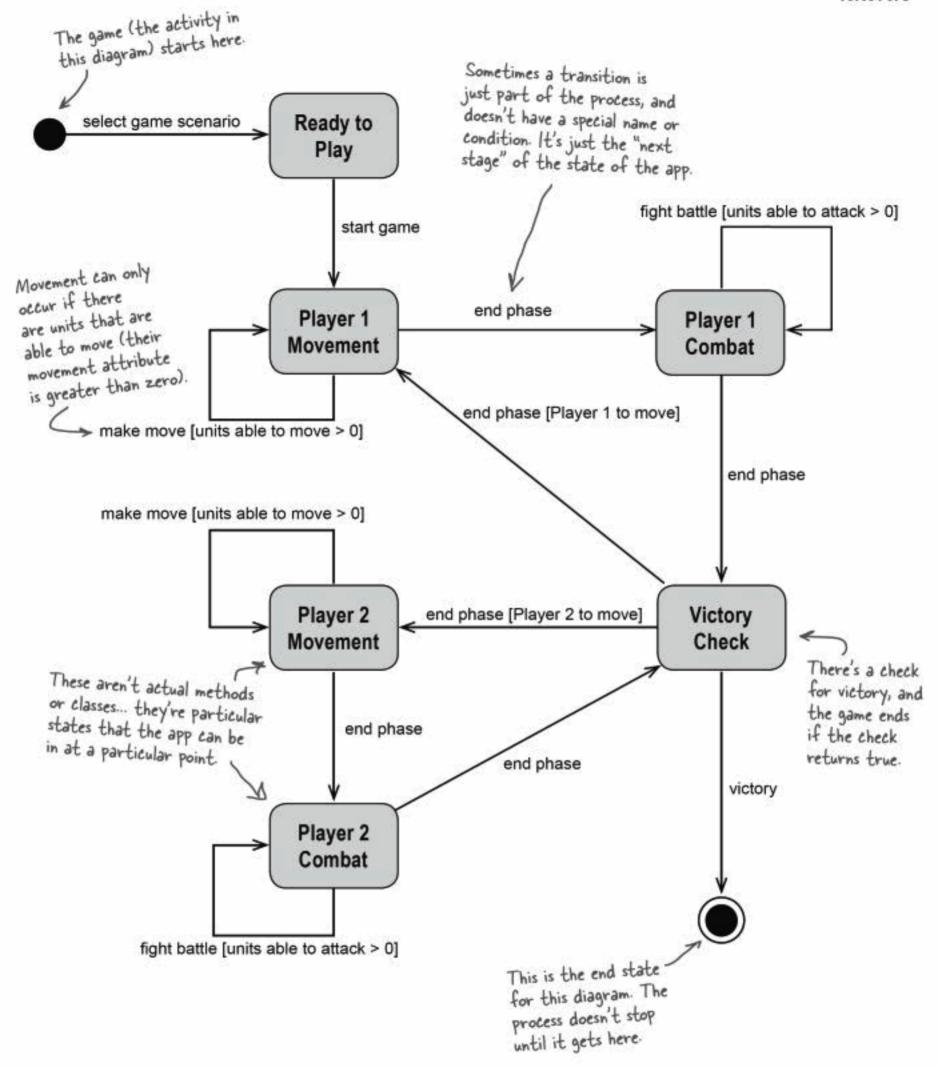
#7. State diagrams

You've already seen class diagrams and sequence diagrams. UML also contains a diagram called a **state machine diagram** or **statechart diagram**, which is usually just referred to as a **state diagram**. This diagram describes a part of your system by showing its various states, and the actions that cause that state to change. These diagrams are great for describing complex behaviors visually.

State diagrams really come into play when you have multiple actions and events that are all going on at the same time. On the right page, we've taken just such a situation, and drawn a state diagram for how a game designer might use Gary's Game System Framework. If game desgners were going to use the framework, they might write a game that behaves a lot like this state diagram demonstrates.

Symbols commonly used in state diagrams





#8. Unit testing

In each chapter that we're worked on an application, we've built "driver" programs to test the code, like **SubwayTester** and **DogDoorSimulator**. These are all a form of **unit testing**. We test each class with a certain set of input data, or with a particular sequence of method calls.

While this is a great way to get a sense of how your application works when used by the customer, it does have some drawbacks:

- You have to write a complete program for each usage of the software.
- You need to produce some kind of output, either to the console or a file, to verify the software is working correctly.
- You have to manually look over the output of the test, each time its run, to make sure things are working correctly.
- Your tests will eventually test such large pieces of functionality that you're no longer testing all the smaller features of your app.

Fortunately, there are testing frameworks that will not only allow you to test very small pieces of functionality, but will also automate much of that testing for you. In Java, the most popular framework is called JUnit (http://www.junit.org), and integrates with lots of the popular Java development environments, like Eclipse.

there are no Dumb Questions

If the tests we wrote in the main part of the book made sure our software worked at a high level, why do we need more tests? Aren't those enough to be sure our software works?

A: Most of the tests we wrote really tested a particular scenario, such as opening the door, letting a dog out, having another dog bark, and then letting the owner's dog back in. Unit tests, and particular the tests we're talking about here, are far more granular. They test each class's functionality, one piece at a time.

The reason that you need both types of tests is because you'll never be able to come up with scenarios that test every possible combination of features and functionality in your software. We're all human, and we all tend to forget just one or two strange situations now and then.

With tests that exercise each individual piece of functionality in your classes, you can be sure that things will work in any scenario, even if you don't specifically test that scenario. It's a way to make sure each small piece works, and one that lets you assume pretty safely that combining those small pieces will then work, as well.

What a test case looks like

A test case has a test method for each and every piece of functionality in the class that it's testing. So for a class like **DogDoor**, we'd test opening the door, and closing the door. JUnit would generate a test class that looked something like this:

```
import junit.framework.TestCase;
              * This test case tests the operation of the dog door by using the
              * remote button.
            */
public class RemoteTest extends TestCase for testing software.
                 public void testOpenDoor() <
                                                                 There's a method
                                                                 for each piece of functionality in DogDoor.
assertTrue()
                     DogDoor door = new DogDoor();
checks to see
                     Remote remote = new Remote(door);
                     remote.pressButton();
if the supplied
                   assertTrue(door.isOpen());
method
returns true,
 which it should
                 public void testCloseDoor() {
                     DogDoor door = new DogDoor();
 in this case.
                     Remote remote = new Remote(door);
                                                                        This method tests for
                     remote.pressButton();
                                                                        the door automatically
   assert False()
                          Thread.currentThread().sleep(6000); closing, rather than just
   checks a
                      ) catch (InterruptedException e) {
                                                                        calling door.close(), which
   method to
                           fail ("interrupted thread");
                                                                        isn't how the door is
   ensure that
                                                                        usually used.
                    > assertFalse(door.isOpen()); 🦔
   it's NOT true.
```

Test your code in context

Notice that instead of directly testing the **DogDoor**'s **open()** and **close()** methods, this test uses the **Remote** class, which is how the door would work in the real world. That ensures that the tests are simulating real usage, even though they are testing just a single piece of functionality at a time.

The same thing is done in **testCloseDoor()**. Instead of calling the **close()** method, the test opens the door with the remote, waits beyond the time it should take for the door to close automatically, and then tests to see if the door is closed. That's how the door will be used, so that's what should be tested.

#9. Coding standards and readable code

Reading source code should be a lot like reading a book. You should be able to tell what's going on, and even if you have a few questions, it shouldn't be too hard to figure out the answers to those questions if you just keep reading. Good developers and designers should be willing to spend a little extra time writing readable code, because it improves the ability to maintain and reuse that code.

Here's an example of a commented and readable version of the **DogDoor** class we wrote back in Chapters 2 and 3.

```
* This class represents the interface to the real dog door.
        * @author Gary Pollice
                                                                 - JavaDoc comments help people
        * @version Aug 11, 2006 <
                                                                  reading the code, and also can be
       public class DogDoor
                                                                  used to generate documentation
                                                                  with Java's javadoc tool.
            // the number of open commands in progress
           private int numberOfOpenCommands = 0;
           boolean doorIsOpen = false; -
                                                    Method and variable
             * Greturn true if the door is open
                                                     names are descriptive, and
                                                     easy to decipher.
           public boolean isOpen() _
                return doorIsOpen; <
            1++
             * Open the door and then, five seconds later, close it.
                                                                    This code is clear and spaced out.
           public void open()
                // Code to tell the hardware to open the door goes here
                doorIsOpen = true;
              numberOfOpenCommands++;
                TimerTask task = new TimerTask() {
Even variables
                    public void run() {
used just within
                        if (--numberOfOpenCommands == 0) {
                             // Code to tell the hardware to close the door goes here
a single method
                             doorIsOpen = false;
are named for
readability.
                                                             Any statements that
                                                             aren't perfectly clear are
                Timer timer = new Timer();
                                                             commented to clarify.
                timer.schedule(task, 5000);
```

Great software is more than just working code

Many developers will tell you that code standards and formatting are a big pain, but take a look at what happens when you don't spend any time making your code readable:

```
No comments at all here ... it's up to
                                             the developer reading this code to
                                             figure everything out on their own.
public class DogDoor
                                 No telling what these
     private int noc = 0; - variables are for ...
     boolean dio = false; <
     public boolean returndio() { return dio; }
                                             ... or these methods.
     public void do my job( ) <
                                              The names are not at
                                              all descriptive.
         dio = true;
         noc++;
         TimerTask tt = new TimerTask() {
         public void run() {
                                                   The lack of
          if (--noc == 0) dio = false;
                                               _ indentation and
                                                   spacing makes
                                                   things even harder
         Timer t = new Timer();
                                                   to understand
         t.schedule(tt, 5000);
1
```

From a purely functional point of view, this version of **DogDoor** works just as well as the one on the last page. But by now you should know that great software is more than just working code—it's code that is maintainable, and can be reused. And most developers will not want to maintain or reuse this second version of **DogDoor**; it's a pain to figure out what it does, or where things might go wrong—now imagine if there were 10,000 lines of code like this, and not just 25 or so.

Writing readable code makes that code easier to maintain and reuse, for you and other developers.

#10. Refactoring

Refactoring is the process of modifying the structure of your code without modifying its behavior. Refactoring is done to increase the cleaness, flexibility, and extensibility of your code, and usually is related to a specific improvement in your design.

Most refactorings are fairly simple, and focus on one specific design aspect of your code. For example:

```
public double getDisabilityAmount() {
 // Check for eligibility
 if (seniority < 2)
   return 0;
 if (monthsDisabled > 12)
   return 0;
 if (isPartTime)
   return 0;
 // Calculate disability amount and return it
```

While there's nothing particularly wrong with this code, it's not as maintainable as it could be. The getDisabilityAmount() method is really doing two things; checking the eligibility for disability, and then calculating the amount.

By now, you should know that violates the Single Responsibility Principle. We really should separate the code that handles eligibility requirements from the code that does disability calculations. So we can refactor this code to look more like this:

```
public double getDisabilityAmount() {
                                                                       We've taken two responsibilities,
and placed them in two separate
methods, adhering to the SRP.
  // Check for eligibility
  if (isEligibleForDisability()) (
     // Calculate disability amount and return it
   | else |
     return 0;
```

Now, if the eligibility requirements for disability change, only the isEligibleForDisability() methods needs to change—and the method responsible for calculating the disability amount doesn't.

Think of refactoring as a checkup for your code. It should be an ongoing process, as code that is left alone tends to become harder and harder to reuse. Go back to old code, and refactor it to take advantage of new design techniques you've learned. The programmers who have to maintain and reuse your code will think you for it.

Refactoring changes the internal structure of your code WITHOUT affecting your code's behavior.

1

appendix ii: welcome to objectville

Speaking the
It says here that you want to change my composition to aggregation, add some delegation,

Language of 00



Get ready to take a trip to a foreign country. It's time to visit Objectville, a land where objects do just what they're supposed to, applications are all well-encapsulated (you'll find out exactly what that means shortly), and designs are easy to reuse and extend. But before we can get going, there are a couple of things you need to know first, and a few language skills you're going to have to learn. Don't worry, though, it won't take long, and before you know it, you'll be speaking the language of OO like you've been living in the well-designed areas of Objectville for years.

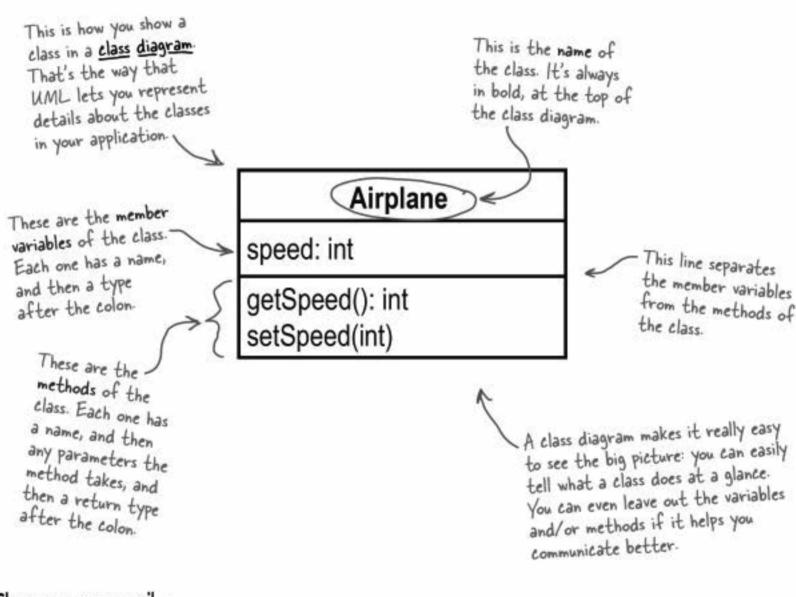
Welcome to Objectville

Whether this is your first trip to Objectville, or you've visited before, there's no place quite like it. But things are a little different here, so we're here to help you get your bearings before you dive into the main part of the book.



UML and class diagrams

We're going to talk about classes and objects a lot in this book, but it's pretty hard to look at 200 lines of code and focus on the big picture. So we'll be using UML, the *Unified Modeling Language*, which is a language used to communicate just the **details** about your **code** and **application's structure** that other developers and customers **need**, without getting details that *aren't* necessary.



Sharpen your pencil

Write the skeleton for the Airplane class.

Using the class diagram above, see if you can write the basic skeleton for the Airplane class. Did you find anything that the class diagram leaves out? Write those things in the blanks below:



Write the skeleton for the Airplane class.

Using the class diagram on page 577, you were supposed to write the basic skeleton for the Airplane class. Here's what we did:

```
public class Airplane {
                                                                 There was nothing about a constructor in
The class diagram
                                                                 the class diagram. You could have written
                         private int speed;
didn't tell us if
                                                                 a constructor that took in an initial speed
speed should be public,
                           public Airplane() {
                                                                 value, and that would be OK, too.
private, or protected.
                           public void setSpeed(int speed) {
                              this.speed = speed; <
Actually, class diagams
                                                                           The class diagram didn't
can provide this
                                                                           tell us what this method
information, but in
                           public int getSpeed() {
                                                                           did ... we made some
most cases, it's not
                              return speed; -
                                                                           assumptions, but we can't
needed for clear
                                                                           be sure if this code is
communication.
                                                                           really what was intended.
```

Dumb Questions

Q: So the class diagram isn't a very complete representation of a class, is it?

A: No, but it's not meant to be. Class diagrams are just a way to communicate the basic details of a class's variables and methods. It also makes it easy to talk about code without forcing you to wade through hundreds of lines of Java, or C, or Perl.

Q: I've got my own way of drawing classes; what's wrong with that?

A: There's nothing wrong with your own notation, but it can make things harder for other people to understand. By using a standard like UML, we can all speak the same language and be sure we're talking about the same thing in our diagrams.

Q: So who came up with this UML deal, anyway?

A: The UML specification was developed by Rational Software, under the leadership of Grady Booch, Ivar Jacobson, and Jim Rumbaugh (three really smart guys). These days it's managed by the OMG, the Object Management Group.

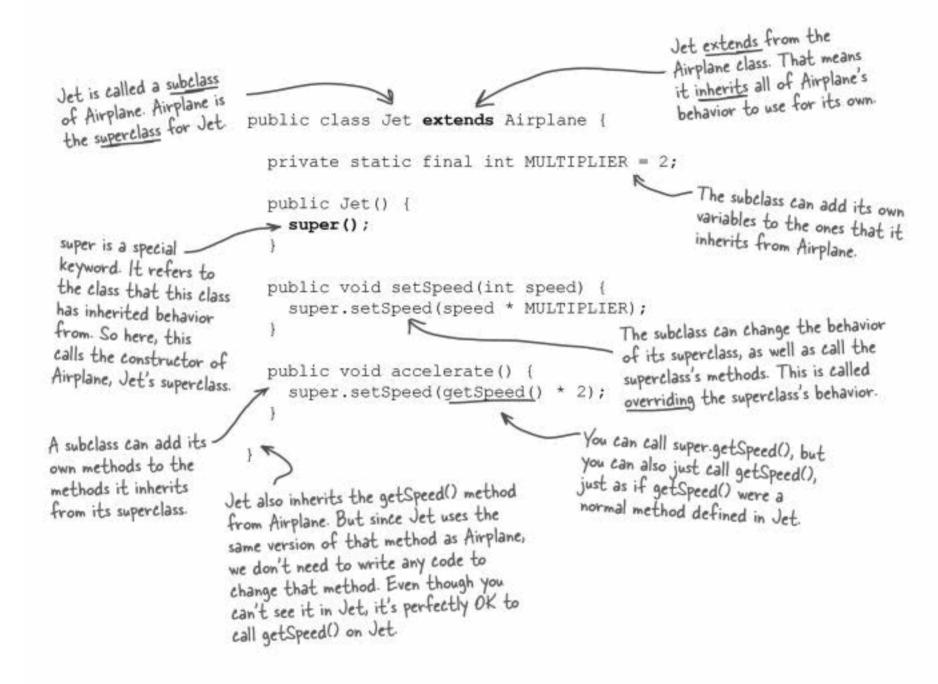
Q: Sounds like a lot of fuss over that simple little class diagram thing.

A: UML is actually a lot more than that class diagram. UML has diagrams for the state of your objects, the sequence of events in your application, and it even has a way to represent customer requirements and interactions with your system. And there's a lot more to learn about class diagrams, too.

At this point, though, you just need the basics on page 577. We'll talk about other things you can show in a class diagram, and other types of diagrams, when we need them later in the book.

Next up: inheritance

One of the fundamental programming topics in Objectville is inheritance. That's when one class inherits behavior from another class, and can then change that behavior if needed. Let's look at how inheritance works in Java; it's similar in other languages, too:



Inheritance lets you build classes based on other classes, and avoid duplicating and repeating code.



Pool Puzzle

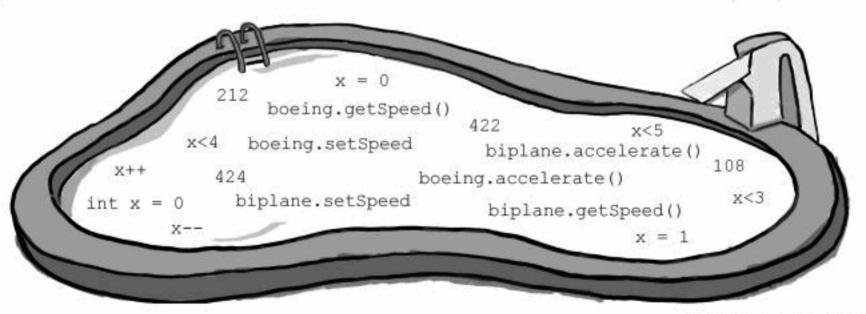
Your **job** is to take code snippets from the pool below and place them into the blank lines in the code

and produce the output listed.

you see on the right.
You may use the same
snippet more than once,
and you won't need
to use all the snippets.
Your goal is to create a
class that will compile, run,

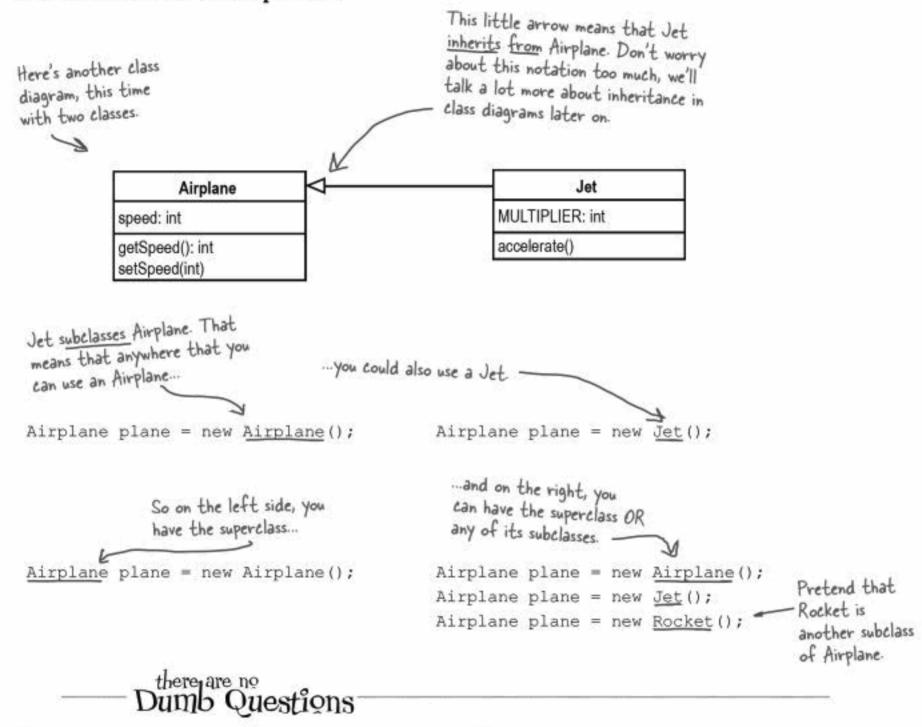
Output:

```
File Edit Window Help LeavingOnAJetplane
%java FlyTest
212
844
1688
6752
13504
27008
```



And polymorphism, too...

Polymorphism is closely related to inheritance. When one class inherits from another, then polymorphism allows a **subclass** to **stand in** for the **superclass**.



Q: What's so useful about polymorphism?

A: You can write code that works on the superclass, like Airplane, but will work with any subclass type, like Jet or Rocket. So your code is more flexible.

Q: I still don't get how polymorphism makes my code flexible.

A: Well, if you need new functionality, you could write a new subclass of Airplane. But since your code uses the superclass, your new subclass will work without any changes to the rest of our code! That means your code is flexible and can change easily.

Last but not least: encapsulation

Encapsulation is when you **hide** parts of your **data** from the rest of your application, and **limit** the ability for other parts of your code to access that data. Suppose we rewrote our **Airplane** class like this:

Encapsulation is when you protect information in your code from being used incorrectly.

Now anyone can set the speed directly

This change means that the rest of your app no longer has to call setSpeed() to set the speed of a plane; the speed variable can be set directly. So this code would compile just fine:

```
public class FlyTest2 {
   public static void main(String[] args) {
     Airplane biplane = new Airplane();
     biplane.speed = 212;
     System.out.println(biplane.speed);
}

Try this code out...
   anything surprising in the results you get?
```

So what's the big deal?

Doesn't seem like much of a problem, does it? But what happens if you create a **Jet** and set its speed like this:

Shar	pen	your	pencil
		•	

What's the value of e	ncapsulating your data?
-----------------------	-------------------------

did your output look like? W	rite the two lines of output in the blanks below
Speed of jet1:	
Speed of jet2:	
What do you think happened speeds that you did for each	d here? Write down why you think you got the instance of Jet:

Type in, compile, and run the code for FlyTest3.java, shown above. What

illy summs	arize what you think the value of encapsulation is:
------------	---



What's the value of encapsulating your data?

Type in, compile, and run the code for FlyTest3.java shown above. What did your output look like? Write the two lines of output in the blanks below:

Speed of jet1: 212

Speed of jet2: 424

What do you think happened here? Write down why you think you got the speeds that you did for each instance of Jet:

In the Jet class, setSpeed() takes the value supplied, and multiples
it by two before setting the speed of the jet. When we set the
speed variable manually, it didn't get multipled by two.

You didn't have to write; down exactly what we did, but you should have gotten something similar.

Finally, summarize what you think the value of encapsulation is:

Encapsulation protects data from being set in an improper way. With encapsulated data, any calculations or checks that the class does on the data are preserved, since the data can't be accessed directly.

So encapsulation does more than just hide information; it makes sure the methods you write to work with your data are actually used!

Taking a college class in programming? Here's the official definition of encapsulation... if you're taking an exam, this is the definition to use.

Scholar's Corner

encapsulation. The process of enclosing programming elements inside larger, more abstract entities. Also known as information hiding, or separation of concerns.



Dumb Questions

Q: So encapsulation is all about making all your variables private?

A: No, encapsulation is about separating information from other parts of your application that shouldn't mess with that information. With member variables, you don't want the rest of your app directly messing with your data, so you separate that data by making it private. If the data needs to be updated, you can provide methods that work with the data responsibly, like we did with the Airplane class, using getSpeed() and setSpeed().

Q: So are there other ways to use encapsulation besides with variables?

A: Absolutely. In fact, in Chapter 1, we'll be looking at how you can encapsulate a group of properties away from an object, and make sure that the object doesn't use those properties incorrectly. Even though we'll deal with an entire set of properties, it's still just separating a set of information away from the rest of your application.

Q: So encapsulation is really about protecting your data, right?

A: Actually, it's even more than that! Encapsulation can also help you separate behavior from other parts of your application. So you might put lots of code in a method, and put that method in a class; you've separated that behavior from the rest of your application, and the app has to use your new class and method to access that behavior. It's the same principles as with data, though: you're separating out parts of your application to protect them from being used improperly.

Q: Wow, I'm not sure I'm following all of this. What do I need to do?

A: Just keep reading. Make sure you understand the exercise solutions on page 584, and you're ready for Chapter 1. We'll spend a lot more time on all of these OO principles and concepts, so don't feel like you need to get everything down perfectly at this point.

Encapsulation
separates
your data
from your
app's
behavior.

Then you can control how each part is used by the rest of your application.

Already gone through
everything? Then you're definitely
ready for the rest of this book. And
welcome again to the well-designed
part of Objectville... we love it here,
I'm sure you will, too.



- UML stands for the Unified Modeling Language.
- UML helps you communicate the structure of your application to other developers, customers, and managers.
- A class diagram gives you an overview of your class, including its methods and variables.
- Inheritance is when one class extends another class to reuse or build upon the inherited class's behavior.
- In inheritance, the class being inherited from is called the superclass; the class that is doing the inheritance is called the subclass.
- A subclass gets all the behavior of its superclass automatically.

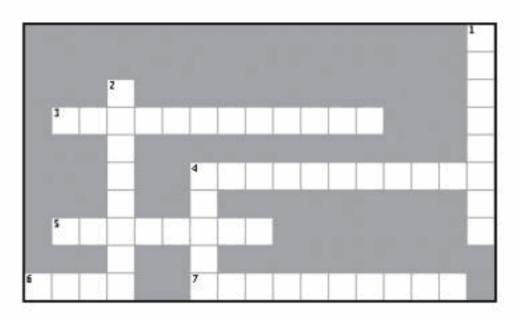
- A subclass can override its superclass's behavior to change how a method works.
- Polymorphism is when a subclass "stands in" for its superclass.
- Polymorphism allows your applications to be more flexible, and less resistant to change.
- Encapsulation is when you separate or hide one part of your code from the rest of your code.
- The simplest form of encapsulation is when you make the variables of your classes private, and only expose that data through methods on the class.
- You can also encapsulate groups of data, or even behavior, to control how they are accessed.





OOA&D Cross

Even though this is Chapter O, here's Crossword #1. Take a moment to review the concepts in this chapter, and then you're ready to step firmly into the world of analysis, design, OO programming, and great software.



Across

- This is when a subclass can substitute for its superclass.
- Class diagrams don't show details about this part of our class.
- 5. A class that inherits from another class is
- Encapsulation lets you do this to information.
- 7. A class that is inherited from is called this.

Down

- Another term for encapsulation is separation of this.
- 2. Polymorphism helps make your code
- Use this kind of diagram to avoid wading through lots of code.



Pool Puzzle Solution

Your **job** was to take code snippets from the pool below, and place them into the blank lines in the code you see on the right. You **may** use the same snippet more than once, and you won't need to use all the snippets. Your **goal** was to create a class that will compile, run, and produce the output listed.

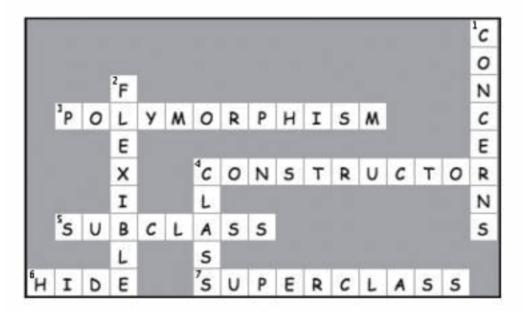
Output:

```
File Edit Window Help LeavingOnAJetplane
% java FlyTest
212
844
1688
6752
13504
27008
1696
```

```
public class FlyTest {
  public static void main(String[] args) (
    Airplane biplane = new Airplane();
    biplane.setSpeed(212);
    System.out.println(biplane.getSpeed());
    Jet boeing = new Jet();
    boeing.setSpeed(422);
    System.out.println(boeing.getSpeed());
    int x = 0:
    while (x<4) (
      boeing.accelerate();
      System.out.println(boeing.getSpeed());
      if (boeing.getSpeed() > 5000) {
        biplane.setSpeed(biplane.getSpeed() * 2);
      } else {
        boeing.accelerate();
      X++;
    System.out.println(biplane.getSpeed());
```

Here's our solution to the pool puzzle.





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