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2nd Edition

Java® Programming for Android® Developers

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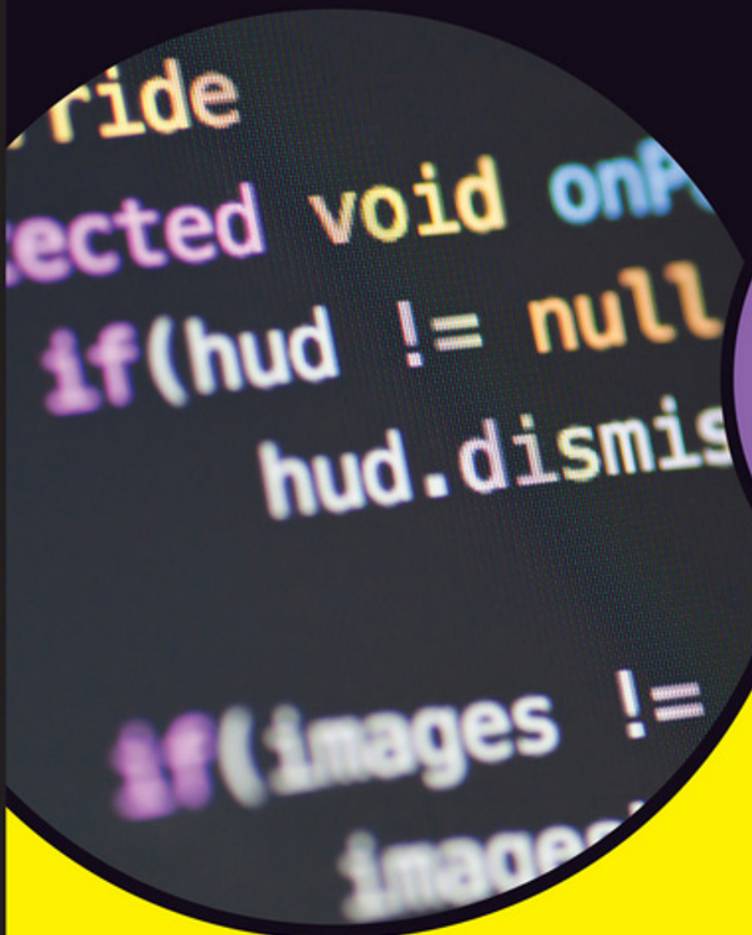

Master basic Java programming

Create an Android program from start to finish

Assemble and debug your own app

Barry Burd, PhD
Author of *Java For Dummies*

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2nd edition

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Introduction

Android is everywhere. In mid-2016, Android runs on 65 percent of all smartphones in the United States, on 75 percent of all smartphones in EU5 countries, and on 77 percent of all smartphones in China.[1] In a study that spans the Americas, Europe, Asia, and the Middle East, GlobalWebIndex reports that "Android is the most favored OS when it comes to tablets, being used by almost a fifth of internet users and leading iPad by 5 points."[2] More than 2.2 million apps are available for download at the Google Play store.[3] And 9 million developers write code using Java, the language that powers Android devices.[4]

If you read this book in a public place (on a commuter train, at the beach, or on the dance floor at the Coyote Ugly saloon, for example), you can read proudly, with a chip on your shoulder and with your head held high. Android is hot stuff, and you're cool because you're reading about it.

How to Use This Book

You can attack this book in either of two ways: Go from cover to cover or poke around from one chapter to another. You can even do both (start at the beginning, and then jump to a section that particularly interests you). This book was designed so that the basic topics come first, and the more-involved topics follow them. But you may already be comfortable with some basics, or you may have specific goals that don't require you to know about certain topics.

[1]See `www.kantarworldpanel.com/global/News/Android-Share-Growth-is-Highest-in-EU5-in-Over-Two-Years`. The EU5 countries are France, Germany, Italy, Spain, and the United Kingdom.

[2]See `www.globalwebindex.net/hubfs/Reports/GWI_Device_Report_-_Q3_2015_Summary.pdf`.

[3]See `www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores`.

[4]See `www.java.com/en/about`.

In general, my advice is this:

- If you already know something, don't bother reading about it.
- If you're curious, don't be afraid to skip ahead. You can always sneak a peek at an earlier chapter, if you need to do so.

Conventions Used in This Book

Almost every technically themed book starts with a little typeface legend, and *Java Programming for Android Developers For Dummies*, 2nd Edition, is no exception. What follows is a brief explanation of the typefaces used in this book:

- New terms are set in *italics.*
- If you need to type something that's mixed in with the regular text, the characters you type appear in bold. For example: "Type **MyNewProject** in the text field."
- You also see this `computerese` font. I use computerese for Java code, filenames, onscreen messages, and other such things. Also, if something you need to type is really long, it appears in computerese font on its own line (or lines).
- You may need to change certain things when you type them on your own computer keyboard. For instance, I may ask you to type

  ```
  public void Anyname
  ```

  which means that you type **public void** and then a name that you make up on your own. Words that you need to replace with your own words are set in *italicized computerese*.

What You Don't Have to Read

Pick the first chapter or section that has material you don't already know and start reading there. Of course, you may hate making decisions as much as I do. If so, here are some guidelines you can follow:

- **If you already know what kind of an animal Java is and you don't care what happens behind the scenes when an Android app runs:** Skip Chapter 1 and go straight to Chapter 2. Believe me — I won't mind.

- **If you already know how to get an Android app running:** Skip Part 1 and start with Part 2.
- **If you have experience writing computer programs in languages other than C and C++:** Start with Part 2. You'll probably find Part II to be easy reading. When you get to Part 3, it'll be time to dive in.
- **If you have experience writing computer programs in C or C++:** Skim Part II and start reading seriously in Part 3. (Java is a bit different from C++ in the way it handles classes and objects.)
- **If you have experience writing Java programs:** Come to my house and help me write *Java Programming for Android Developers For Dummies,* 3rd Edition.

If you want to skip the sidebars and the paragraphs with Technical Stuff icons, please do. In fact, if you want to skip anything at all, feel free.

Foolish Assumptions

In this book, I make a few assumptions about you, the reader. If one of these assumptions is incorrect, you're probably okay. If all these assumptions are incorrect . . . well, buy the book anyway.

- **I assume that you have access to a computer.** Access to an Android device is helpful but not absolutely necessary! All the software you need in order to test Android apps on a laptop or desktop computer is freely available. You simply download, install, and get going.
- **I assume that you can navigate your computer's common menus and dialog boxes.** You don't have to be a Windows, Macintosh, or Linux power user, but you should be able to start a program, find a file, put a file into a certain directory — that sort of thing. Much of the time, when you follow the instructions in this book, you're typing code on the keyboard, not pointing and clicking the mouse.

  On those occasions when you need to drag and drop, cut and paste, or plug and play, I guide you carefully through the steps. But your computer may be configured in any of several billion ways, and my instructions may not quite fit your special situation. When you reach one of these platform-specific tasks, try following the steps in this book. If the steps don't quite fit, consult a book with instructions tailored to your system. If you can't find such a book, send me an email. (My address appears later in the Introduction.)

- **I assume that you can think logically.** That's all there is to application development — thinking logically. If you can think logically, you've got it made. If you don't believe that you can think logically, read on. You may be pleasantly surprised.
- **I make very few assumptions about your computer programming experience (or your lack of such experience).** In writing this book, I've tried to do the impossible: make the book interesting for experienced programmers yet accessible to people with little or no programming experience. This means that I don't assume any particular programming background on your part. If you've never created a loop or indexed an array, that's okay.

  On the other hand, if you've done these things (maybe in Visual Basic, COBOL, or C++), you'll discover some interesting plot twists in Java. The creators of Java took the best ideas from object-oriented programming, streamlined them, reworked them, and reorganized them into a sleek, powerful way of thinking about problems. You'll find many new, thought-provoking features in Java. As you find out about these features, many of them will seem quite natural to you. One way or another, you'll feel good about using Java.

How This Book Is Organized

This book is divided into subsections, which are grouped into sections, which come together to make chapters, which are lumped, finally, into five parts (like one of those Russian *matryoshka* dolls). The parts of the book are described here.

Part 1: Getting Started with Java Programming for Android Developers

Part 1 covers all the nuts and bolts. It introduces you to the major ideas behind Java and Android software development and walks you through the installation of the necessary software products. You also run a few simple Java and Android programs.

The instructions in these chapters cover both Windows and Macintosh computers. They cover many computer configurations, including some not-so-new operating system versions, 32-bit systems and 64-bit systems, and situations in which you already have some form of Java on your computer. But installing software is always tricky, and you might have a few hurdles to overcome. If you do, check the end of this chapter for ways to reach me (the author) and get some quick advice. (Yes, I answer emails, tweets, Facebook posts, and notes sent by carrier pigeons.)

Part 2: Writing Your Own Java Programs

Chapters 4 through 8 cover Java's basic building blocks. These chapters describe the things you need to know so that you can get your computer humming along.

If you've written programs in Visual Basic, C++, or any other language, some of the material in Part 2 may be familiar to you. If so, you can skip sections or read this stuff quickly. But don't read *too* quickly. Java is a little different from some other programming languages, and Java's differences are worth noting.

Part 3: Working with the Big Picture: Object-Oriented Programming

Part 3 has some of my favorite chapters. This part covers the all-important topic of object-oriented programming. In these chapters, you find out how to map solutions to big problems. (Sure, the examples in these chapters aren't big, but the examples involve big ideas.) You discover, in bite-worthy increments, how to design classes, reuse existing classes, and construct objects.

Have you read any of those books that explain object-oriented programming in vague, general terms? I'm very proud to say that *Java Programming for Android Developers For Dummies,* 2nd Edition, isn't like that. In this book, I illustrate each concept with a simple-yet-concrete program example.

Part 4: Powering Android with Java Code

If you've tasted some Java and want more, you can find what you need in Part 4 of this book. This part's chapters are devoted to details — the things you don't see when you first glance at the material. This part includes some fully functional Android apps. So, after you read the earlier parts and write some programs on your own, you can dive in a little deeper by reading Part 4.

Part 5: The Part of Tens

In The Part of Tens, which is a little Java candy store, you can find lists — lists of tips for avoiding mistakes, tracking down resources, and finding all kinds of interesting goodies.

More on the web!

You've read the *Java Programming for Android Developers* book, seen the *Java Programming for Android Developers* movie, worn the *Java Programming for Android Developers* T-shirt, and eaten the *Java Programming for Android Developers* candy. What more is there to do?

That's easy. Just visit this book's website: `www.allmycode.com/Java4Android`. There you can find updates, comments, additional information, and answers to commonly asked questions from readers. You can also find a small chat application for sending me quick questions when I'm online. (When I'm not online, you can contact me in other ways. See the end of this chapter for more info.)

Icons Used in This Book

If you could watch me write this book, you'd see me sitting at my computer, talking to myself. I say each sentence in my head. Most of the sentences I mutter several times. When I have an extra thought, a side comment, or something else that doesn't belong in the regular stream, I twist my head a little bit. That way, whoever's listening to me (usually nobody) knows that I'm off on a momentary tangent.

Of course, in print, you can't see me twisting my head. I need some other way to set a side thought in a corner by itself. I do it with icons. When you see a Tip icon or a Remember icon, you know that I'm taking a quick detour.

Here's a list of icons that I use in this book:


TIP

A tip is an extra piece of information — helpful advice that the other books may forget to tell you.


WARNING

Everyone makes mistakes. Heaven knows that I've made a few in my time. Anyway, when I think people are especially prone to make a mistake, I mark the text with a Warning icon.


REMEMBER

Question: What's stronger than a tip but not as strong as a warning?

Answer: A Remember icon.

CROSS-REFERENCE

"If you don't remember what *such-and-such* means, see *blah-blah-blah,*" or "For more information, read *blahbity-blah-blah.*"

ON THE WEB

This icon calls attention to useful material that you can find online. (You don't have to wait long to see one of these icons. I use one at the end of this introduction!)

TECHNICAL STUFF

Occasionally, I run across a technical tidbit. The tidbit may help you understand what the people behind the scenes (the people who created Java) were thinking. You don't have to read it, but you may find it useful. You may also find the tidbit helpful if you plan to read other (geekier) books about Java and Android.

Beyond the Book

In addition to what you're reading right now, this book comes with a free access-anywhere Cheat Sheet containing code that you can copy and paste into your own Android program. To get this Cheat Sheet, simply go to `www.dummies.com` and type **"Java Programming for Android Developers For Dummies Cheat Sheet"** in the Search box.

Where to Go from Here

If you've gotten this far, you're ready to start reading about Java and Android application development. Think of me (the author) as your guide, your host, your personal assistant. I do everything I can to keep things interesting and, most importantly, to help you understand.

ON THE WEB

If you like what you read, send me a note. My email address, which I created just for comments and questions about this book, is java4android @allmycode.com. If email and chat aren't your favorites, you can reach me instead on Twitter (`@allmycode`) and on Facebook (`/allmycode`). And don't forget — for the latest updates, visit this book's website. The site's address is `www.allmycode.com/java4android`.

1

Getting Started with Java Programming for Android Developers

IN THIS PART . . .

Downloading the software

Installing Java and Android

Creating dirt-simple Android apps

Testing Android apps on your computer

IN THIS CHAPTER

- The consumer's view of the Android ecosystem
- The ten-cent tour of Java and Android technologies

Chapter 1

All about Java and Android

Until the mid-2000s, the word *android* represented a mechanical, human-like creature — a rootin'-tootin' officer of the law with built-in machine guns or a hyperlogical space traveler who can do everything except speak using contractions. And then in 2005, Google purchased Android, Inc. — a 22-month-old company creating software for mobile phones. That move changed everything.

In 2007, a group of 34 companies formed the Open Handset Alliance. Its task is "to accelerate innovation in mobile and offer consumers a richer, less expensive, and better mobile experience"; its primary project is *Android*, an open, free operating system based on the Linux operating system kernel.

Though HTC released the first commercially available Android phone near the end of 2008, in the United States the public's awareness of Android and its potential didn't surface until early 2010.

Since then, Android's ecosystem has enjoyed steady growth. Kantar Worldpanel ComTech reports (at `www.kantarworldpanel.com/global/smartphone-os-market-share/article`): "The latest smartphone OS data . . . for the three months ending March 2016 shows Android continuing to grow sales across the EU5, US, and Urban China. There were solid gains in the EU5 (Great Britain, Germany,

France, Italy, and Spain), up 7.1% points to 75.6%. In the US, Android share increased 7.3% points to 65.5%, and in China, it rose nearly 6% points to over 77%."[1]

The Consumer Perspective

A consumer considers the alternatives:

- **Possibility #1: No mobile phone**

  Advantages: Inexpensive; no interruptions from callers.

  Disadvantages: No instant contact with friends and family; no calls to services in case of emergencies.

- **Possibility #2: A feature phone**

  This type of mobile phone isn't a smartphone. Though no official rule defines the boundary between feature phone and smartphone, a feature phone generally has an inflexible menu of Home screen options, compared with a smartphone's "desktop" of downloaded apps.

  Advantage: Less expensive than a smartphone.

  Disadvantages: Less versatile than a smartphone, not nearly as cool as a smartphone, and nowhere near as much fun as a smartphone.

- **Possibility #3: An iPhone**

  Advantages: Great-looking graphics.

  Disadvantages: Little or no flexibility with the single-vendor iOS operating system; only a handful of models to choose from.

- **Possibility #4: A Windows phone or another non-Android, non-Apple smartphone**

  Advantage: Having a smartphone without having to belong to a crowd.

  Disadvantage: The possibility of owning an orphan product when the smartphone wars come to a climax.

[1]See `www.kantarworldpanel.com/global/smartphone-os-market-share/article`.

- **Possibility #5: An Android phone**

  Advantages: Using a popular, open platform with lots of industry support and powerful market momentum; writing your own software and installing it on your own phone (without having to post the software on a company's website); publishing software without having to face a challenging approval process.

  Disadvantages: Security concerns when using an open platform; dismay when iPhone users make fun of your phone.

For me, Android's advantages far outweigh its possible disadvantages. And you're reading a paragraph from *Java Programming for Android Developers For Dummies*, 2nd Edition, so you're likely to agree with me.

The Many Faces of Android

Version numbers can be tricky. My PC's model number is T420s. When I download the users' guide, I download one guide for any laptop in the T400 series. (No guide specifically addresses the T420, let alone the T420s.) But when I have driver problems, knowing that I have a T420s isn't good enough. I need drivers that are specific to my laptop's 7-digit model number. The moral to this story: What constitutes a "version number" depends on who's asking for the number.

With that in mind, you can see a history of Android versions in Figure 1-1.

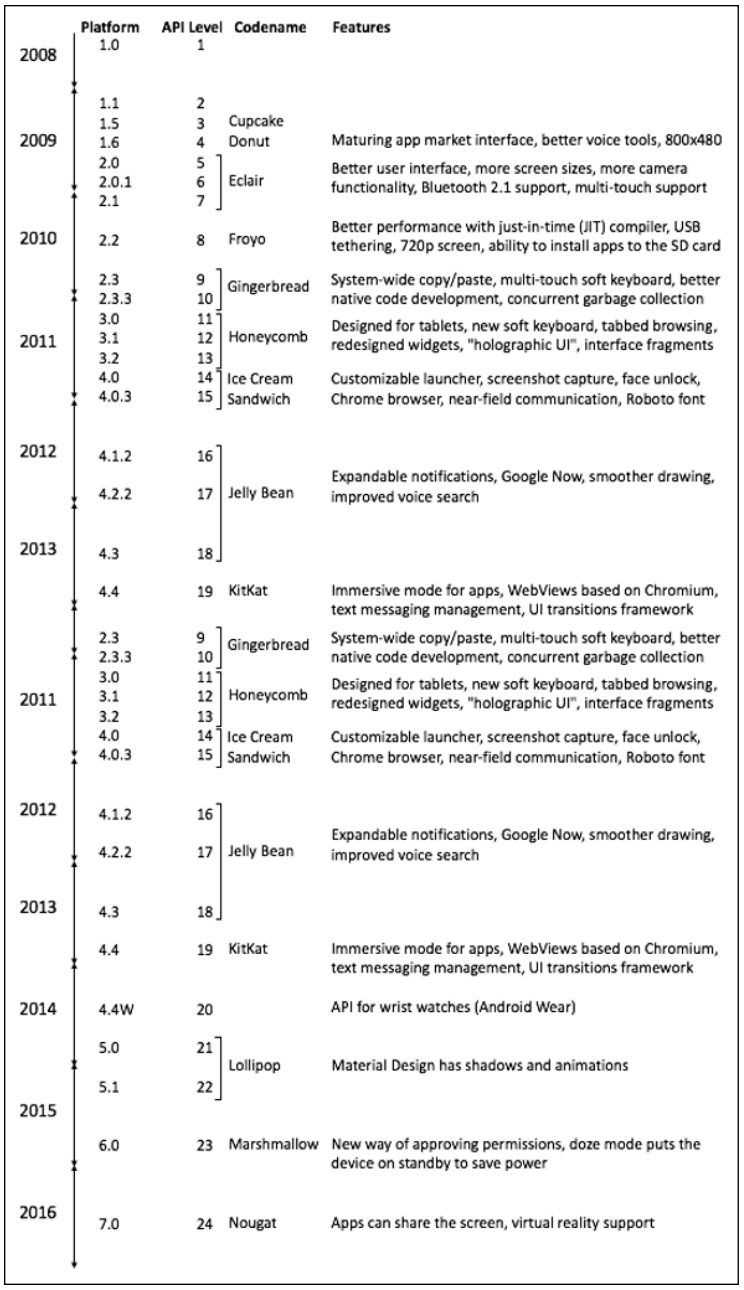
A few notes on Figure 1-1 are in order:

- **The platform number is of interest to the consumer and to the company that sells the hardware.**

  If you're buying a phone with Android 5.1, for example, you might want to know whether the vendor will upgrade your phone to Android 6.0.

- **The API level (also known as the SDK version) is of interest to the Android app developer.**

  For example, the word `MATCH_PARENT` has a specific meaning in Android API Levels 8 and higher. You might type `MATCH_PARENT` in code that uses API Level 7. If you do (and if you expect `MATCH_PARENT` to have that specific meaning), you'll get a nasty-looking error message.



	Platform	API Level	Codename	Features
2008	1.0	1		
	1.1	2		
	1.5	3	Cupcake	
2009	1.6	4	Donut	Maturing app market interface, better voice tools, 800x480
	2.0	5	Eclair	Better user interface, more screen sizes, more camera functionality, Bluetooth 2.1 support, multi-touch support
	2.0.1	6		
	2.1	7		
2010	2.2	8	Froyo	Better performance with just-in-time (JIT) compiler, USB tethering, 720p screen, ability to install apps to the SD card
	2.3	9	Gingerbread	System-wide copy/paste, multi-touch soft keyboard, better native code development, concurrent garbage collection
	2.3.3	10		
	3.0	11	Honeycomb	Designed for tablets, new soft keyboard, tabbed browsing, redesigned widgets, "holographic UI", interface fragments
2011	3.1	12		
	3.2	13		
	4.0	14	Ice Cream	Customizable launcher, screenshot capture, face unlock,
	4.0.3	15	Sandwich	Chrome browser, near-field communication, Roboto font
2012	4.1.2	16	Jelly Bean	Expandable notifications, Google Now, smoother drawing, improved voice search
	4.2.2	17		
2013	4.3	18		
	4.4	19	KitKat	Immersive mode for apps, WebViews based on Chromium, text messaging management, UI transitions framework
	2.3	9	Gingerbread	System-wide copy/paste, multi-touch soft keyboard, better native code development, concurrent garbage collection
	2.3.3	10		
	3.0	11	Honeycomb	Designed for tablets, new soft keyboard, tabbed browsing, redesigned widgets, "holographic UI", interface fragments
2011	3.1	12		
	3.2	13		
	4.0	14	Ice Cream	Customizable launcher, screenshot capture, face unlock,
	4.0.3	15	Sandwich	Chrome browser, near-field communication, Roboto font
2012	4.1.2	16	Jelly Bean	Expandable notifications, Google Now, smoother drawing, improved voice search
	4.2.2	17		
2013	4.3	18		
	4.4	19	KitKat	Immersive mode for apps, WebViews based on Chromium, text messaging management, UI transitions framework
2014	4.4W	20		API for wrist watches (Android Wear)
	5.0	21	Lollipop	Material Design has shadows and animations
	5.1	22		
2015	6.0	23	Marshmallow	New way of approving permissions, doze mode puts the device on standby to save power
2016	7.0	24	Nougat	Apps can share the screen, virtual reality support

FIGURE 1-1: Versions of Android.

CROSS-REFERENCE

You can read more about the Application Programming Interface (API) in Chapter 2. For more information about the use of Android's API levels (SDK versions) in your code, see Chapter 3. For even more information about Android API levels, visit

```
http://developer.android.com/guide/appendix/api-levels.html-level
```

» **The code name is of interest to the creators of Android.**

A *code name* refers to the work done by the creators of Android to bring Android to the next official level. Android's code names are desserts, working in alphabetical order starting with Cupcake, Donut, Eclair, and so on. Picture Google's engineers working for months behind closed doors on Project Marshmallow.

In recent years, this naming scheme has become a lot more transparent. For example, Google created an online poll to help decide on an *N* word as the successor to Android Marshmallow. After a month of voting, Android Nougat was announced.

REMEMBER

An Android version may have variations. For example, plain ol' Android 6.0 has an established set of features. To plain ol' Android 6.0 you can add the Google Play Services (the ability to install apps from Google Play) and still be using platform 6.0. You can also add a special set of features tailored for various phone manufacturers.

As a developer, your job is to balance portability with feature-richness. When you create an app, you specify a minimum Android version. (You can read more about this topic in Chapter 3.) The higher the version, the more features your app can have. On the flip side, the higher the version, the fewer devices that can run your app.

The Developer Perspective

Android is a multifaceted beast. When you develop for the Android platform, you use many toolsets. This section gives you a brief rundown.

Java

James Gosling of Sun Microsystems created the Java programming language in the mid-1990s. (Sun Microsystems has since been bought by Oracle.) Java's meteoric rise in use stemmed from the elegance of the language and its well-conceived platform architecture. After a brief blaze of glory with applets and

the web, Java settled into being a solid, general-purpose language with a special strength in servers and middleware.

In the meantime, Java was quietly seeping into embedded processors. Sun Microsystems was developing Java Mobile Edition (Java ME) for creating small apps to run on mobile phones. Java became a major technology in Blu-ray disc players. So the decision to make Java the primary development language for Android apps is no big surprise.


TECHNICAL STUFF

An *embedded processor* is a computer chip that is hidden from the user as part of a special-purpose device. The chips in cars are now embedded processors, and the silicon that powers the photocopier at your workplace is an embedded processor. Pretty soon, the flowerpots on your windowsill will probably have embedded processors.

Figure 1-2 describes the development of new Java versions over time. Like Android, each Java version has several names. The *product version* is an official name that's used for the world in general, and the *developer version* is a number that identifies versions so that programmers can keep track of them. (In casual conversation, developers use all kinds of names for the various Java versions.) The *code name* is a more playful name that identifies a version while it's being created.

The asterisks in Figure 1-2 mark changes in the formulation of Java product-version names. Back in 1996, the product versions were *Java Development Kit 1.0* and *Java Development Kit 1.1*. In 1998, someone decided to christen the product *Java 2 Standard Edition 1.2*, which confuses everyone to this day. At the time, anyone using the term *Java Development Kit* was asked to use *Software Development Kit* (SDK) instead.

In 2004 the *1.* business went away from the platform version name, and in 2006, Java platform names lost the *2* and the *.0*. For Java SE 9, the developer versions stopped being numbers like *1.9* and became plain old *9*.

By far the most significant changes for Java developers came about with J2SE 5.0 and Java SE 8. With the release of J2SE 5.0, the overseers of Java made changes to the language by adding many new features — features such as generic types, annotations, varargs, and the enhanced `for` statement. With Java SE 8 came new functional programming features.


CROSS-REFERENCE

To see Java annotations in action, go to Chapter 10. For examples of the use of generic types, varargs, and the enhanced `for` statement, see Chapter 12. To read about functional programming features, see Chapter 11.

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Year	Product Version	Developer Version	Codename	Features
1995	(Beta)			
1996	**JDK* 1.0**	1.0		
1997	**JDK 1.1**	1.1		Inner classes, Java Beans, reflection
1998	**J2SE* 1.2**	1.2	Playground	Collections, Swing classes for creation of GUI interfaces
1999				
2000	**J2SE 1.3**	1.3	Kestrel	Java Naming and Directory Interface (JNDI)
2001				
2002	**J2SE 1.4**	1.4	Merlin	New I/O, regular expressions, XML parsing
2003				
2004	**J2SE 5.0***	1.5	Tiger	Generic types, annotations, enum types, varargs, enhanced for statement, static imports, new concurrency classes
2005				
2006	**Java SE* 6**	1.6	Mustang	Scripting language support, performance enhancements
2007				
2008				
2009				
2010				
2011	**Java SE 7**	1.7	Dolphin	Strings in switch statement, catching multiple exceptions try statement with resources , integration with JavaFX
2012				
2013	**Java SE 8**	1.8		Lambda expressions and other functional programming features
2014				
2015				
2016				
2017	**Java SE 9**	9*		Division of code into modules and an interactive environment (known as a Read-eval-print loop or a REPL) to test code quickly

FIGURE 1-2: Versions of Java.

TIP

In addition to all the numbers in Figure 1-2, you'll see codes like *Java SE 8u91*. A code such as *8u91* stands for the 91st update of Java 8. For a novice Java developer, these updates don't make very much difference.

XML

If you find View Source among your web browser's options one day and decide to use it, you'll see a bunch of HyperText Markup Language (HTML) tags. A *tag* is some text, enclosed in angle brackets, that describes something about its neighboring content.

For example, to create boldface type on a web page, a web designer writes

```
<b>Look at this!</b>
```

The `b` tags in angle brackets turn boldface type on and off.

The *M* in HTML stands for *Markup* — a general term describing any extra text that annotates a document's content. When you annotate a document's content, you embed information about the content into the document itself. For example, in the previous line of code, the content is `Look at this!` The markup (information about the content) consists of the tags `<b>` and `</b>`.

The HTML standard is an outgrowth of Standard Generalized Markup Language (SGML), an all-things-to-all-people technology for marking up documents for use by all kinds of processors running all kinds of software and sold by all kinds of vendors.

In the mid-1990s, a working group of the World Wide Web Consortium (W3C) began developing the eXtensible Markup Language, commonly known as *XML*. The working group's goal was to create a subset of SGML for use in transmitting data over the Internet. It succeeded. XML is now a well-established standard for encoding information of all kinds.

CROSS-REFERENCE

For an overview of XML, see the sidebar "All about XML files" in Chapter 3.

Java is good for describing step-by-step instructions, and XML is good for describing the way things are (or the way they should be). A Java program says, "Do this and then do that." In contrast, an XML document says, "It's this way and it's that way." Android uses XML for two purposes:

- **To describe an app's data**

  An app's XML documents describe the layout of the app's screens, the translations of the app into one or more languages, and other kinds of data.

- **To describe the app itself**

  Every Android app has an `AndroidManifest.xml` file, an XML document that describes features of the app. A device's operating system uses the

`AndroidManifest.xml` document's contents to manage the running of the app.

For example, an app's `AndroidManifest.xml` file lists the screens that the user sees during a run of the app and tells a device which screen to display when the app is first launched. The same file tells the device which of the app's screens can be borrowed for use by other apps.

CROSS-REFERENCE

For more information about the `AndroidManifest.xml` file, see Chapter 4.

Concerning XML, I have bad news and good news. The bad news is that XML isn't always easy to compose. At best, writing XML code is boring. At worst, writing XML code is downright confusing. The good news is that automated software tools compose most of the world's XML code. As an Android programmer, I know that the software on your development processor composes much of your app's XML code. You often tweak the XML code, read part of the code for information from its source, make minor changes, and compose brief additions. But you hardly ever create XML documents from scratch.

Linux

An *operating system* is a big program that manages the overall running of a processor or a device. Most operating systems are built in layers. An operating system's outer layers are usually in the user's face. For example, both Windows and Macintosh OS X have standard desktops. From the desktop, the user launches programs, manages windows, and does other important things.

An operating system's inner layers are (for the most part) invisible to the user. While the user plays Solitaire, for example, the operating system juggles processes, manages files, keeps an eye on security, and generally does the kinds of things that the user shouldn't have to micromanage.

At the deepest level of an operating system is the system's kernel. The *kernel* runs directly on the processor's hardware and does the low-level work required to make the processor run. In a truly layered system, higher layers accomplish work by making calls to lower layers. So an app with a specific hardware request sends the request (directly or indirectly) through the kernel.

The best-known, best-loved general purpose operating systems are Windows, Macintosh OS X (which is really Unix), and Linux. Both Windows and Mac OS X are the properties of their respective companies. But Linux is open source. That's one reason why your TiVo runs Linux and why the creators of Android based their platform on the Linux kernel.

As a developer, your most intimate contact with the Android operating system is via the command line, also known as the *Linux shell.* The shell uses commands such as `cd` to change to a directory, `ls` to list a directory's files and subdirectories, `rm` to delete files, and many others.

Google Play has plenty of free terminal apps. A *terminal* app's interface is a plain-text screen on which you type Linux shell commands. And by using one of Android's developer tools, the Android Debug Bridge, you can issue shell commands to an Android device via your development computer. If you like getting your virtual hands dirty, the Linux shell is for you.

From Development to Execution with Java

Before Java became popular, running a computer program involved one translation step. Someone (or something) translated the code that a developer wrote into more cryptic code that a computer could actually execute. But then Java came along and added an extra translation layer, and then Android added another layer. This section describes all those layers.

What is a compiler?

A Java program (such as an Android application program) undergoes several translation steps between the time you write the program and the time a processor runs the program. One of the reasons is simple: Instructions that are convenient for processors to run are not convenient for people to write.

People can write and comprehend the code in Listing 1-1.

LISTING 1-1: Java Source Code

```
public void checkVacancy(View view) {
    if (room.numGuests == 0) {
        label.setText("Available");
    } else {
        label.setText("Taken :-(");
    }
}
```

The Java code in Listing 1-1 checks for a vacancy in a hotel. You can't run the code in this listing without adding several additional lines. But here in Chapter 1, those additional lines aren't important. What's important is that, by staring at the code,

squinting a bit, and looking past all its strange punctuation, you can see what the code is trying to do:

```
If the room has no guests in it,
    then set the label's text to "Available".
Otherwise,
    set the label's text to "Taken :-(".
```

The content of Listing 1-1 is *Java source code.*

The processors in computers, phones, and other devices don't normally follow instructions like the instructions in Listing 1-1. That is, processors don't follow Java source code instructions. Instead, processors follow cryptic instructions like the ones in Listing 1-2.

LISTING 1-2: **Java Bytecode**

```
 0 aload_0
 1 getfield #19 <com/allmycode/samples/MyActivity/room
 Lcom/allmycode/samples/Room;>
 4 getfield #47 <com/allmycode/samples/Room/numGuests I>
 7 ifne 22 (+15)
10 aload_0
11 getfield #41 <com/allmycode/samples/MyActivity/label
 Landroid/widget/TextView;>
14 ldc #54 <Available>
16 invokevirtual #56
   <android/widget/TextView/setText
   (Ljava/lang/CharSequence;)V>
19 goto 31 (+12)
22 aload_0
23 getfield #41 <com/allmycode/samples/MyActivity/label
 Landroid/widget/TextView;>
26 ldc #60 <Taken :-(>
28 invokevirtual #56
   <android/widget/TextView/setText
   (Ljava/lang/CharSequence;)V>
31 return
```

The instructions in Listing 1-2 aren't Java source code instructions. They're *Java bytecode instructions*. When you write a Java program, you write source code instructions. (Refer to Listing 1-1.) After writing the source code, you run a program (that is, you apply a tool) to the source code. The program is a *compiler:* It translates your source code instructions into Java bytecode instructions. In other

words, the compiler translates code that you can write and understand (again, refer to Listing 1-1) into code that a processor can execute. (Refer to Listing 1-2.)

At this point, you might ask, "What will I have to do to get the compiler running?" The answer to your question is "Android Studio." All the translation steps described in this chapter come down to using Android Studio — a piece of software that you download for free using the instructions in Chapter 2. So when you read in this chapter about compiling and other translation steps, don't become intimidated. You don't have to repair an alternator in order to drive a car, and you won't have to understand how compilers work in order to use Android Studio.


REMEMBER

No one (except for a few crazy developers in isolated labs in faraway places) writes Java bytecode. You run software (a compiler) to create Java bytecode. The only reason to look at Listing 1-2 is to understand what a hard worker your computer is.

If compiling is a good thing, compiling twice is even better.

In 2007, Dan Bornstein at Google created *Dalvik bytecode* — another way to represent instructions for processors to follow. (To find out where some of Bornstein's ancestors come from, run your favorite map application and look for Dalvik in Iceland.) Dalvik bytecode is optimized for the limited resources on a phone or a tablet device.

Listing 1-3 contains sample Dalvik instructions.

* To see the code in Listing 1-3, I used the Dedexer program (from `http://dedexer.sourceforge.net`).

LISTING 1-3: Dalvik Bytecode

```
.method public checkVacancy(Landroid/view/View;)V
.limit registers 4
; this: v2 (Lcom/allmycode/samples/MyActivity;)
; parameter[0] : v3 (Landroid/view/View;)
.line 30
    iget-object
    v0,v2,com/allmycode/samples/MyActivity.room
    Lcom/allmycode/samples/Room;
; v0 : Lcom/allmycode/samples/Room; , v2 :
    Lcom/allmycode/samples/MyActivity;
    iget    v0,v0,com/allmycode/samples/Room.numGuests I
; v0 : single-length , v0 : single-length
    if-nez    v0,l4b4
```

```
; v0 : single-length
.line 31
    iget-object
    v0,v2,com/allmycode/samples/MyActivity.label
    Landroid/widget/TextView;
; v0 : Landroid/widget/TextView; , v2 :
    Lcom/allmycode/samples/MyActivity;
    const-string    v1,"Available"
; v1 : Ljava/lang/String;
    invoke-virtual
    {v0,v1},android/widget/TextView/setText
    ; setText(Ljava/lang/CharSequence;)V
; v0 : Landroid/widget/TextView; , v1 : Ljava/lang/String;
l4b2:
.line 36
    return-void
l4b4:
.line 33
    iget-object
    v0,v2,com/allmycode/samples/MyActivity.label
    Landroid/widget/TextView;
; v0 : Landroid/widget/TextView; , v2 :
    Lcom/allmycode/samples/MyActivity;
    const-string    v1,"Taken :-("
; v1 : Ljava/lang/String;
    invoke-virtual
    {v0,v1},android/widget/TextView/setText ;
    setText(Ljava/lang/CharSequence;)V
; v0 : Landroid/widget/TextView; , v1 : Ljava/lang/String;
    goto    l4b2
.end method
```

When you create an app, Android Studio performs at least two compilations:

- **One compilation creates Java bytecode from your Java source files.** The source filenames have the `.java` extension; the Java bytecode filenames have the `.class` extension.
- **Another compilation creates Dalvik bytecode from your Java bytecode files.** Dalvik bytecode filenames have the `.dex` extension.

But that's not all! In addition to its Java code, an Android app has XML files, image files, and possibly other elements. Before you install an app on a device, Android Studio combines all these elements into a single file — one with the `.apk`

extension. When you publish the app on an app store, you copy that `.apk` file to the app store's servers. Then, to install your app, a user visits the app store and downloads your `.apk` file.

To perform the compilation from source code to Java bytecode, Android Studio uses a program named javac, also known as the Java compiler. To perform the compilation from Java bytecode to Dalvik code, Android Studio uses a program named dx (known affectionately as "the dx tool"). To combine all your app's files into one `.apk` file, Android Studio uses a program named apkbuilder.

What is a virtual machine?

In the section "What is a compiler?" earlier in this chapter, I make a big fuss about phones and other devices following instructions like the ones in Listing 1-3. As fusses go, it's a nice fuss. But if you don't read every fussy word, you may be misguided. The exact wording is ". . . processors follow cryptic instructions *like* the ones in Listing 'blah-blah-blah.'" The instructions in Listing 1-3 are a lot like instructions that a phone or tablet can execute, but computers generally don't execute Java bytecode instructions, and phones don't execute Dalvik bytecode instructions. Instead, each kind of processor has its own set of executable instructions, and each operating system uses the processor's instructions in a slightly different way.

Imagine that you have two different devices: a smartphone and a tablet computer. The devices have two different kinds of processors: The phone has an ARM processor, and the tablet has an Intel Atom processor. (The acronym ARM once stood for Advanced RISC Machine. These days, *ARM* simply stands for ARM Holdings, a company whose employees design processors.) On the ARM processor, the *multiply* instruction is 000000. On an Intel processor, the *multiply* instructions are D8, DC, F6, F7, and others. Many ARM instructions have no counterparts in the Atom architecture, and many Atom instructions have no equivalents on an ARM processor. An ARM processor's instructions make no sense to your tablet's Atom processor, and an Atom processor's instructions would give your phone's ARM processor a virtual headache.

What's a developer to do? Does a developer provide translations of every app into every processor's instruction set?

No. Virtual machines create order from all this chaos. Dalvik bytecode is similar to the code in Listing 1-3, but Dalvik bytecode isn't specific to a single kind of processor or to a single operating system. Instead, a set of Dalvik bytecode

instructions runs on any processor. If you write a Java program and compile that Java program into Dalvik bytecode, your Android phone can run the bytecode, your Android tablet can run the bytecode, your Chromebook can run the bytecode, and even your grandmother's supercomputer can run the bytecode. (If your grandmother wants to do this, she should install *Remix OS*, a special port of the Android operating system, on her Intel-based machine. Tell her to visit `www.jide.com/remixos-for-pc`.)

REMEMBER

You never have to write or decipher Java bytecode or Dalvik bytecode. Writing bytecode is the compiler's job. Deciphering bytecode is the virtual machine's job.

Both Java bytecode and Dalvik bytecode have virtual machines. Java bytecode's virtual machine is called (big surprise) the *Java virtual machine* (JVM). Dalvik bytecode's virtual machine is called the *Android runtime* (ART).

With the Android runtime, you can take a bytecode file that you created for one Android device, copy the bytecode to another Android device, and then run the bytecode with no trouble. That's one of the many reasons Android has become popular quickly. This outstanding feature, which lets you run code on many different kinds of processors, is called *portability.*

Imagine that you're the Intel representative to the United Nations Security Council, as shown in Figure 1-3. The ARM representative is seated to your right, and the representative from Qualcomm is to your left. (Naturally, you don't get along with either of these people. You're always cordial to one another, but you're never sincere. What do you expect? It's politics!) The distinguished representative from Dalvik is at the podium. The Dalvik representative speaks in Dalvik bytecode, and neither you nor your fellow ambassadors (ARM and Qualcomm) understand a word of Dalvik bytecode.

But each of you has an interpreter. Your interpreter translates from Dalvik bytecode to Intel instructions as the Dalvik representative speaks. Another interpreter translates from bytecode to "ARM-ese." And a third interpreter translates bytecode into "Qualcomm-speak."

Think of your interpreter as a virtual ambassador. The interpreter doesn't really represent your country, but the interpreter performs one important task that a real ambassador performs: It listens to Dalvik bytecode on your behalf. The interpreter does what you would do if your native language were Dalvik bytecode. The interpreter, pretending to be the Intel ambassador, endures the boring bytecode speech, taking in every word and processing each one in some way or another.

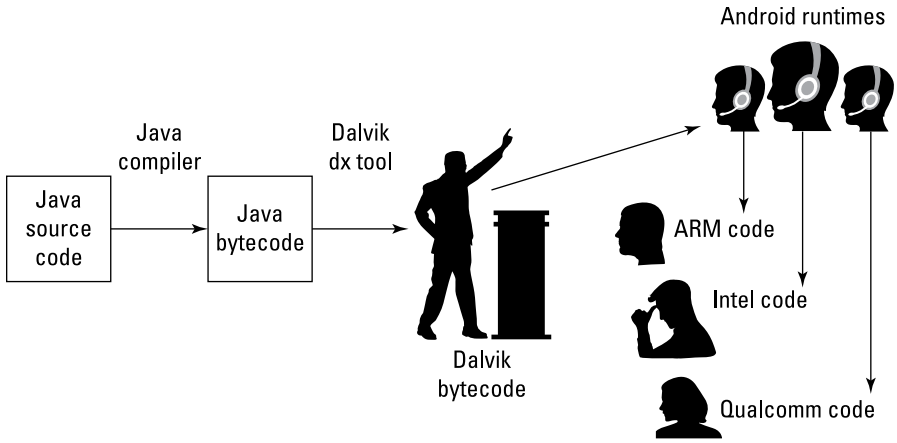


FIGURE 1-3: An imaginary meeting of the U.N. Security Council.

You have an interpreter — a virtual ambassador. In the same way, an Intel processor runs its own bytecode-interpreting software. That software is the Dalvik virtual machine — a proxy, an errand boy, a go-between. The *Android runtime* serves as an interpreter between Dalvik's run-anywhere bytecode and your device's own system. As it runs, the virtual machine walks your device through the execution of bytecode instructions. It examines your bytecode, bit by bit, and carries out the instructions described in the bytecode. The virtual machine interprets bytecode for your ARM processor, your Intel processor, your Qualcomm chip, or whatever kind of processor you're using. That's a good thing. It's what makes Java code and Dalvik code more portable than code written in any other language.

Java, Android, and Horticulture

"You don't see the forest for the trees," said my Uncle Harvey. To which my Aunt Clara said, "You don't see the trees for the forest." This argument went on until they were both too tired to discuss the matter.

As an author, I like to present both the forest and the trees. The "forest" is the broad overview, which helps you understand why you perform various steps. The "trees" are the steps themselves, getting you from Point A to Point B until you complete a task.

This chapter shows you the forest. The rest of this book shows you the trees.

IN THIS CHAPTER

- Installing Java
- Downloading and installing the Android software tools
- Checking your Android Studio installation
- Getting the code in this book's examples

Chapter 2
Getting the Tools That You Need

ergaliophile /ɜr gə li ə faɪ əl/ *noun* 1. A lover of tools. 2. A person who visits garage sales for rusty metal implements that might be useful someday but probably won't. 3. A person whose computer runs slowly because of the daily, indiscriminate installation of free software tools.

Several years ago, I found an enormous monkey wrench (more than a yard long and weighing 35 pounds) at a nearby garage sale. I wasn't a good plumber, and to this day any pipe that I fix starts leaking again immediately. But I couldn't resist buying this fine piece of hardware. The only problem was, my wife was sitting in the car about halfway down the street. She's much more sensible than I am about these matters, so I couldn't bring the wrench back to the car. "Put it aside and I'll come back for it later," I told the seller.

When I returned to the car empty-handed, my wife said, "I saw someone carrying the world's largest pipe wrench. I'm glad you weren't the one who bought it." And I agreed with her. "I don't need more junk like that."

So of course I returned later that day to buy the monkey wrench, and to this day the wrench sits in our attic, where no one ever sees it. If my wife ever reads this chapter, she'll be either amused or angry. I hope she's not angry, but I'm taking the risk because I enjoy the little drama. To add excitement to my life, I'm turning this trivial secret into a public announcement.

The Stuff You Need

This book tells you how to write Java programs, and before you can write them, you need some software tools. Here's a list of the tools you need:

- **The Java Development Kit (JDK)**

  This includes a Java virtual machine, the Java code libraries, and some additional software for developing Java code.

- **An integrated development environment**

  You can create Android apps using geeky, keyboard-only tools, but eventually you'll tire of typing and retyping commands. An *integrated development environment* (IDE), on the other hand, is a little like a word processor: A word processor helps you compose documents (memos, poems, and other works of fine literature); in contrast, an IDE helps you compose instructions for processors.

  For composing Android apps, you need the Android Studio IDE.

- **The Android Software Development Kit**

  The Android *Software Development Kit (SDK)* includes lots and lots of prewritten, reusable Android code and a bunch of software tools for running and testing Android apps.

  The prewritten Android code is the Android *Application Programming Interface (API).* The API comes in several versions — versions 21 and 22 (both code-named Lollipop), version 23 (Marshmallow), version 24 (Nougat), and so on.

- **Some sample Android code projects to help you get started**

  All examples in this book are available for download from `www.allmycode.com/Java4Android`.

All these tools run on the *development computer* — the laptop or desktop computer you use to develop Java programs and Android apps. After you create an Android

app, you copy the app's code from the development computer to a *target device* — a phone, a tablet, or (someday soon) a refrigerator that runs Android.

Here's good news: You can download from the web all the software you need to run this book's examples for free. The software is separated into three downloads:

- When you visit `www.oracle.com/technetwork/java/javase/downloads`, you can click a button to install the Java JDK.
- A button at the page `http://developer.android.com/studio` gives you the Android Studio IDE download and the Android Software Development Kit.
- This book's website (`www.allmycode.com/Java4Android`) has a link to all code in this book.


WARNING

The Java and Android websites I describe in this chapter are always changing. The software programs you download from these sites change, too. A specific instruction such as "Click the button in the upper-right corner" becomes obsolete (and even misleading) in no time at all. So, in this chapter, I provide explicit steps, but I also describe the ideas behind them. Browse the suggested sites and look for ways to get the software I describe. When a website offers you several options, check the instructions in this chapter for hints on choosing the best option. If your Android Studio window doesn't look quite like the one in this chapter's figures, scan your computer's window for whatever options I describe. If, after all that effort, you can't find the elements you're looking for, check this book's website (`www.allmycode.com/Java4Android`) or send an email to me at Java4Android@allmycode.com.

If You Don't Like to Read the Instructions . . .

I start this chapter with a brief (but useful) overview of the steps required in order to set up the software you need. If you're an old hand at installing software, and if your computer isn't quirky, these fast-track steps will probably serve you well. If not, you can read the more detailed instructions in the next several sections.

1. **Visit `www.allmycode.com/Java4Android` and download a file containing all the program examples in this book.**

   The downloaded file is a `.zip` archive file. (See the sidebars entitled "Those pesky filename extensions" and "Compressed archive files , later in this chapter.")

2. **Extract the contents of the downloaded file to a place on your computer's hard drive.**

3. **Visit** `www.oracle.com/technetwork/java/javase/downloads` **and download the Java Standard Edition JDK.**

   Choose a version of the software that matches your operating system (Windows, Macintosh, or whatever) and your operating system's word length (32-bit or 64-bit).

4. **Install the Java Standard Edition JDK.**

   Double-click the `.exe` file or the `.dmg` file that you downloaded in Step 3, and proceed with whatever steps you usually take when you install software.

5. **Visit** `http://developer.android.com/studio` **and download the Android Studio IDE along with the Android Software Development Kit (SDK).**

   The combined download bundle is an `.exe` file, a `.dmg` file, or a `.zip` file (or maybe something else).

6. **Install the software that you downloaded in Step 5.**

   Double-click the downloaded file, accept all kinds of legal disclaimers, drag things, drop things, and so on**.**

7. **Launch the Android Studio application.**

   The first time you run a fresh, new copy of Android Studio, you see some introductory screens.

8. **Click past the introductory screens until you see a screen with options like Start a New Android Studio Project and Open an Existing Android Studio Project.**

   On your phone, an app is an app and that's all there is to it. But on your development computer, all your work is divided into projects. For professional purposes, you're not absolutely correct if you think of one app as equaling one project. But for the examples in this book, the "one project equals one app" model works just fine.

9. **Select the Open an Existing Android Studio Project option.**

   As a result, the Open dialog box appears.

10. **In the Open dialog box, navigate to the folder containing the stuff that you downloaded from this book's website.**

    That folder contains subfolders with names like `02_01`, `03_01`, and `03_04`.

TIP

You say "directory." I say "folder." Let's call the whole thing off because, in this book, I use these two words interchangeably.

11. **Select the folder named 02_01 (or any of the other such folders) and click OK.**

    After a brief pause (or maybe a not-so-brief pause), Android Studio's main window appears. This window displays all the stuff you need in order to work with the Android app that's inside the `02_01` folder.

For details about any of these steps, see the next several sections.

THOSE PESKY FILENAME EXTENSIONS

The filenames displayed in File Explorer or in a Finder window can be misleading. You may browse a directory and see the name `MainActivity`. The file's real name might be `MainActivity.java`, `MainActivity.class`, `Mortgage.`*somethingElse*, or plain old `MainActivity`. Filename endings such as `.zip`, `.exe`, `.dmg`, `.app`, `.java`, and `.class` are *filename extensions*.

The ugly truth is that, by default, Windows and the Mac hide many filename extensions. This awful feature tends to confuse people. If you don't want to be confused, change your computer's system-wide settings. Here's how to do it:

- **In Windows 7:** Choose Start ➪ Control Panel ➪ Appearance and Personalization ➪ Folder Options. Then skip to the third bullet.
- **In Windows 8:** On the Charms bar, choose Settings ➪ Control Panel. In the Control Panel, choose Appearance and Personalization ➪ Folder Options. Then proceed to the following bullet.
- **In all versions of Windows (7 and newer):** Follow the instructions in one of the preceding bullets. Then, in the Folder Options dialog box, click the View tab. Look for the Hide File Extensions for Known File Types option. Make sure that this check box is *not* selected.
- **In Mac OS X:** On the Finder application's menu, select Preferences. In the resulting dialog box, select the Advanced tab and look for the Show All File Extensions option. Make sure that this check box *is* selected.

Getting This Book's Sample Programs

To get copies of this book's sample programs, visit `www.allmycode.com/Java4Android` and click the link to download the programs in this book. Save the download file (`Java4Android_Projects.zip`) to the computer's hard drive.


TIP

In some cases, you can click a download link all you want but the web browser doesn't offer you the option to save a file. If this happens to you, right-click the link (or control-click on a Mac). From the resulting contextual menu, select Save Target As, Save Link As, Download Linked File As, or a similarly labeled menu item.

COMPRESSED ARCHIVE FILES

When you visit `www.allmycode.com/Java4Android` and you download this book's examples, you download a file named `Java4Android_Projects.zip`. A *zip* file is a single file that encodes a bunch of smaller files and folders. For example, my `Java4Android_Projects.zip` file encodes folders named `02_01`, `03_04`, and so on. The `03_04` folder contains subfolders, which in turn contain files. (The folder named `03_04` contains the code in Listing 3-4 — the fourth listing in Chapter 3. And because Listings 3-1 and 3-4 belong to the same app, the folder named `03_04` also contains the code in Listing 3-1.)

A `.zip` file is an example of a *compressed archive* file. Other examples of compressed archives include `.tar.gz` files, `.rar` files, and `.7z` files. When you *uncompress* a file, you extract the original files and folders stored inside the larger archive file. (For a `.zip` file, another word for uncompressing is *unzipping*.) Uncompressing normally re-creates the folder structure encoded in the archive file. So, after uncompressing my `Java4Android_Projects.zip` file, the hard drive has folders named `02_01`, `03_04`, with subfolders named `gradle`, `build`, and app, which in turn contain files named `proguard-rules.pro`, `build.gradle`, and so on.

When you download `Java4Android_Projects.zip`, the web browser may uncompress the file automatically for you. If not, you can get your computer to uncompress the file. Here's how:

- On a Windows computer, double-click the `.zip` file's icon. When you do this, Windows File Explorer shows you the files and folders inside the compressed `.zip` archive. Drag all these files and folders to another place on your computer's hard drive (a place that's not inside the archive file).
- On a Mac, double-click the `.zip` file's icon. When you do this, the Mac extracts the contents of the archive file and shows you the extracted contents in a Finder window.

Most web browsers save files to the `Downloads` directory on the computer's hard drive. But your browser may be configured a bit differently. One way or another, make note of the folder containing the downloaded file `Java4Android_Projects.zip`.

Setting Up Java

You can get the latest, greatest version of Java by visiting `www.oracle.com/technetwork/java/javase/downloads`. Figure 2-1 shows that page circa June 2016. In the figure, I've circled the button that you should click.

The page that you see might not look exactly like the page in Figure 2-1. In particular, you probably won't see *8u91 / 8u92* on your page. Instead, you might see some other numbers, such as *8u105* or *9u13*. If so, that's okay. A version code such as *9u13* stands for the 13th update of Java 9. The version codes on Oracle's download page change all the time.

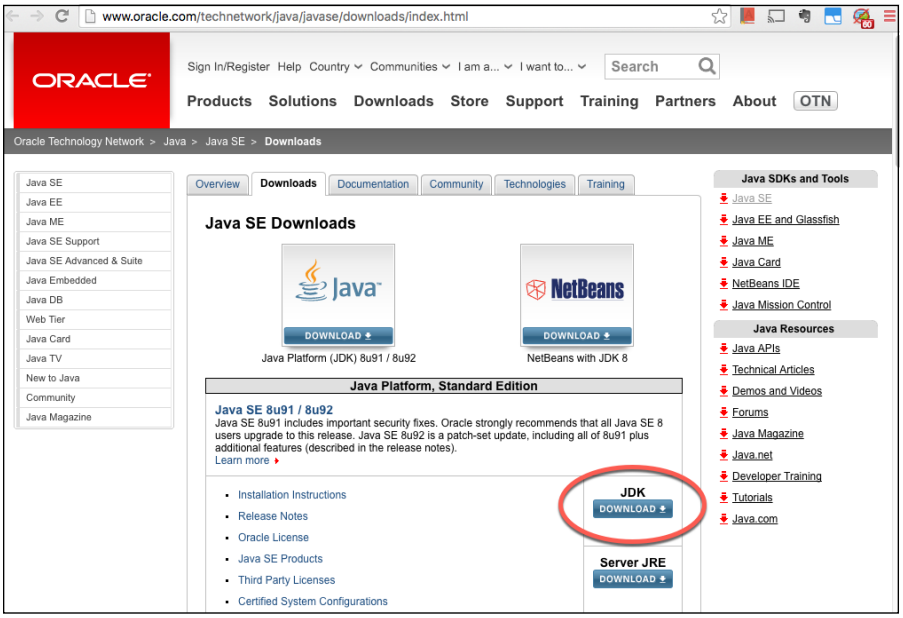


FIGURE 2-1: Look for Java Platform, Standard Edition, JDK.

HOW TO PUT THE CART BEFORE THE HORSE

To run Android's app development software, you need software for creating Java programs. So normally, you install Java and then you install Android's app development software.

Of course, you may already have the required Java software on your laptop or desktop computer. And Google sometimes bundles Java with the Android developer software. You may get lucky and download Java and Android all in one big gulp.

So if you're in a hurry to get started, you can try skipping this "Setting Up Java" section and go straight to the section entitled "Setting up Android Studio and the Android SDK." If you see error messages indicating that Java isn't installed on your computer, come back to this section where you install a fresh, new copy of Java.

REMEMBER

Look for the Standard Edition JDK. Don't bother with the Enterprise Edition or any other such edition. Don't bother to get any other software such as NetBeans with your download. Also, go for the JDK, not the JRE.

TECHNICAL STUFF

When you visit Oracle's website, you choose between Java's JRE download and Java's JDK download. Technically, the JRE has the software that you need in order to run Java programs, but not to create new Java programs. The JDK has the software that you need in order to create new Java programs.

TIP

There's one tiny flaw in the wording on Oracle's website. The site seems to give you a choice between Java's JRE and Java's JDK. What the site really offers is a choice between downloading only Java's JRE and downloading *both* the JRE *and* the JDK. When you choose the JDK option, you get both Java's JRE and Java's JDK. That's just fine.

Figure 2-2 shows you the page that you might see after you click the button in Figure 2-1. The page in Figure 2-2 lists several versions of Java, each for a different operating system.

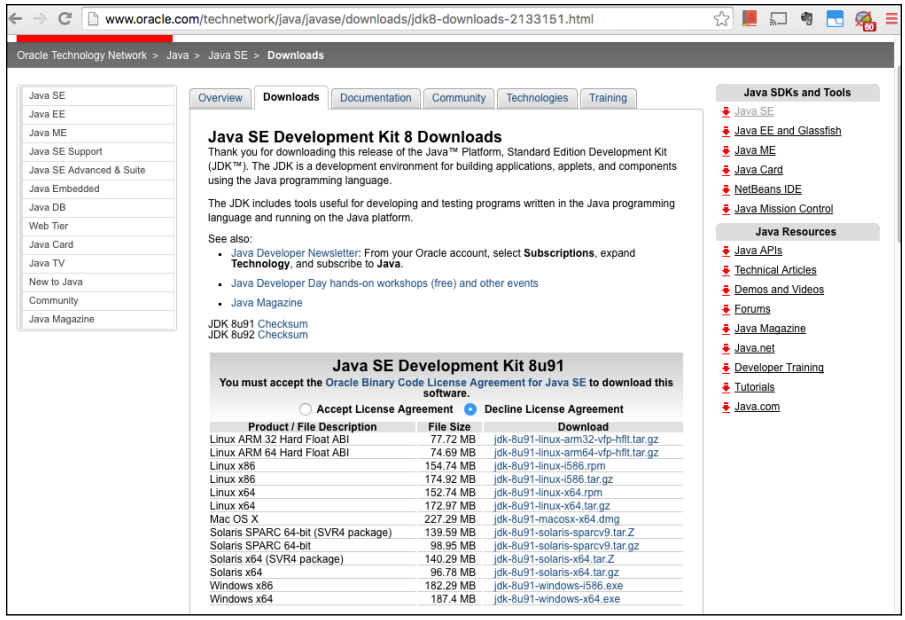


FIGURE 2-2: Many Java JDK downloads.

A FISTFUL OF BITS

If you're a Windows user, the `www.oracle.com/technetwork/java/javase/downloads` page offers you a choice between 32-bit Java and 64-bit Java. The 32-bit alternative might have the digits *586* in its name. More sensibly, the 64-bit alternative probably has the digits *64* in its name. So the question is, which version of Java should you choose?

If you're like most computer users, you want the 64-bit version of Java. Most computers sold in the past several years have 64-bit processors. If you're not sure which version of Java to download, try the 64-bit version.

Some older computers have 32-bit processors, and some newer computers have 64-bit processors with 32-bit operating systems. If your Windows computer falls into one of these categories, an attempt to install 64-bit Java will generate an error message. At best, the message says that this installation file isn't compatible with your version of Windows. At worst, the message says that the thing you're trying to run isn't a valid Windows program. In either case, you want the 32-bit version of Java.

If you want to be safe, you can check to find out how many bits your Windows system has. Search for *Control Panel* in order to launch the Control Panel screen. In the Control Panel's search field, type **About.** When you do, Windows offers System as one of its alternatives. After choosing this System option, you see a panel showing some of your computer's properties. Somewhere in this list of properties, you'll see either *32-bit* or *64-bit*.

THE GREATEST? YES! THE LATEST? MAYBE NOT!

In mid-2016, the page `https://developer.android.com/studio/install.html` observes ". . . known stability issues in Android Studio on Mac when using JDK 1.8. Until these issues are resolved, you can improve stability by downgrading your JDK to an older version (but no lower than JDK 1.6)." To make things even trickier, I've tried running Android Studio with the soon-to-be-released Java 9 and it's a complete "no go." If you're squeamish about Java versions, you might want to install Java 7 instead of whatever version is foremost on Oracle's download page. Look for the words *Archive* or *Legacy* on the `www.oracle.com/technetwork/java/javase/downloads` page, and follow the links to download older versions of the Java JDK.

Should you remove existing versions of Java before installing new versions? Not necessarily. Different versions of Java can coexist on a single computer. But sometimes, when you have more than one Java version, Android Studio can't find the most appropriate version. In this case, you can't install Android Studio. Or, if you can install Android Studio, you can't launch Android Studio. Instead, you get a message saying that your computer has no version of the Java JDK or has the wrong version of the Java JDK. If that happens, I recommend uninstalling all versions of Java except the one that you installed most recently. Here's how:

- On Windows, search for *Control Panel* in order to launch the Control Panel screen. In the Control Panel's search field, type **Programs and Features** or type **Add or Remove Programs.** When you've reached the Programs and Features or Add or Remove Programs screen, look for anything with the word *Java* in its name, such as *Java 8 Update 91* or *Java SE Development Kit 8 Update 91*. Try clicking, double-clicking, or right-clicking any item that you want to uninstall.
- On a Mac, look for the Terminal app in the `Utilities` subfolder of your `Applications` folder. On the Terminal app's screen, type

  ```
  cd /Library/Java/JavaVirtualMachines
  ```

  In the computer's response, look for names like `jdk–9.jdk`, `jdk1.8.0_06.jdk`, or `1.7.0.jdk`. Say, for the sake of argument, that you want to delete `jdk1.8.0_06.jdk` in order to remove Java 8 from your Mac. Then type the following command in the Terminal window:

  ```
  sudo rm –rf jdk1.8.0_06.jdk
  ```

  After you do so, the Terminal asks for your password. After typing your password and pressing Enter, you're all set.

www.allitebooks.com

Setting Up Android Studio and the Android SDK

WARNING

In the Android world, things change very quickly. The instructions that I write on Tuesday can be out-of-date by Thursday morning. The folks at Google are always creating new features and new tools. The old tools stop working and the old instructions no longer apply. If you see something on your screen that doesn't look like one of my screen shots, don't despair. It might be something very new, or you might have reached a corner of the software that I don't describe in this book. One way or another, send me an email, a tweet, or some other form of communication. (Don't try sending a carrier pigeon. My cat will get to it before I find the note.) My contact info is in this book's introduction.

You download Android's SDK and Android Studio in one big gulp. Here's how:

1. **Visit** `http://developer.android.com/studio`.

   Figure 2-3 shows you what this web page looks like in July of 2016 (commonly known as "the good old days").

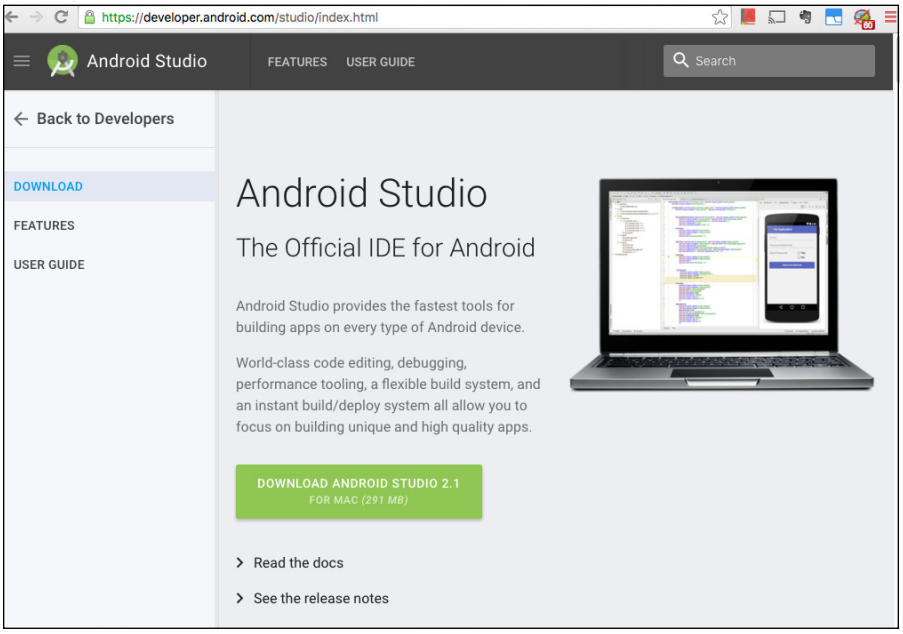


FIGURE 2-3: Downloading Android Studio.

The page has a big button for downloading Android Studio. The Android Studio download includes the much-needed Android SDK.

By the time you read this book, the web page will probably have changed. But you'll still see an Android Studio download.

2. **Click the Download button on the web page.**
3. **Agree to all the legal mumbo-jumbo.**
4. **Save the download to your local hard drive.**

   If you run Windows, the downloaded file is probably an `.exe` file. If you have a Mac, the downloaded file is probably a `.dmg` file. Of course, I make no guarantees. The downloaded file might be a `.zip` archive or maybe some other exotic kind of archive file.


CROSS-REFERENCE

For more information on things like `.exe` and `.dmg`, refer to the sidebar entitled "Those pesky filename extensions." And, if you need help with `.zip` files, see the earlier sidebar "Compressed archive files."

What happens next depends on your computer's operating system.

- **In Windows:** Double-click the `.exe` file's icon.

  When you double-click the `.exe` file's icon, a wizard guides you through the installation.

- **On a Mac:** Double-click the `.dmg` file's icon.

  When you double-click the `.dmg` file's icon, you see an Android Studio icon (also known as an Android Studio.app icon). Drag the Android Studio icon to your `Applications` folder.

Launching the Android Studio IDE

In the previous section, you download and install Android Studio. Your next task (should you decide to accept it) is to launch Android Studio. This section has the details.

- **In Windows:** If your version of Windows has a Start button, click the Start button and look for the Android Studio entry.

  If you don't have a Start button, press Windows-Q to make a search field appear. In the search field, start typing *Android Studio*. When your computer offers the Android Studio application as one of the options, select that option.

TIP

» **On a Mac:** Press Command-space to make the Spotlight appear. In the Spotlight's search field, start typing *Android Studio*. When your Mac makes the full name *Android Studio* appear in the Spotlight's search field, press Enter.

If your Mac complains that Android Studio is from an unidentified developer, look for the Android Studio icon in your Applications folder. Control-click the Android Studio icon and select Open. When another "unidentified developer" box appears, click the box's Open button.

When you launch Android Studio for the first time, you might see a dialog box offering to import settings from a previous Android Studio installation. Chances are, you don't have a previous Android Studio installation, so you should firmly but politely decline this offer.

Next, you might see a few dialog boxes with information about installing the development environment (the Android SDK). Accept all the defaults and, if Android Studio offers to download more stuff, let Android Studio do it.

When the dust settles, Android Studio displays a Welcome screen. The Welcome screen has options such as Start a New Android Studio Project, Open an Existing Android Studio Project, and so on. (See Figure 2-4.)

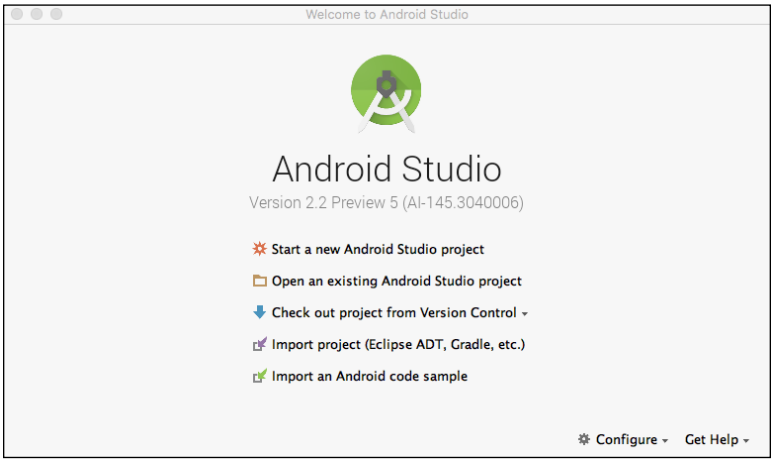


FIGURE 2-4: Android Studio's Welcome screen.

You'll see this Welcome screen again and again. Stated informally, the Welcome screen says "At the moment, you're not working on any particular project (any particular Android app). So what do you want to do next?"

What you want to do next is to open this book's first project. The next section has all the details.

Opening One of This Book's Sample Programs

When you first launch Android Studio, you see the Welcome screen. It probably looks something like the screen in Figure 2-4. But, because time passes between my writing of this book and your reading the book, the screen might look a bit different. One way or another, the Welcome screen affords you the opportunity to open a full-fledged Android project. Here's what you do:

1. **Follow the steps in this chapter's earlier section "Getting This Book's Sample Programs."**

2. **Make sure that you've uncompressed the file from Step 1.**

   For details, refer to that "Getting This Book's Sample Programs" section.


CROSS-REFERENCE

   Safari on a Mac generally uncompresses `.zip` archives automatically, and Windows browsers (Internet Explorer, Firefox, Chrome, and others) do not uncompress `.zip` archives automatically. For the complete scoop on archive files, see the earlier sidebar "Compressed archive files."

   If you look inside the uncompressed download, you notice folders with names such as `02_01`, `03_01`, `03_04`, and so on. With a few exceptions, the names of folders are chapter numbers followed by listing numbers. For example, in the folder named `03_04`, the `03` stands for Chapter 3, and the `04` stands for the fourth code listing in that chapter.

3. **Launch Android Studio.**

   What you do next depends on what you see when you launch Android Studio.

4. **If you see Android Studio's Welcome screen (refer to Figure 2-4), select Open an Existing Android Project.**

   If you see another Android Studio window with a File option on the main menu bar, choose File ➪ Open in the main menu bar.

   Either way, the aptly named Open File or Project dialog box appears.

5. **In the Open File or Project dialog box, navigate to the folder containing the project that you want to open.**

   For this experiment, I suggest that you navigate to the `02_01` folder. In the name `02_01`, the `02` stands for *Chapter 2*. The `01` stands for this chapter's first (and only) Android project. (There's no code listed anywhere in this chapter. So, in this unusual case, `02_01` doesn't refer to a project whose code is in Listing 2-1.)


TIP

   If you're unsure where to find the `02_01` folder, look first in a folder named `Downloads`. Then look in a subfolder named `Java4Android_Projects`.

6. **Click OK.**

WARNING

When you click OK, Android Studio may have to download the default Gradle wrapper from the Internet. If so, downloading this Gradle wrapper might take some time. You may even think that your computer has stalled. Wait for several minutes if that's what it takes.

Eventually, you see Android Studio's main window. In the main window, you find a project containing one of this book's examples. See Figure 2-5.

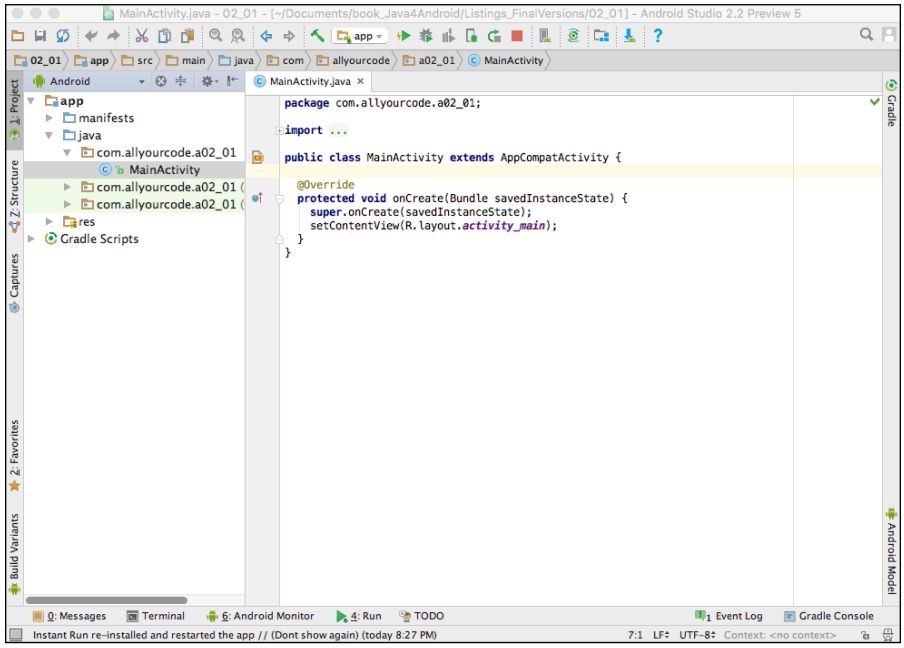


FIGURE 2-5: Android Studio's main window.

TIP

If Android Studio's main window looks fairly empty (that is, if you don't see all the stuff in 2-5), look at the status bar on the bottom of Android Studio's main window. If the text in the status bar is changing, Android Studio is taking some time to figure out how the newly opened Android project works. If the status bar is calm and Android Studio's main window still looks mostly empty, look for the word *Project* displayed vertically on the left edge of Android Studio's window. This word *Project* is the label on one of Android Studio's *tool buttons*. Click the Project tool button to reveal some of the stuff that you see earlier, in Figure 2-5.

After opening an example from this book, you may see an error message indicating trouble syncing the Gradle project. If you do, stay calm. The most likely cause is that the tools I used to create the example are older than the tools in your

version of Android Studio. You can probably find a link offering to fix the problem in the bottommost pane of the Android Studio window. (See Figure 2-6.) "Fix Gradle wrapper and re-import project Gradle settings," says one such link. "Install missing platform(s) and sync project," says another such link. "Install Build Tools 21.1.2 and sync project," says yet another link.

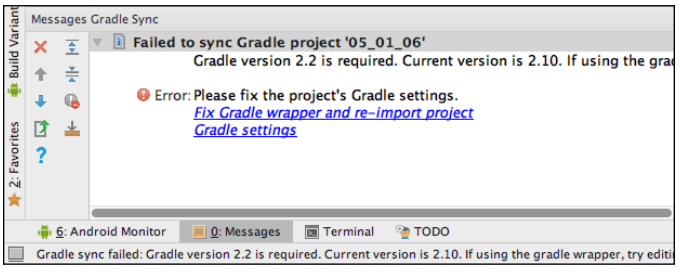


FIGURE 2-6: Android Studio's Messages pane provides a link to fix a problem.

Whatever link you see, click the link and accept any solutions that the link offers. Keep your eye on the status bar at the bottom of the Android Studio window. When the messages in the status bar stop changing, the error messages should be gone.

REMEMBER

If the error messages don't go away, you can always send me an email. My email address is in this book's introduction.

Using Android Studio

Android Studio is the Swiss army knife for Android app developers. Android Studio is a customized version of IntelliJ IDEA — a general-purpose IDE with tools for Java development, C/C++ development, PHP development, modeling, project management, testing, debugging, and much more.

In this section, you get an overview of Android Studio's main window. I focus on the most useful features that help you build Android apps, but keep in mind that Android Studio has hundreds of features and many ways to access each feature.

Starting up

Each Android app belongs to a project. You can have dozens of projects on your computer's hard drive. When you run Android Studio, each of your projects is either open or closed. An *open* project appears in a window (its own window) on your computer screen. A *closed* project doesn't appear in a window.

Several of your projects can be open at the same time. You can switch between projects by moving from window to window.


TECHNICAL STUFF

I often refer to an open project's window as Android Studio's *main window*. This can be slightly misleading because, with several projects open at a time, you have several main windows open at a time. None of these windows is more "main" than the others.

If Android Studio is running and no projects are open, Android Studio displays its Welcome screen. (Refer to Figure 2-4.) The Welcome screen may display some recently closed projects. If so, you can open a project by clicking its name on the Welcome screen. For an app that's not on the Recent Projects list, you can click the Welcome screen's Open an Existing Android Studio Project option.

If you have any open projects, Android Studio doesn't display the Welcome screen. In that case, you can open another project by choosing File➪ Open or File➪ Open Recent in an open project's window. To close a project, you can choose File➪ Close Project, or you can do whatever you normally do to close one of the windows on your computer. (On a PC, click the X in the window's upper-right corner. On a Mac, click the little red button in the window's upper-left corner.)


TIP

Android Studio remembers which projects were open from one run to the next. If any projects are open when you quit Android Studio, those projects open again (with their main windows showing) the next time you launch Android Studio. You can override this behavior (so that only the Welcome screen appears each time you launch Android Studio). In Android Studio on a Windows computer, start by choosing File➪ Settings➪ Appearance and Behavior➪ System Settings. In Android Studio on a Mac, choose Android Studio➪ Preferences➪ Appearance and Behavior➪ System Settings. In either case, uncheck the Reopen Last Project on Startup check box.

The main window

Android Studio's main window is divided into several areas. Some of these areas can appear and disappear on your command. What comes next is a description of the areas in Figure 2-7, moving from the top of the main window to the bottom.


REMEMBER

The areas that you see on your computer screen may be different from the areas in Figure 2-7. Usually, that's okay. You can make areas come and go by choosing certain menu options, including the View option on Android Studio's main menu bar. You can also click the little tool buttons on the edges of the main window.

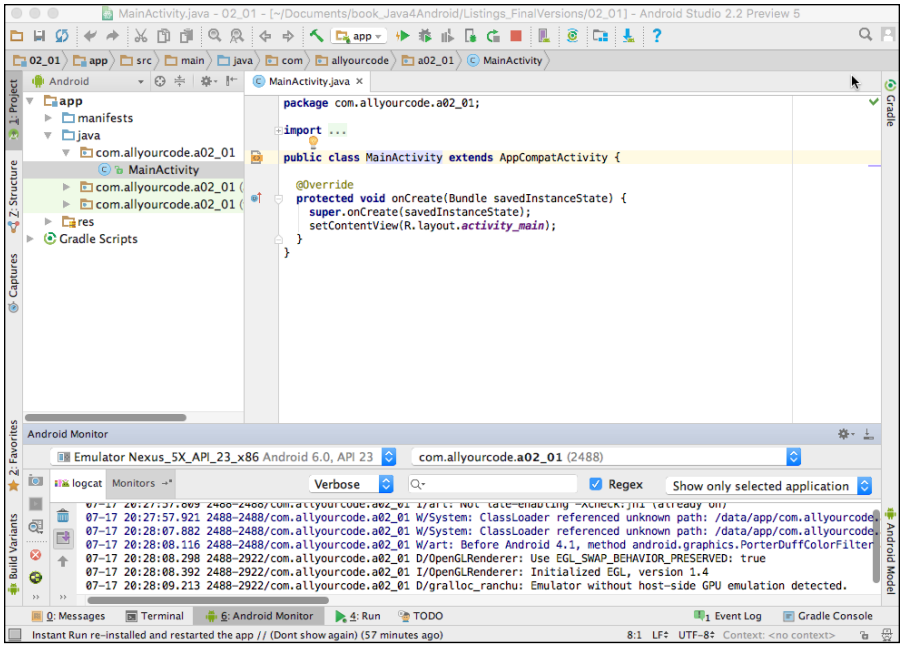


FIGURE 2-7: The main window has several areas.

The top of the main window

The topmost area contains the toolbar and the navigation bar.

- **The *toolbar* contains action buttons such as Open, Save All, Cut, Copy, and Paste.**

  Near the middle of the toolbar, you'll find a rightward-pointing green arrow. This arrow is the Run button. You can click that button to run the current Android app.

- **The navigation bar displays the path to one of the files in your Android project.**

  An Android project contains many files and, at any particular moment, you work on one of these files. The navigation bar points to that file.

The Project tool window

Below the main menu and the toolbars you'll see two different areas. The area on the left contains the Project tool window. You use the *Project tool window* to navigate from one file to another within your Android app.

At any given moment, the Project tool window displays one of several possible views. For example, back in Figure 2-7, the Project tool window displays its *Android view*. In Figure 2-8, I click the drop-down list and select the Packages view (instead of the Android view).

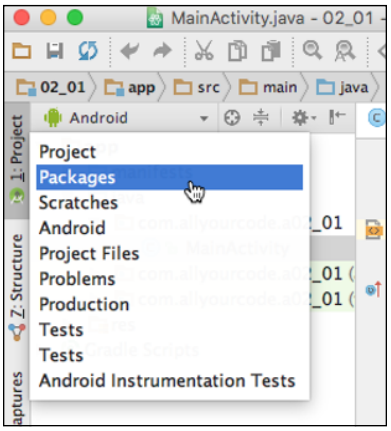


FIGURE 2-8: Selecting the Packages view.

The *Packages view* displays many of the same files as the Android view, but in the Packages view, the files are grouped differently. For most of this book's instructions, I assume that the Project tool window is in its default view; namely, the Android view.

REMEMBER

If Android Studio doesn't display the Project tool window, look for the Project tool button — the little button displaying the word *Project* on the left edge of the main window. Click that Project tool button.

TECHNICAL STUFF

Android Studio has lots of tool buttons on the edge of its main window — buttons with labels such as Project, Structure, Captures, Build Variants, Message, Gradle, and so on. I'm going to be very blunt about the endless number of ways that you can click and unclick these buttons: "For a complete discussion of all the things you can possibly do to customize the Android Studio main window, read someone else's book!" (Editor's note: Barry is tired of writing about tool button-clicking so he's being cantankerous. He also isn't giving himself enough credit. He's actually written more about customizing Android Studio's main window in his *Android Application Development All-in-One For Dummies*, 2nd Edition book. However, you don't need all those main window tweaks in order to follow the examples in this book.)

The Editor area

The area to the right of the Project tool window is the *Editor area*.

What you see in the Editor area depends on the kind of file that you're editing:

- **When you edit a Java program file, the editor displays the file's text. (Refer to Figure 2-7.)**

  You can type, cut, copy, and paste text as you would in other text editors.

  The text editor can have several tabs. Each tab contains a file that's open for editing. To open a file for editing, double-click the file's branch in the Project tool window. To close the file, click the little x next to the file's name in the Editor tab.

- **When you edit a layout file, the Editor area displays the Designer tool.**

  A typical Android app contains one or more layout files. A *layout file* describes the buttons, text fields, and other components that appear on a device's screen when a device runs your app. A layout file isn't written in Java.

  The Designer tool presents a visual representation of the layout file to help you arrange your app's buttons, text fields, and other components.

  For a careful look at Android Studio's Designer tool, see Chapter 3.

CROSS-REFERENCE

Continuing your tour of the areas in Figure 2-7. . . .

The lower area

Below the Project tool window and the editor is another area that contains several tool windows. The tool window that I use most often is the Android Monitor tool window. (Refer to the lower portion of Figure 2-7.)

The Android Monitor tool window displays information about the run of an Android app. This tool window appears automatically when your app starts running on an Android device.

CROSS-REFERENCE

An Android device isn't necessarily a real phone or a real tablet. Your development computer can emulate the behavior of an Android device. For details, see this chapter's later section "Creating an Android virtual device."

The Android Monitor tool window has the Logcat pane, the Monitors pane, and possibly others. (Notice the tabs with these labels earlier, in Figure 2-7.) The pane that I find most useful is the Logcat pane. In the Logcat pane, you see all messages being logged by the Android device that's running your app. If your app isn't running correctly, you can filter the messages that are displayed and focus on the messages that are most helpful for diagnosing the problem.

You can force other tool windows to appear in the lower area by clicking tool buttons near the bottom of the Android Studio window. Here are two other useful tool windows:

- The Terminal tool window displays a PC's MS-DOS command prompt, a Mac's Terminal app, or another text-based command screen that you specify. (See Figure 2-9.)

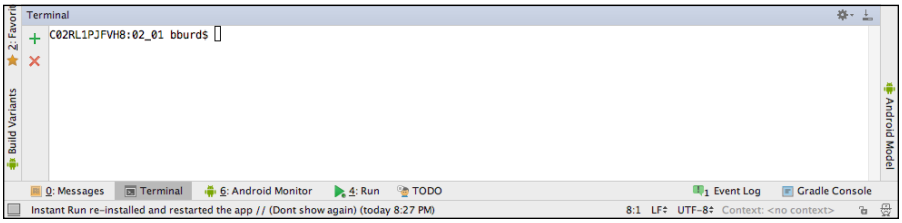


FIGURE 2-9: The Terminal tool window on a Mac.

- The Run tool window displays information about the launching of an Android app. (In Figure 2-10, phrases such as `Launching app` refer to the movement of an app from your development computer to the Android device.)

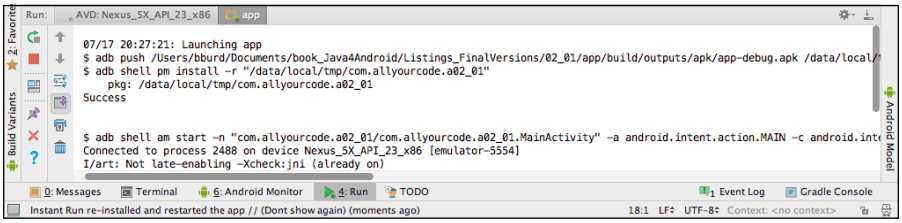


FIGURE 2-10: The Run tool window.

REMEMBER

A particular tool button might not appear when there's nothing you can do with it. For example, if you're not trying to run an Android app, you might not see the Run tool button.

Finishing your tour of the areas in Figure 2-7. . . .

The status bar

The status bar is at the very bottom of Android Studio's window.

The status bar tells you what's happening now. For example, if the cursor is on the 37th character of the 11th line in the editor, you see *11:37* somewhere on the status line. When you tell Android Studio to run your app, you see `Gradle: Executing Tasks` on the status line. When Android Studio has finished executing Gradle tasks, you see `Gradle Build Finished` on the status line. Messages like these are helpful because they confirm that Android Studio is doing what you want it to do.

The kitchen sink

In addition to the areas that I mention in this section, other areas might pop up as the need arises. You can dismiss an area by clicking the area's Hide icon. (See Figure 2-11.)

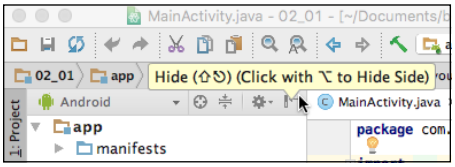


FIGURE 2-11: Hiding the Project tool window area.

Things You Might Eventually Have to Do

When you download Android Studio, you get the code library (the API) for the current release of Android. You also get several developer tools — tools for compiling, testing, and debugging Android code.

Here's what you don't get:

- **You don't get older Android APIs or older versions of the developer tools.**

  Sometimes you have to work with older versions of Android. By the time you read this book, the version of Android that I used to create the book's examples will already be an older version. You'll open one of the examples that you download from this book's web page, and you'll see Android Studio prompting you to install an older Android API. You'll accept the prompt's advice and you'll be well on your way to running the apps that I describe in this book.

- **You don't get future Android APIs or future versions of the developer tools. (You couldn't possibly get those things.)**

  Google updates Android frequently, and you might want to follow the latest trends. So, in the near future, you might install a newer release of Android than the release you have now.

You can get older software and newer software by clicking links in Android Studio's notifications, but you can also be proactive and reach out for different versions of Android's tools and APIs. To help you do this, you have two useful "manager" tools — the SDK Manager and the AVD Manager. The next few sections cover these tools in depth.

REMEMBER

When you first install Android Studio, you can probably skip the next two sections. Return to these sections when Google releases updated versions of Android or when you work on a project that requires older versions of Android (versions that you haven't already installed).

Installing new versions (and older versions) of Android

The *Android SDK Manager* lists the versions of Android and helps you download and install the versions that you need on your development computer. Figure 2-12 shows the SDK Manager with the manager's SDK Platforms tab open.

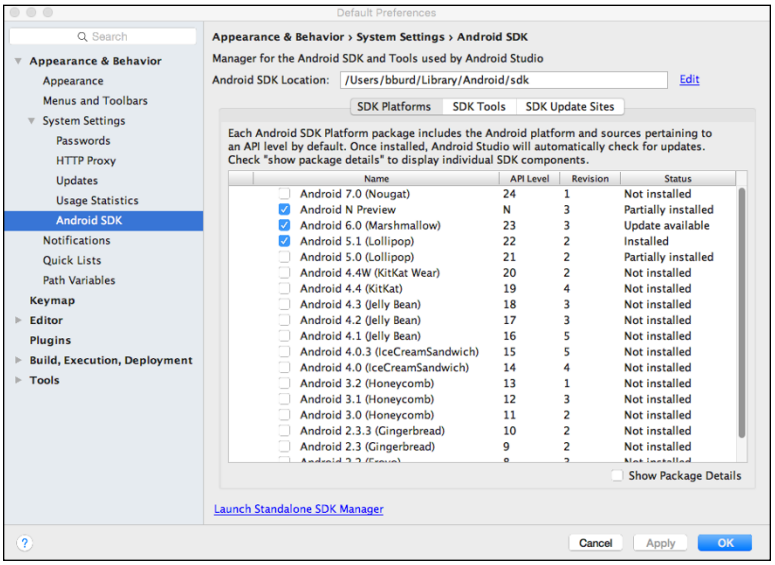


FIGURE 2-12: The Android SDK Manager.

To open the SDK Manager, go to Android Studio's main menu bar and choose Tools➪ Android➪ SDK Manager.

In truth, Android has two SDK managers. The one that I describe in this section is embedded inside Android Studio's Settings dialog box. The other runs on its own, with no help from the Android Studio IDE. The two SDK managers perform roughly the same tasks.

In the Android SDK Manager, you see tabs labeled SDK Platforms, SDK Tools, and SDK Update Sites.

- **The SDK Platforms tab lists versions of Android.**

  In Figure 2-12, the list includes Nougat, a preview release of Nougat when it was called Android N, two versions of Android Lollipop, and many others. The list's rightmost column tells you which Android versions are installed (either fully or partially) on your development computer. The rightmost column may also indicate that an update to an Android version is available for downloading. Adding a check mark next to a version tells the SDK Manager to install that version on your computer.

- **The SDK Tools tab lists software tools that are already installed, and some that aren't installed but are available for download.**

- **The SDK Update Sites tab lists the URLs of the places where SDK Manager looks for updates.**

To run this book's examples, you may have to visit the SDK Platforms tab. But you probably won't visit the SDK Tools tab. And you're very unlikely to need the SDK Update Sites tab.

Sometimes, you need a version of Android that's not already installed on your development computer. Somebody sent you a project that requires Android 3.2 and you haven't yet installed Android 3.2 on your machine. Then put a check mark next to Android 3.2 in the SDK Platforms tab of the Android SDK Manager. Click OK and watch Android 3.2 being installed.

Creating an Android virtual device

You might be itching to run some code, but first you must have something that can run an Android program. By *something*, I mean either a physical device or an emulated device.

- **A *physical device* is a piece of hardware that's meant to run Android. It's a phone, a tablet, an Android-enabled toaster — whatever.**

  Another name for a physical device is a *real device*.

» **An *emulated device* is a picture of a phone or a tablet on your development computer's screen.**

With an emulated device, Android is made to run on your development computer's processor. The emulated device shows you how your code will probably behave when you later run your code on a real phone, a real tablet, or another Android device.

MIMICKING A PHYSICAL DEVICE

An emulated device is really three pieces of software rolled into one:

- **A *system image* is a copy of one version of the Android operating system.**

  For example, a particular system image might be for Android Marshmallow (API Level 23) running on an *Intel x86_64* processor.

- **An *emulator* bridges the gap between the system image and the processor on your development computer.**

  You might have a system image for an Atom_64 processor, but your development computer runs a Core i5 processor. The emulator translates instructions for the Atom_64 processor into instructions that the Core i5 processor can execute.

- **An Android Virtual Device (AVD) is a piece of software that describes a real (physical) device's hardware.**

  An AVD contains a bunch of settings, telling the emulator all the details about the device to be emulated. What's the screen resolution of the device? Does the device have a physical keyboard? Does it have a camera? How much memory does it have? Does it have an SD card? All these choices belong to a particular AVD.

Android Studio's menus and dialog boxes make it easy to confuse these three items. When you download a new AVD, you often download a new system image to go with that AVD. But Android Studio's dialog boxes blur the distinction between the AVD and the system image. You'll also see the word *emulator,* when the correct term is *AVD*. If the subtle differences between system images, emulators, and AVDs don't bother you, don't worry about them.

A seasoned Android developer typically has several system images and several AVDs on the development computer, but only one Android emulator program.

An AVD is a piece of software that tells your development computer all about a particular phone, a particular tablet, or some other kind of device. When you install Android Studio, the installer creates an AVD for you to use. But you can create several additional AVDs and use several different AVDs to run and test your Android apps.

You use the AVD Manager tool to create and customize your Android virtual devices. To open the AVD Manager, go to Android Studio's main menu bar and choose Tools➪Android➪AVD Manager.

Figures 2-13 through 2-16 show the dialog boxes that you might find in the AVD Manager.

I'm reluctant to list instructions for using the AVD Manager, because the look of the AVD Manager tool is constantly in flux. Chances are, what you see on your computer's screen doesn't look much like the mid-2016 screen shots in Figures 2-13 to 2-16.

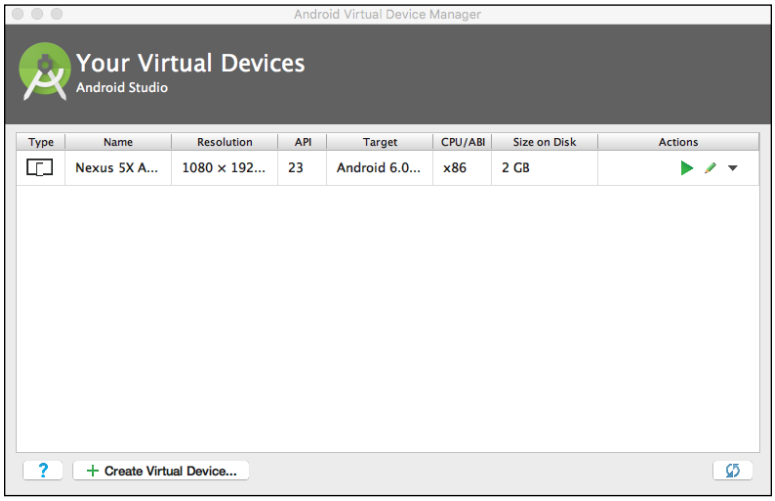


FIGURE 2-13: The opening page of the AVD Manager.

Instead of giving explicit instructions, my general advice when creating a new AVD is to select the newer phones or tablets and the higher-numbered API levels, and to accept defaults whenever you're tempted to play eeny-meeny-miney-mo. Just keep clicking Next until you can click Finish. If you don't like the AVD that you've created, you can always reopen the AVD Manager and select different options to create another AVD. When you reach the level of proficiency where you're finicky about your AVD's characteristics, you'll probably know your way around many of the AVD Manager's options and you'll be able to choose wisely.

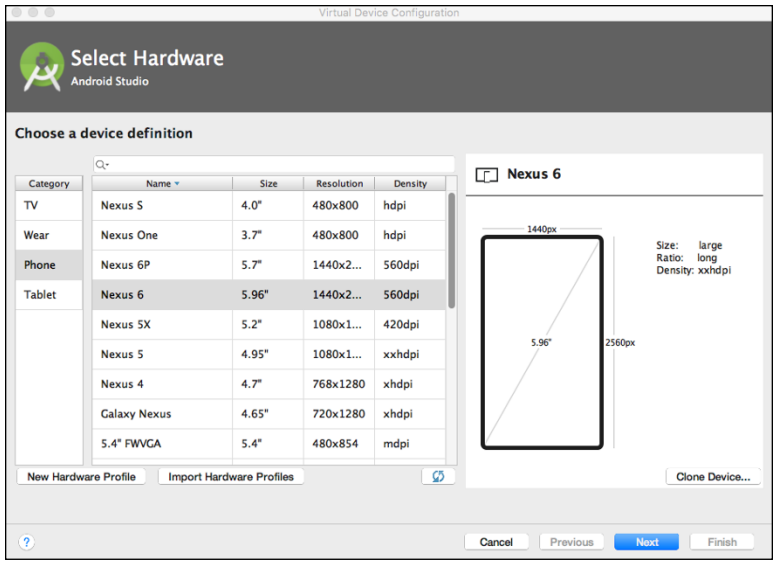


FIGURE 2-14: The first page in creating a new AVD.

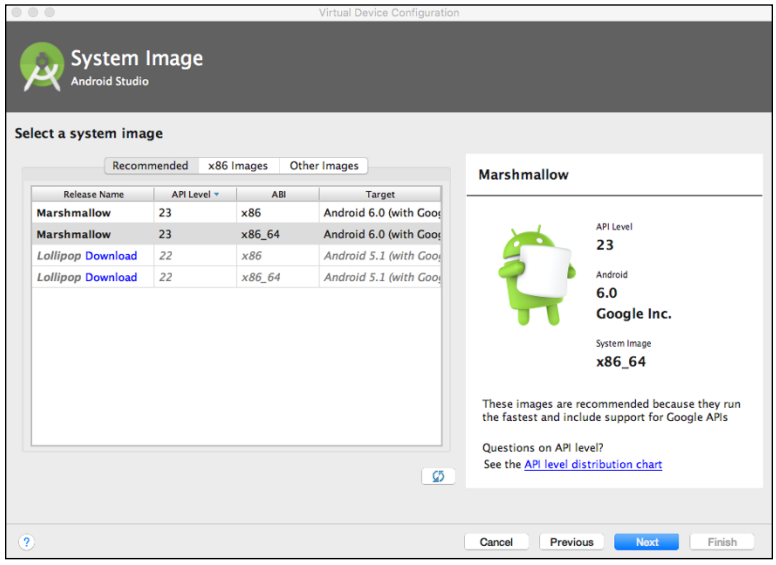


FIGURE 2-15: The second page in creating a new AVD.

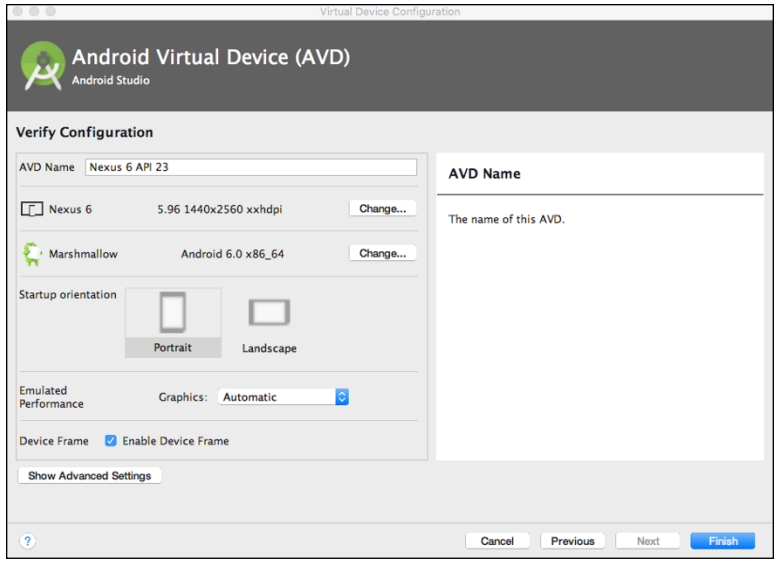


FIGURE 2-16: The final page in creating a new AVD.

And that does it! You're ready to run your first Android app. I don't know about you, but I'm excited. (Sure, I'm not watching you read this book, but I'm excited on your behalf.) Chapter 3 guides you through the running of an Android application. Go for it!

IN THIS CHAPTER

- Creating an elementary Android app
- Running an app on an emulator or a physical device
- Adding buttons, text fields, and other components to an app

Chapter 3

Creating and Running an Android App

In a quiet neighborhood in south Philadelphia, there's a maternity shop named Hello World. I stumbled onto the store on my way to Pat's (to get a delicious Philly cheesesteak, of course), and I couldn't resist taking a picture of the store's sign.

Computer geek that I am, I'd never thought of Hello World as anything but an app. A *Hello World* app is the simplest program that can run in a particular programming language or on a particular platform.* Authors create Hello World apps to show people how to get started writing code for a particular system.

So, in this chapter, you make an Android Hello World app. The app doesn't do much. (In fact, you might argue that the app doesn't do anything!) But the example shows you how to create and run new Android projects.

* For an interesting discussion of the phrase *Hello World,* visit `www.mzlabs.com/JMPubs/HelloWorld.pdf`. To see Hello World apps for more than 450 different programming languages, visit `www.helloworldcollection.de`.)

Creating Your First App

A typical gadget comes with a manual. The manual's first sentence is "Read all 37 safety warnings before attempting to install this product." Don't you love it? You can't get to the good stuff without wading through the preliminaries.

Well, nothing in this chapter can set your house on fire or even break your electronic device. But before you follow this chapter's instructions, you need a bunch of software on your development computer. To make sure that you have this software and that the software is properly configured, return to Chapter 2. (Do not pass Go; do not collect $200.)

When at last you have all the software you need, you're ready to launch Android Studio and create a real, live Android app.

REMEMBER

In the Android developer's world, things change quickly. If your screens don't look like the screens that I describe in this chapter, Google may have updated parts of Android Studio. If you have trouble figuring out what to do in any new versions of Android Studio, send me an email. The address is `Java4Android@allmycode.com`.

First things first

To start the IDE and create your first app, you start, naturally, at the beginning:

CROSS-REFERENCE

1. **Launch Android Studio.**

   For details on launching Android Studio, see Chapter 2.

   What you do next depends on what you see on your screen.

2. **If you see a project's main window, go to the window's main menu bar and select File ➪ New ➪ New Project.**

   If you see the Welcome screen, select Start a New Android Studio Project.

   As a result, the New Project dialog box appears, as shown in Figure 3-1. The New Project dialog box has fields for the application name, your company domain, and your project location. These fields contain some default values, such as *My Application* for the application name, and *example.com* for the company domain. You can change the values in these fields, as I do in Figure 3-1. But if you accept the defaults, you'll be just fine.

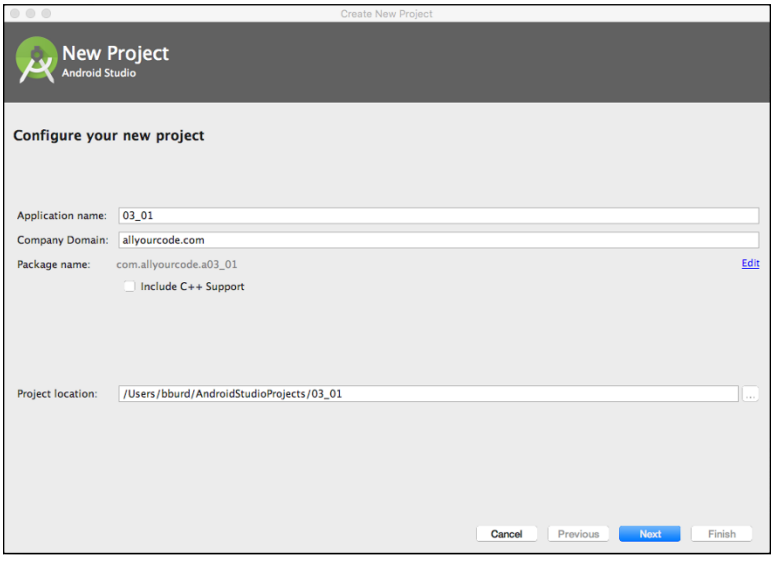


FIGURE 3-1: Configure your new project.

3. **In the New Project window, click Next.**

Doing so brings up the Target Android Devices window, as shown in Figure 3-2. This window has check boxes for Phone and Tablet, Wear, TV, Android Auto, and Glass. The window also has a number of Minimum SDK drop-down lists.

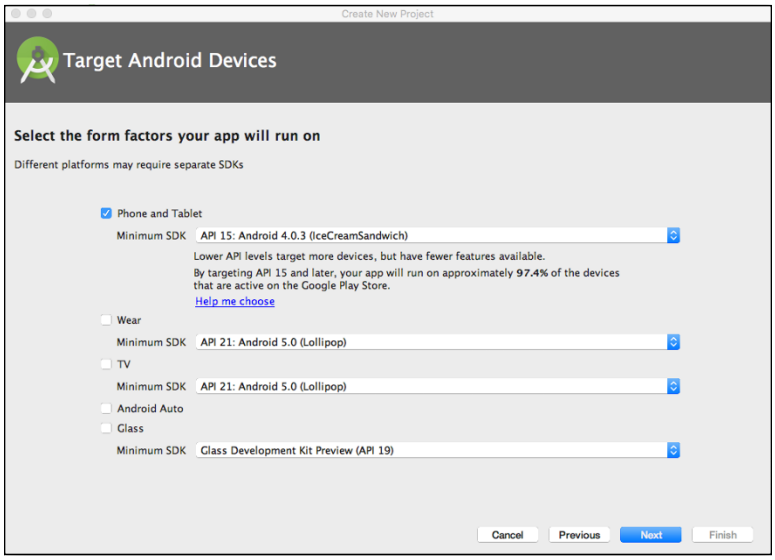


FIGURE 3-2: Select form factors and minimum SDKs.

In this example, I guide you through the creation of a Phone and Tablet app, so you can accept the minimum SDK value offered in the Phone and Tablet drop-down list. Of course, if you want to try creating a TV, Wear, or Glass app, or if you want to change the choice in the Minimum SDK drop-down list, feel free to do so.

TIP

For a minimum SDK, you can select any API level that's available in the drop-down list. You need a phone, a tablet, or an Android Virtual Device (AVD) that can run your chosen API level, but you probably don't have to worry about that. If you've recently downloaded Android Studio, the installation created an appropriate AVD. For example, if the installation of Android Studio created an AVD that runs Android 6.0, that AVD can handle projects whose minimum SDK is Android 6.0, Android 5.1, Android 5.0, Android 4.4, Android 4.0.3, Android 3.2, and so on. Looking from the other direction, a project whose minimum SDK is Android 4.0.3 can run on a phone or an AVD that has Android 4.0.3, Android 4.4, Android 5.0, Android 5.1, Android 6.0, and so on.

CROSS-REFERENCE

For an overview of Android versions, see Chapter 1. To find out about installing AVDs, see Chapter 2.

4. **Click Next.**

   As a result, the Add an Activity to Mobile window appears. (See Figure 3-3.) On this page, you tell Android Studio to create some Java code for you. The Java code describes an Android activity. The options for the kind of Android activity include Basic Activity, Empty Activity, Fullscreen Activity, and so on.

5. **Select the Empty Activity option.**


REMEMBER

   This is important: In Android developer lingo, an *activity* is one "screenful" of components. Each Android application can contain many activities. For example, an app's initial activity might list the films playing in your neighborhood. When you click a film's title, Android covers the entire list activity with another activity (perhaps an activity displaying a relevant film review).

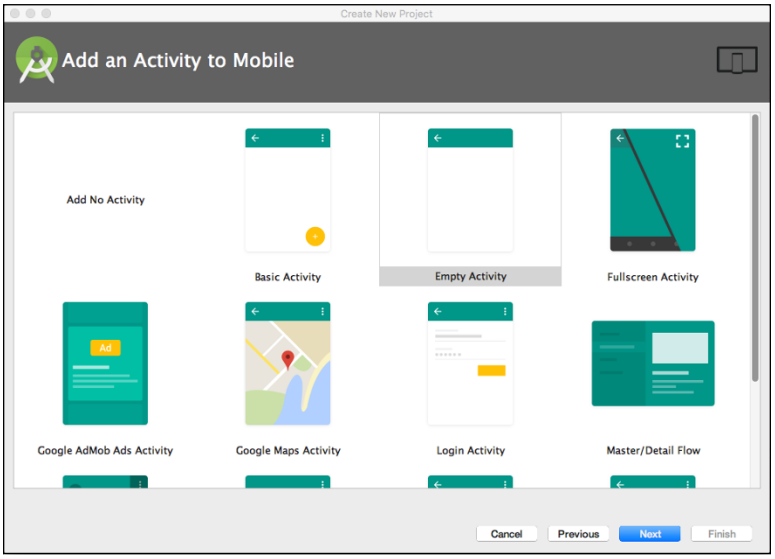


FIGURE 3-3: Add an activity.

When you select Empty Activity in the Add an Activity to Mobile window, Android Studio writes the Java code for an activity with no bells or whistles. The newly created activity has a text field that displays the words *Hello World!* and not much more. Unlike other choices, Empty Activity has no options menu, no floating action button, no scrollbar, no Google Maps — nothing of the sort. To learn Java, you don't need all that stuff.

6. **Click Next again.**

   You see the Customize the Activity page. (What a surprise!) On this page, you make up the names of things associated with your activity, as shown in Figure 3-4. Again, I recommend the path of least resistance — accepting the defaults.

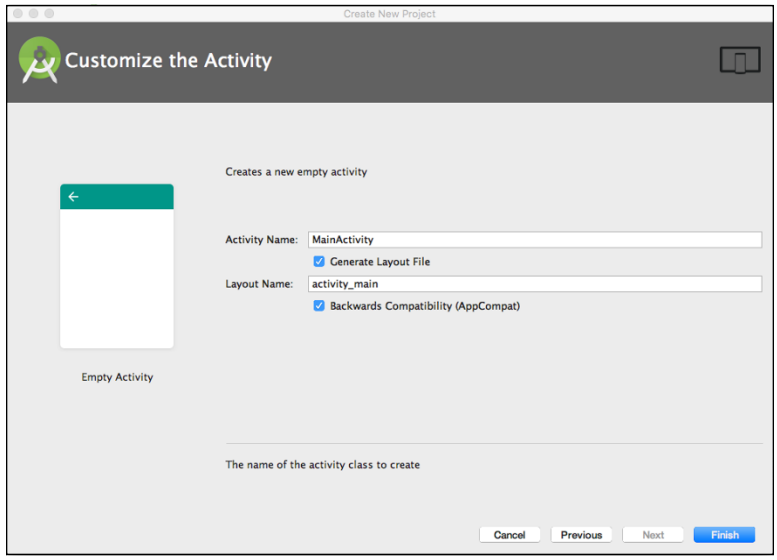


FIGURE 3-4: Choose options for your new activity.

7. **Click Finish.**

   The Customize the Activity page goes away. Android Studio displays its main window, as shown in Figure 3-5.

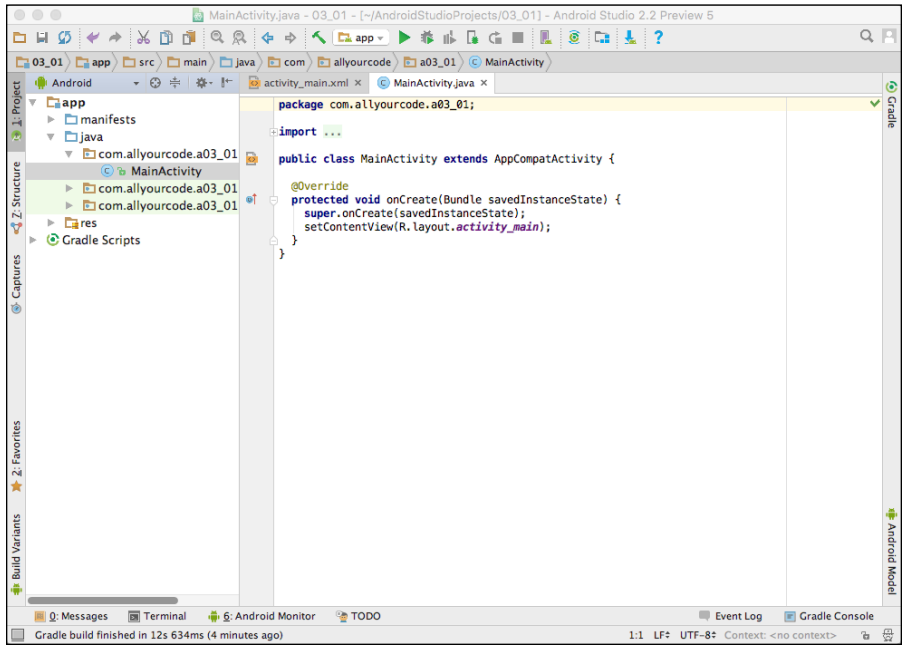


FIGURE 3-5: Android Studio's main window.

WARNING

The first time you create a project, you may have to wait a l-o-n-g time for Android Studio to build the Gradle project info (whatever that is). You see a pop-up dialog box indicating that Android Studio is downloading something. Be prepared to wait several minutes for any signs of life on your screen.

Launching your first app

You've started up Android Studio and created your first project. The project doesn't do much except display *Hello World!* on the screen. Even so, you can run the project and see it in action. Here's how you start:

1. **Take a look at Android Studio's main window.**

   Refer to Figure 3-5. In Android Studio, your new app consumes the entire main window. If, for some reason, more than one Android Studio window is open, make sure that the window you're looking at is the one containing your newly created Android app.

2. **In Android Studio's main menu, choose Run ➪ Run 'app'.**

   The Select Deployment Target dialog box appears, as shown in Figure 3-6.

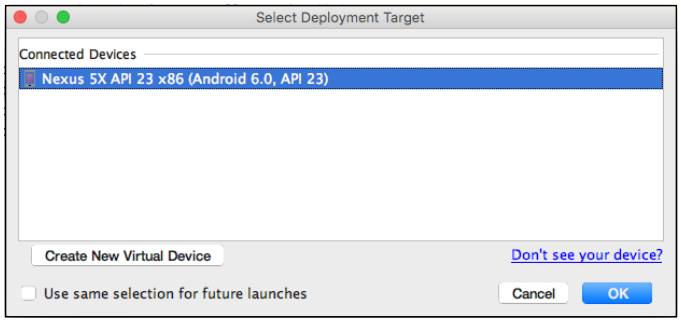


FIGURE 3-6: The Select Deployment Target dialog box.

In the Select Deployment Target dialog box, you see a list of devices (both physical and emulated) that can run your newly created app. One of them is the AVD that you created when you installed Android Studio. In Figure 3-6, that AVD is named *Nexus 5X API 23 x86*. On your screen, that AVD probably has a different name.

TIP

If the Select Deployment Target dialog box doesn't appear, your computer might be skipping the Select Deployment Target dialog box and going straight to an AVD or a physical device that's the default for this app. If this happens, your app (after a long wait) probably starts running in the emulator window. That's okay, but if you don't like skipping the Select Deployment Target dialog box, visit the section "Testing apps on a physical device," later in this chapter.

3. **Choose an item in the Select Deployment Target dialog box's list.**

CROSS-REFERENCE

If the drop-down list is empty, refer to the section in Chapter 2 on creating an Android Virtual Device.

4. **Click OK.**

When you do, several things happen, though they don't happen all at once. If you wait long enough, you should see your new app running on a device. The device may be a phone that's connected to your development computer. More likely, the device is an emulator window that appears on your development computer's screen. (See Figure 3-7.) The emulator window runs whichever AVD you chose in Step 3.

FIGURE 3-7: Your Hello World app in action.

WARNING

Android's emulator may take a very long time to get going. For example, my primary development computer has a 3.1GHz processor with 16GB of RAM. On that computer, the emulator takes 75 seconds to start up and run my app. On another computer with a 2.6GHz processor with 8GB of RAM, the emulator takes a few minutes to mimic a fully booted Android device. On yet another computer of mine, one with less than 8GB of RAM, the emulator doesn't even run. If your computer has less than 16GB of RAM, you may need lots of patience when you deal with Android's emulator. If you have trouble getting the emulator to run, consider attaching a real physical device to your

development computer, or running a third-party emulator. For more details, refer to this chapter's later section "If the Emulator Doesn't Behave."

Figure 3-7 shows the running of Android's Hello World app. (The screen even has *Hello World!* on it.) Android's development tools create this tiny app when you create a new Android project.

Android's Hello World app has no buttons to click and no fields to fill in. The app doesn't do anything interesting. But the appearance of an app on the Android screen is a very good start. Following the steps in this chapter, you can start creating many exciting apps.

TIP

Don't close an Android emulator unless you know you won't be using it for a while. The emulator is quite reliable after it gets going. While the emulator runs, you can modify your Android code and tell Android Studio to run the code again. When you do, Android Studio implements your changes on the running emulator.

While your app runs, you see the Logcat pane (part of the Android Monitor tool window) along the bottom of Android Studio's main window, as shown in Figure 3-8.

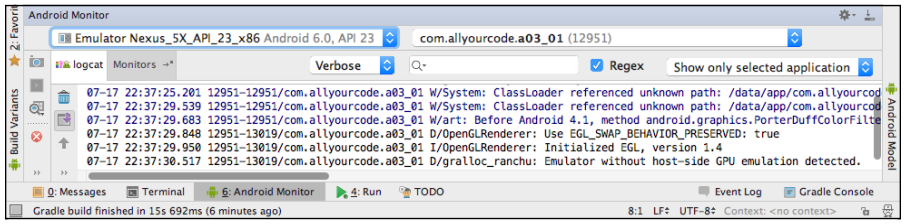


FIGURE 3-8: The Logcat pane in the Android Monitor tool window.

The *Logcat pane* displays diagnostics about the running of your app.

REMEMBER

You can make parts of Android Studio's window appear and disappear. For example, if you don't see the Logcat pane, look for a tab labeled *logcat* in the lower-left portion of the Android Studio window. (Refer to Figure 3-8.) If you don't see the logcat tab, look for the Android Monitor tool button in the lower-left corner of the Android Studio window. Click that tool button.

If the Emulator Doesn't Behave

The emulator that comes with Android Studio swallows up lots of resources on your development computer. If you're like me and you don't always have the latest, most powerful hardware, you may have trouble running apps in the emulator. This section provides some helpful tips.

If, after five minutes or so, you don't see Android's home screen and you don't see your app running, here are several things you can try:

- **Lather, rinse, repeat.**

  Close the emulator and launch your application again. Sometimes, the second or third time's a charm. On rare occasions, my first three attempts fail, but my fourth attempt succeeds.

- **If you have access to a computer with more RAM, try running your app on it.**

  Horsepower matters.

- **Try a different AVD.**

  The "Creating an Android virtual device" section, back in Chapter 2, tells you how to add a new AVD to your system. An AVD with an *x86* system image is better than an AVD with an *armeabi* image. (Fortunately, when a dialog box lets you choose between *x86* and *armeabi*, you don't have to know what *x86* or *armeabi* means.)

  In my experience, AVDs with lower resolution and screen density consume fewer resources on your development computer. So, if the AVD that you're running drags you down, follow the instructions in the "Creating an Android virtual device" section to make yourself a lower-resolution AVD (one that satisfies your app's minimum SDK requirement). Then, when you run an app, Android Studio prompts you with the Select Deployment Target dialog box. Pick the lower-resolution AVD from the dialog box's list, and you'll be on your way.

This section's bulleted list describes a few remedies for problems with Android Studio's emulator. Unfortunately, none of the bullets in this list is a silver bullet. If you've tried these tricks and you're still having trouble, you might try abandoning the emulator that comes with Android Studio. The next two sections have the details.

Running third-party emulators

Android's standard emulator and AVDs (the software that you get when you install Android Studio) don't run flawlessly on every computer. If you don't have at least 16GB of RAM, the emulator's start-up may be very slow. Even after start-up, the emulator's response may be painfully sluggish. If you don't like the standard emulator, you can try one of the third-party emulators.

- **At `www.genymotion.com`, you can download an alternative to the standard Android emulator.**

This alternative is available for Windows, Macintosh, and some Linux systems. Genymotion's product is free for personal use, but costs $135 per year for commercial use.

» **At** `www.visualstudio.com/en-us/features/msft-android-emulator-vs.aspx`**, you can download Visual Studio Emulator for Android.**

This alternative is free to use, but it runs only on Windows computers.

If you have trouble running the emulator that comes with Android Studio, these third-party emulators are definitely worth considering.

Testing apps on a physical device

You can bypass emulators and test your apps on a real phone, a tablet device, or even an Android-enabled coffee pot. To do so, you have to prepare the device, prepare your development computer, and then hook together the two. This section describes the process.


REMEMBER

Your device's Android version must be at least as high as your project's minimum SDK version.

To test your app on a physical device, follow these steps:

1. **On your Android device, find the USB Debugging option:**

   - If your Android device runs version 3.2 or older, choose Settings ➪ Applications ➪ Development.
   - If your Android device runs version 4.0, 4.0.3, or 4.1, choose Settings ➪ Developer Options.
   - If your Android device runs version 4.2 or higher, choose Settings ➪ About. In the About list, tap the Build Number item seven times. (Yes, seven times.) Then press the Back button to return to the Settings list. In the Settings list, tap Developer Options.

   Now your Android device displays the Development list (also known as the Developer Options list).

2. **In the Development (or Developer Options) list, turn on USB debugging.**

   Here's what one of my devices displays when I mess with this setting:

```
USB debugging is intended for development purposes.
Use it to copy data between your computer and your device,
install apps on your device without notification, and read log data.
```

The stewards of Android are warning me that the USB Debugging option can expose my device to malware.

On my device, I keep USB debugging on all the time. But if you're nervous about security, turn off USB debugging whenever you're not using the device to develop apps.

3. **(For Windows users only:) Visit** `https://developer.android.com/studio/run/oem-usb.html` **to download your Android device's Windows USB driver. Install the driver on your Windows development computer.**

4. **When you start running an app, make sure that your development computer displays the Select Deployment Target dialog box.**

   If you don't see the Select Deployment Target dialog box, from Android Studio's main menu choose Run ➪ Edit Configurations. On the left side of the resulting dialog box, select Android Application ➪ App. In the main body of the dialog box, under Deployment Target Options, choose the Open Select Deployment Target Dialog option and deselect the Use Same Device for Future Launches check box. Seal the deal by clicking OK.

5. **Make sure that your Android device's screen is illuminated.**

   This particular step might not be necessary, but I've scraped so many knuckles trying to get Android devices to connect with computers that I want every advantage I can possibly get.

   While you follow the next step, keep an eye on your Android device's screen.

6. **With a USB cable, connect the device to the development computer.**


TIP

Not all USB cables are created equal. Some cables have wires and metal in places where other cables (with compatible fittings) have nothing except plastic. Try to use whatever USB cable came with your Android device. If, like me, you can't find the cable that came with your device or you don't know which cable came with your device, try more than one cable. When you find a cable that works, label that able cable. (If the cable *always* works, label it Stable Able Cable.)

When you plug in the cable, you see a pop-up dialog box on the Android device's screen. The pop-up asks: Allow USB Debugging?

7. **In response to the Allow USB Debugging? question, click the screen's OK button.**


REMEMBER

If you're not looking for it, you can miss the Allow USB Debugging? pop-up dialog box. Be sure to look for this pop-up when you plug in your device. If you definitely don't see the pop-up, you might be okay anyway. But if the message appears and you don't respond to it, you definitely won't be okay.

8. **In Android Studio, run your project.**

   Android Studio offers you the Select Deployment Target dialog box. Select your connected device, and (lickety-split) your app starts running on your Android device.

CHECKING THE CONNECTION AND BREAKING THE CONNECTION

To find out whether your physical device is properly connected to your development computer, follow these steps:

1. **Find your computer's `ANDROID_HOME` directory.**

   What I call your computer's `ANDROID_HOME` directory is the directory containing the Android SDK. To find your computer's `ANDROID_HOME` directory, select File➪ Project Structure in Android Studio's main menu bar. On the left side of the resulting dialog box, select SDK Location. Then, in the main body of the dialog box, look for a section labeled Android SDK Location. On my Windows computer, the text field in that section points to `C:\Users\barry\AppData\Local\Android\Sdk`. On my Mac, the text field points to `/Users/bburd/Library/Android/sdk`.

2. **Select the Terminal tool button at the bottom of Android Studio's main window.**

   When you do, the lower portion of the main window turns into a command window for your computer's operating system. (On Windows, it's like running `cmd`. On a Mac, it's like running the Terminal app.)

3. **In the command window, use the `cd` command to navigate to the `platform-tools` subdirectory of your computer's `ANDROID_HOME` directory.**

   I'm a rootin'-tootin' two-fisted computer user. On my PC, I type the following, and then press Enter.

   ```
   cd \Users\barry\AppData\Local\Android\Sdk\platform-tools
   ```

   On my Mac, I type the following, and then press Enter.

   ```
   cd /Users/bburd/Library/Android/sdk/platform-tools/
   ```

4. **Type** adb devices**, and then press Enter. (On a Mac, type** ./adb devices**, and then press Enter.)**

(continued)

(continued)

If your computer's response includes a very long hexadecimal number (such as 2885046445FF097), that number represents your connected device. For example, with one particular phone connected, my computer's response is

```
emulator-5554 device
emulator-5556 device
2885046445FF097 device
```

If you see the word *unauthorized* next to the long hexadecimal number, you probably didn't answer OK to the Allow USB Debugging? question in Step 7 of the earlier section "Testing apps on a physical device."

If your computer's response doesn't include a long hexadecimal number, you might have missed the boat on one of the other steps in the "Testing apps on a physical device" section.

Eventually, you'll want to disconnect your device from the development computer. If you get the dreaded Not Safe to Remove Device message, then, in the Terminal tool window, type **adb kill-server**. (On a Mac, type **./adb kill-server**.) After that, you get the friendly Safe to Remove Hardware message.

The Project Tool Window

A bare-bones Android project contains over 1,000 files in nearly 500 folders. That's a lot of stuff. If you expand some of the branches in Android Studio's Project tool window, you see the tree shown in Figure 3-9.

To follow this book's examples, you can forget about 99 percent of the stuff in the Project tool window. You can focus on only a few of its branches. I describe them in this section.

The app/manifests branch

The `app/manifests` branch contains the `AndroidManifest.xml` file. (Refer to Figure 3-9.) The `AndroidManifest.xml` file provides information that a device needs in order to run the app. For example, an app may contain several activities. The `AndroidManifest.xml` file tells Android which of these activities to run when the user launches the app.

CROSS-REFERENCE

You can read more about `AndroidManifest.xml` files in Chapter 4.

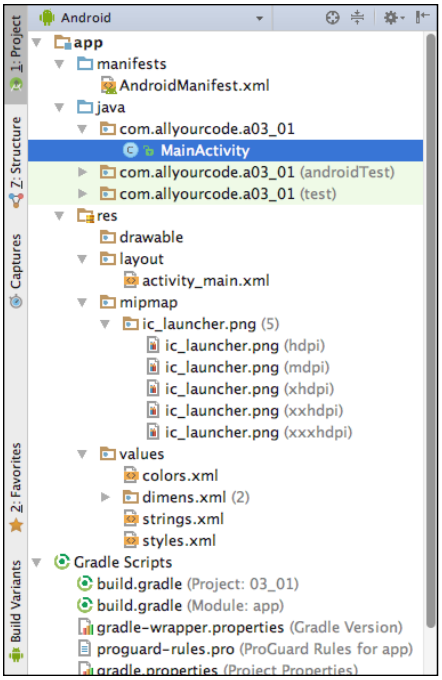


FIGURE 3-9: The Project tool window displays some parts of an Android app.

The app/java branch

The `app/java` branch contains your app's Java code. In fact, the branch contains several versions of your app's Java code. Earlier, in Figure 3-9, you see three branches:

- **The `com.allyourcode.a03_01` branch contains the code that the user's device will run.**
- **The `com.allyourcode.a03_01 (androidTest)` and `com.allyourcode.a03_01 (test)` branches contain extra code that you can use to test the app on your development computer.**

In this book, you don't bother with the code in the `androidTest` or `test` branches.

The app/res branches

The word `res` stands for *resources*. The `res` branch contains extra items — items that your app uses other than its own Java code:

- **The `app/res/drawable` branch contains any regular-size images that your app uses.**

- **The `app/res/layout` branch contains files that describe the look of your app's activities.**

  You deal with just such a file in this chapter's later section "Creating the 'look.'"

- **The `app/res/mipmap` branch contains some additional images — the images of your app's icons.**

  The term *mipmap* stands for *multum in parvo* mapping. And the Latin phrase *multum in parvo* means "much in little." A *mipmap* image contains copies of textures for many different screen resolutions.

- **The `app/res/values` branch contains other kinds of information that an app needs when it runs.**

  For example, the branch's `strings.xml` file may contain strings of characters that your app displays. When you first create an app, the `strings.xml` file may contain the line

  ```
  ‹string name="app_name"›My Application‹/string›
  ```

  If you want Romanian users to enjoy your app, you can right-click or control-click the `strings.xml` file's branch and select Open Translations Editor. In Android Studio's Translations Editor, you can create an additional `app/res/values` branch (a `strings.xml (ro)` branch) containing the following line:

  ```
  ‹string name="app_name"›Aplicatia mea‹/string›
  ```

The Gradle scripts branch

Gradle is a software tool. When the tool runs, it takes a whole bunch of files and combines them to form a complete application — a single file that you can post on Google Play. Of course, Gradle can combine files in many different ways, so to get Gradle to do things properly, someone has to provide it with a script of some kind. The heart of that script is in the `build.gradle (Module: app)` branch of the Project tool window. That branch describes your app's version number, minimum SDK, and other goodies.

Dragging, Dropping, and Otherwise Tweaking an App

At the start of this chapter, you create a brand-new Android app. The app displays the words *Hello World!* on the device's screen.

Wow! I'll bet you're really impressed! 

In this section, I explore new frontiers. I show you how to add components to your app — simple components that copy the user's text. The new app isn't very useful. You wouldn't spend money for this app at Google Play. But with this app, you find out how to get input from the user and how to display text on the user's screen.

Creating the "look"

A general guideline in app development tells you to separate logic from presentation. In less technical terms, the guideline warns against confusing what an app does with how an app looks. The guideline applies to many aspects of life. For example, if you're designing a website, have artists do the layout and have geeks do the coding. If you're writing a report, get the ideas written first. Later, you can worry about fonts and paragraph styles. (I wonder whether this book's copy editor would agree with me about fonts and styles.)

The literature on app development describes specific techniques and frameworks to help you separate form from function. But in this chapter I do the simplest thing — I chop an app's creation into two sets of instructions. The first set is about creating an app's look; the second set is about coding the app's behavior.

To add buttons, boxes, and other goodies to your app, do the following:

1. **Follow the steps earlier in this chapter, in the "First things first" section.**

   When you're finished with these steps, you have a brand-new project with an empty activity. The project appears in Android Studio's main window.

2. **In the new project's `app/res/layout` branch (in the main window's Project tool window), double-click `activity_main.xml`.**

   As a result, Android Studio's Designer tool displays the contents of `activity_main.xml`. The Designer tool has two modes: Design mode for drag-and-drop visual editing and Text mode for XML code editing. So the bottom of the Designer tool has two tabs: a Design tab and a Text tab.

3. **Click the Design tab.**

   In Design mode, you see the palette, the component tree, two preview screens, and the Properties pane. (See Figure 3-10.)

   For details about Android Studio's Design mode, check out the earlier sidebar "Android Studio's Designer tool."

TIP

If you don't see the palette, look for the little Palette button on the left edge of the Designer tool. If you click that button, the palette should appear.

The component tree has a branch labeled *TextView – "Hello World!"* This branch represents the text *Hello World!* that appears automatically as part of your app. You don't need this text in your app.

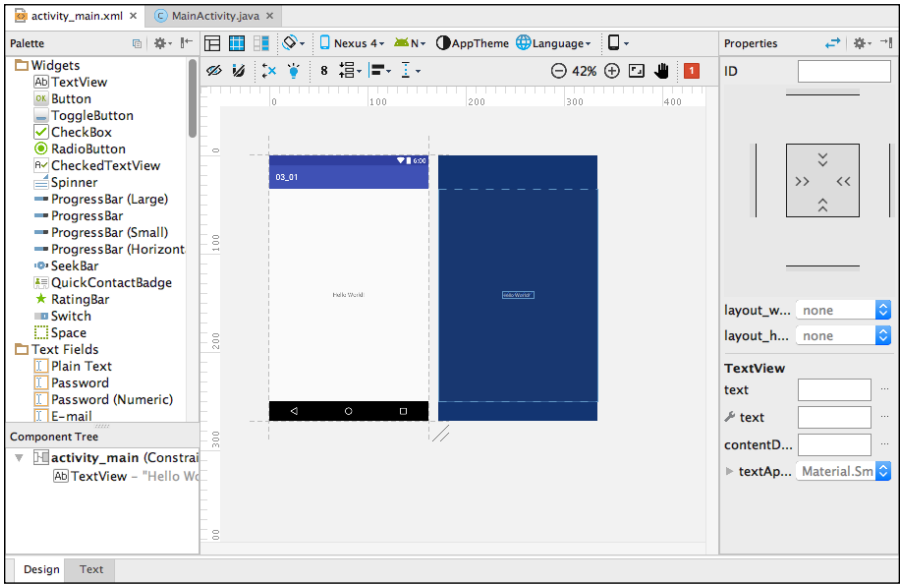


FIGURE 3-10: The Designer tool's Design mode.

4. Select the `TextView – "Hello World!"` branch in the component tree, and then press Delete.

The `"Hello World!"` branch disappears from the component tree, and the words *Hello World!* disappear from the preview screen.

The next several steps guide you through the creation of the app shown in Figure 3-11.

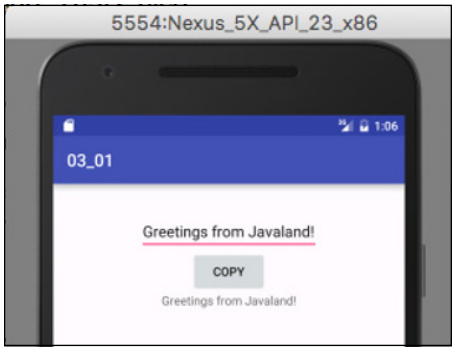


FIGURE 3-11: Running this section's app.

The app's layout has three different kinds of components, and each kind of component goes by several different names. Here are the three kinds of components:

- **`EditText` (also known as Plain Text):** A place where the user can edit a single line of text.

  A common name for this kind of component is a *text field*.

- **`Button`:** A button is a button is a button.

  Do you want to click the button? Go right ahead and click it.

- **`TextView` (also known as Plain TextView, Large Text, Medium Text, and so on):** A place where the app displays text.

  Normally, the user doesn't edit the text in a `TextView` component.


TECHNICAL STUFF

To be painfully precise, Android's `EditText`, `Button`, and `TextView` components aren't really different kinds of components. Every `EditText` component is a kind of `TextView`, and every `Button` is also a kind of `TextView`. In the language of object-oriented programming, the `EditText` class *extends* the `TextView` class. The `Button` class also extends the `TextView` class. You can read all about classes extending other classes in Chapter 10 of this book. With or without that chapter, this book's examples don't make use of the relationships between `EditText`, `Button`, and `TextView`. You can forget that you ever read this paragraph, and everything will be okay.

5. **Drag a Plain Text (that is, `EditText`) item from the palette's Widgets group to either of the preview screens.**

   The Plain Text item may land in an ugly-looking place. That's okay. You're not creating a work of art. You're learning to write Java code.


TIP

My book *Android Application Development All-in-One For Dummies,* 2nd Edition (published by Wiley), has advice on refining the look of your Android layouts.

6. **Repeat Step 5, this time putting a Button item on the preview screen.**

   I suggest putting the `Button` component below the Plain Text (`EditText`) component. Later, if you don't like where you put the `Button` component, you can easily move it by dragging it elsewhere on the preview screen.

7. **Repeat Step 6, this time putting a `TextView` component on the preview screen.**

   I suggest putting the `TextView` component below the `Button` component but, once again, it's up to you.

   In the remaining steps of this section, you change the text that appears in each component.

8. **Select the `Button` component on the preview screen or in the component tree.**

   As a result, the Designer tool's Properties pane displays some of the `Button` component's properties. (See Figure 3-12.)

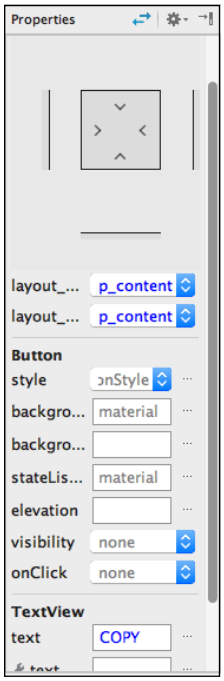


FIGURE 3-12: Setting the properties of a button.

TIP

After selecting the `Button` component, you may see the word *TextView* in the Properties pane. Don't confuse this with the `TextView` component that you dragged from the palette in Step 7. With the button selected, all the fields in the Properties pane refer to that `Button` component. If the appearance of the word *TextView* in the Properties pane confuses you, refer to the Technical Stuff icon in Step 4. (If the word *TextView* doesn't confuse you, don't bother reading the Technical Stuff icon!)

9. **In the Properties pane, in the field labeled *text*, type the word** COPY. **(Refer to Figure 3-12.)**

   When you do, the word *COPY* appears on the face of the `Button` component. You can check this by looking at the wysiwyg preview screen.

TIP

In the Properties pane, you may see two fields labeled *text*. If so, one is for testing and the other is for running the app. When in doubt, it doesn't hurt to type the word **COPY** in both of those fields.

10. **Repeat Steps 8 and 9 with your activity's `EditText` and `TextView` components, but this time, don't put the word *COPY* into those components. Instead, remove the characters from these components.**

    When you're finished, the preview screens look similar to the screens in Figure 3-13. If your preview screens don't look exactly like Figure 3-13, don't worry about it. Your components may be scattered in different places on the preview screens, or the creators of Android Studio may have changed the way the preview screens look since the time I wrote this book. As long as you have an `EditText` component, a `Button` component, and a `TextView` component, you're okay.

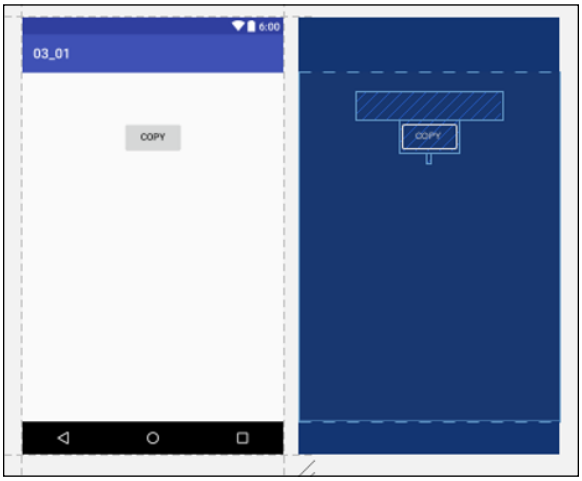


FIGURE 3-13: Preview screens containing the three components.

11. **Choose File ➪ Save All to save your work so far.**

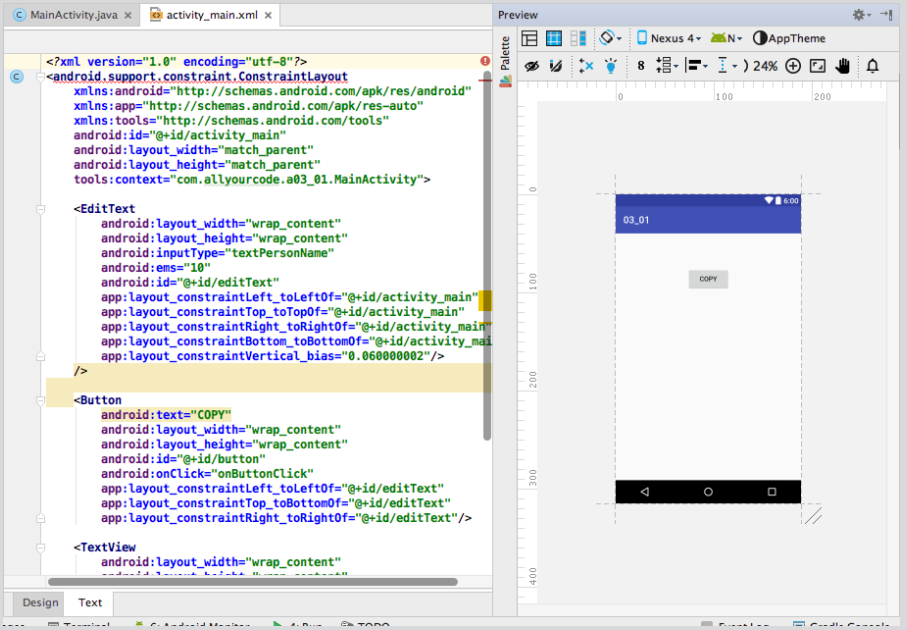
With this section's steps, you edit your app visually. Behind the scenes, Android Studio is editing the text in your app's `activity_main.xml` document. You can see what changes Android Studio has made to your app's `activity_main.xml` document by selecting the Text tab at the bottom of Android Studio's editor. My `activity_main.xml` document is reproduced in Listing 3-1. Your `activity_main.xml` document's contents may be different.

ANDROID STUDIO'S DESIGNER TOOL

A typical Android app has at least one layout file. A layout file describes the look of an Android device's screen. A layout file also describes the positions of text fields, buttons, images, and other items. The layout file can describe other properties of components on the screen. For example, a layout file can indicate the piece of Java code that Android calls when the user clicks a particular button.

Layout files aren't written in Java. They're written in XML. So you don't do anything exciting with layout files in this book. But you can do some simple, fun things with layouts by dragging and dropping components (buttons, text fields, and so on) in Android Studio's Designer tool.

One of the layout files in a typical Android app is named `activity_main.xml`. You may also see a file named `content_main.xml`. When you expand the `app/res/layout` branches in the Project tool window and you double-click the `activity_main.xml` item inside those branches, Android Studio displays its Designer tool. The Designer tool has two modes: Design mode and Text mode. (Refer to Figure 3-10 and the figure in this sidebar.) So the bottom of the Designer tool has two tabs: a Design tab and a Text tab.



In Design mode, you edit the layout by dragging and dropping components onto one of the Designer tool's preview screens. In Text mode, you edit the same layout by typing text in the XML file.

In Design mode, shown in Figure 3-10, the Designer tool has five parts:

- **The leftmost preview screen is a place to drop new components onto your app's screen.**

  I call this leftmost preview screen the *wysiwyg* ("what you see is what you get") preview screen.

- **To the right of the wysiwyg preview screen is the blueprint preview screen.**

  The *blueprint* screen is good for adjusting the positions of components. However, you can drop new components onto both the wysiwyg and blueprint screens. You can also adjust the positions of components on both the wysiwyg and blueprint screens. Whatever you do to a component on one preview screen automatically changes that same component on the other preview screen.

- **The palette on the left side of the Designer tool is a place to get the components that you drop onto the preview screens.**

  The palette has components such as TextView, Button, CheckBox, and many others.

- **The component tree (immediately below the palette) lists all components on your activity's screen.**

  When you create a project and select Empty Activity, Android Studio places a few of these components on your activity's screen. You may have dropped other components from the palette.

  Some components can live inside other components. That's why the component tree isn't a simple list. Instead, it's a tree with branches within branches.

- **The Properties pane on the right displays facts about the components in your layout. You can change the layout by modifying the values that you find here.**

In Text mode (shown in this sidebar's figure), the Designer tool has two parts:

- **The left half of the Text mode Designer tool is an editor.**

  In the editor, you see the XML file describing the layout of your app.

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- **In the right half of the Text mode Designer tool is yet another preview screen.**

  The Text mode's preview screen is only a viewer. It's not an editor. You can't modify the layout by dragging and dropping items on this preview screen.

  If Android Studio's Designer tool is in Text mode and you don't see the preview, click the Preview tool button. You'll find this button on the rightmost edge of the main window.

When you drag and drop components on Design mode's preview screens, Android Studio automatically updates the XML file. And it works both ways: When you edit the XML file, Android Studio keeps the preview screens up-to-date.

When you go to the Project tool window and double-click a file that's not a layout file, Android Studio dismisses the Designer tool and replaces it with the plain, old editor area.

LISTING 3-1: **The activity_main.xml Document**

```
<?xml version="1.0" encoding="utf-8"?>
<android.support.constraint.ConstraintLayout
    xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:app="http://schemas.android.com/apk/res-auto"
    xmlns:tools="http://schemas.android.com/tools"
    android:id="@+id/activity_main"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    tools:context="com.allyourcode.a03_01.MainActivity">

    <EditText
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:inputType="textPersonName"
        android:ems="10"
        android:id="@+id/editText"
        app:layout_constraintLeft_toLeftOf="@+id/activity_main"
        app:layout_constraintTop_toTopOf="@+id/activity_main"
        app:layout_constraintRight_toRightOf="@+id/activity_main"
        app:layout_constraintBottom_toBottomOf="@+id/activity_main"
        app:layout_constraintVertical_bias="0.06"/>
```

```
    <Button
        android:text="COPY"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:id="@+id/button"
        app:layout_constraintLeft_toLeftOf="@+id/editText"
        app:layout_constraintTop_toBottomOf="@+id/editText"
        app:layout_constraintRight_toRightOf="@+id/editText"/>

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:id="@+id/textView"
        app:layout_constraintLeft_toLeftOf="@+id/button"
        app:layout_constraintTop_toBottomOf="@+id/button"
        app:layout_constraintRight_toRightOf="@+id/button"/>

</android.support.constraint.ConstraintLayout>
```

REMEMBER

The code in a *something_or_other*`.xml` file isn't Java code. It's XML (eXtensible Markup Language) code. You don't have to type any XML code in an app's `activity_main.xml` file. For most of this book's examples, you can create the XML code indirectly by dragging and dropping components, and tweaking properties in Android Studio's Designer tool. That's what this section's instructions are all about. Of course, it's helpful to know something about XML code. That's why I wrote this section's "All about XML files" sidebar.

ALL ABOUT XML FILES

The acronym *XML* stands for eXtensible Markup Language. Every Android app consists of some Java code files, some XML files, and some other files.

Listing 3-1 contains an XML document. You might already be familiar with HTML documents — the bread and butter of the World Wide Web. Like an HTML document, every XML document consists of tags (angle-bracketed descriptions of various pieces of information). But unlike an HTML document, an XML document doesn't necessarily describe a displayable page.

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Here are some facts about XML code:

- **A *tag* consists of text surrounded by angle brackets.**

  For example, the code in Listing 3-1 consists of three tags: The first tag is the `<android.support.constraint.ConstraintLayout ... >` tag. The second tag is the `<EditText ... />` tag. The remaining tags are the `<Button ... />` tag, the `<TextView ... />` tag, and the `</android.support.constraint.ConstraintLayout>` tag.

  With its question marks, the first line in Listing 3-1, `<?xml version="1.0" encoding="utf–8"?>`, doesn't count as a tag.

- **An XML document may have three different kinds of tags: start tags, empty element tags, and end tags.**

  A *start tag* begins with an open angle bracket and a name. A start tag's last character is a closing angle bracket.

  The first tag in Listing 3-1 (the `<android.support.constraint.ConstraintLayout ... >` tag on lines 2 through 9) is a start tag. Its name is `android.support.constraint.ConstraintLayout`.

  An *empty element tag* begins with an open angle bracket followed by a name. An empty element tag's last two characters are a forward slash followed by a closing angle bracket.

  The second tag in Listing 3-1 (the `<EditText ... />` tag on lines 11 through 18 in the listing) is an empty element tag. Its name is `EditText`. The `<Button ... />` and `<TextView ... />` tags are also empty element tags.

  An *end tag* begins with an open angle bracket followed by a forward slash and a name. An end tag's last character is a closing angle bracket.

  The last tag in Listing 3-1 (the `</android.support.constraint.ConstraintLayout>` tag on the last line of the listing) is an end tag. Its name is `android.support.constraint.ConstraintLayout`.

- **An XML *element* has both a start tag and an end tag or it has an empty element tag.**

  In Listing 3-1, the document's `android.support.constraint.ConstraintLayout` element has both a start tag and an end tag. (Both the start and end tags have the same name, `android.support.constraint.ConstraintLayout`, so the name of the entire element is `android.support.constraint.ConstraintLayout`.)

  In Listing 3-1, the document's `EditText` element has only one tag: an empty element tag. The same is true of the `Button` and `TextView` elements.

- **Either elements are nested inside one another or they have no overlap.**

  For example, in the following code, a `TableLayout` element contains two `TableRow` elements:

```
<TableLayout xmlns:android=
      "http://schemas.android.com/apk/res/android"
      android:layout_width="fill_parent"
      android:layout_height="fill_parent" >

  <TableRow>

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:text="@string/name"/>

  </TableRow>

  <TableRow>

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:text="@string/address"/>

  </TableRow>

</TableLayout>
```

  The preceding code works because the first `TableRow` ends before the second `TableRow` begins. But the following XML code is illegal:

```
<!-- The following code isn't legal XML code. -->
<TableRow>

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:text="@string/name"/>
<TableRow>

</TableRow>

    <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:text="@string/address"/>
</TableRow>
```

(continued)

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With two start tags followed by two end tags, this new XML code doesn't pass muster.

- **Each XML document contains a *root element* — one element in which all other elements are nested.**

  In Listing 3-2 (a little later in this chapter), the root element is the `android.support.constraint.ConstraintLayout` element. The listing's other elements (the `EditText`, `Button`, and `TextView` elements) are nested inside that `android.support.constraint.ConstraintLayout` element.

- **Different XML documents use different element names.**

  In every HTML document, the `<br />` element stands for *line break*. But in XML, names such as `android.support.constraint.ConstraintLayout` and `EditText` are particular to Android layout documents. And the names `portfolio` and `trade` are particular to financial product XML (`FpML`) documents. The names `prompt` and `phoneme` are peculiar to voice XML (`VoiceXML`). Each kind of document has its own list of element names.

- **The text in an XML document is case-sensitive.**

  For example, if you change `EditText` to `eDITtEXT` in Listing 3-2, the app won't run.

- **Start tags and empty element tags may contain attributes.**

  An *attribute* is a name-value pair. Each attribute has the form *name="value"*. The quotation marks around the *value* are required.

  In Listing 3-1, the start tag (`android.support.constraint.ConstraintLayout`) has seven attributes, and the empty element tag (`EditText`) has seven of its own attributes. For example, in the `EditText` empty element tag, the text `android:layout_width="wrap_content"` is the first attribute. This attribute has the name `android:layout_width` and the value `"wrap_content"`.

- **A non-empty XML element may contain *content*.**

  For example, in the `app/res/values` branch in Android Studio's Project tool window, you can find a file named `strings.xml`. In that `strings.xml` file, you may see

```
<string name="app_name">03_01</string>
```

  In the `string` element, the content `03_01` is sandwiched between the start tag (`<string name="app_name">`) and the end tag (`</string>`).

Coding the behavior

Assuming you've followed the instructions in the earlier section "Creating the 'look,'" what's next? Well, what's next depends on how much you want to work. This section describes the easy way. If you read the later section "Going Pro," you'll find out how to do it the not-so-easy way.

Android 1.6 (also known as Donut) introduced an `android:onClick` attribute that streamlines the coding of an app's actions. Here's what you do:

1. **Follow the steps in this chapter's earlier section "Creating the 'look.'"**
2. **If you don't see the Designer tool with its preview screens, double-click the `app/res/layout/activity_main.xml` branch in the Project tool window. When the Designer tool appears, select the Design tab.**

   For details, refer to Steps 2 and 3 in the "Creating the 'look'" section.
3. **Make note of the labels on the branches in the component tree.**

   The component tree is on the left side of the Designer tool, immediately below the palette. Notice the labels on the branches of the tree. Each element on the screen has an *id* (a name to identify that element). In Figure 3-14, the ids of some of the screen's elements are `editText`, `button`, and `textView`.

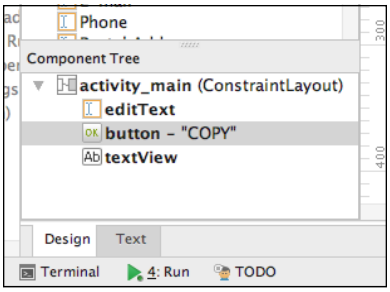


FIGURE 3-14: The component tree.

TIP

You may be wondering why, in place of the word "identification," I use the strange lowercase abbreviation *id* instead of the more conventional English language abbreviation *ID*. To find out what's going on, select the Text tab in Android Studio's designer tool. In the XML code for the activity's layout you'll find lines such as `android:id="@+id/textView"`. In Android's XML files, `id` is a code word.

When you drop a component onto the preview screen, Android Studio assigns that component an id. You can experiment with this by dropping a second `TextView` component onto the preview screen. If you do, the component tree has an additional branch, and the label on the branch (the id of the new component) is likely to be textView2.

REMEMBER

Java is case-sensitive, so you have to pay attention to the way words are capitalized. For example, the word `EditText` isn't the same as the word `editText`. In this example, the word `EditText` stands for a *kind* of component (a kind of text field), and `editText` stands for a *particular* component (the text field in your app — the text field that you dropped onto the preview screen).

You can change a component's id, if you want. (For example, you can change the name `editText` to `thatTextThingie`.) In this example, I recommend accepting whatever you see in the component tree. But before proceeding to the next step, make note of the ids in your app's component tree. (They may not be the same as the ids in Figure 3-14.)

TECHNICAL STUFF

To change a component's id, select that component on the preview screen or in the component tree. Then, in the Properties pane on the right side of the Designer tool, look for an ID field. Change the text that you find in this ID field. (Yes. In the Properties pane, *ID* has capital letters. Don't blame me. It's not my fault.)

4. **On the preview screen or in the component tree, select the COPY button. (Refer to Figure 3-14.)**

   As a result, the Properties pane displays information about your button component.

5. **In the Properties pane, type** onButtonClick **in the `onClick` field. (See Figure 3-15.)**

   Actually, the word you type in the `onClick` field doesn't have to be **onButtonClick**. But in these instructions, I use the word *onButtonClick*. So please indulge me and use the same word that I use. Thank you!

FIGURE 3-15: Setting the button's `onClick` value.

6. **Inside the `app/java` branch of the Project tool window, double-click `MainActivity`.**

   Of course, if you didn't accept the default activity name (`MainActivity`) when you created the new project, double-click whatever activity name you used.

REMEMBER

In the Project tool window, the `MainActivity` branch is located in a branch that's labeled with your app's package name. (The package name is `com.example.myapplication` or `com.allyourcode.a03_01` or something like that.) That package name branch is directly in the `java` branch, which is, in turn, in the `app` branch.

When you're finished with double-clicking, the activity's code appears in Android Studio's editor.

7. **Modify the activity's code, as shown in Listing 3-2.**

CROSS-REFERENCE

The lines that you type are set in boldface in Listing 3-2.

For some hints about typing code, see the later sidebar "Make Android Studio do the work."

WARNING

In Listing 3-2, I assume that the branches on your app's component tree have the same labels as the tree pictured in Figure 3-14. In other words, I assume that your app's components have the ids `editText`, `button`, and `textView`. If your app's components have different ids, change the code in Listing 3-2 accordingly. For example, if your first `EditText` component has the id `editText2`, change your first `findViewById` call to `findViewById(R.id.editText2)`.

LISTING 3-2: **A Button Responds to a Click**

```
package com.allyourcode.a03_01;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.EditText;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  EditText editText;
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    editText = (EditText) findViewById(R.id.editText);
    textView = (TextView) findViewById(R.id.textView);
  }
```

(continued)

LISTING 3-2: *(continued)*

```
    public void onButtonClick(View view) {
      textView.setText(editText.getText());
    }
}
```

8. **Run the app.**

9. **When the app starts running, type something (anything) in your app's `EditText` component. Then click the button.**

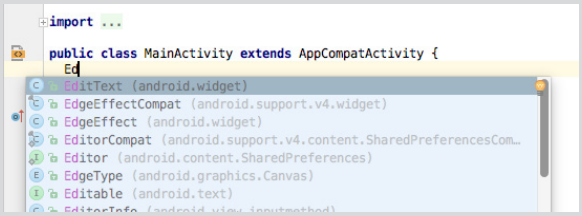
   When you click the button, Android copies the text from your `EditText` component to your `TextView` component. The running app is shown in Figure 3-11.

REMEMBER

If your app doesn't run, you can ask me for help via email. The address is `Java4Android@allmycode.com`.

MAKE ANDROID STUDIO DO THE WORK

When you type code in Android Studio, the editor guesses what you're trying to type and offers to finish typing it for you. In the first sidebar figure, I start to type the word *EditText.* When I type the letters *Ed,* Android Studio displays a drop-down list with entries such as `EditText`, `EdgeEffectCompat`, and `EdgeEffect`. (See the first sidebar figure.) I can select one of these by double-clicking the entry in the pop-up menu. Alternatively, I can select an entry from the pop-up menu and then press Enter or Tab.



Another cool feature of Android Studio's editor is intention actions. You're minding your own business, typing code, and having a good time — and suddenly you see some commotion in the Editor window. (See the second sidebar figure.) A callout signals the presence of one or more *intention actions* — proposals to make small changes in order to

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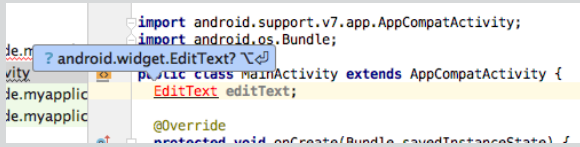
improve your code. In response to the callout's appearance, you press Alt+Enter. Doing so may add an `import` line at the top of your code or make another beneficial change.



You can tweak Android Studio's settings so that you get the `import` lines at the top of Listing 4-2 without even pressing Alt+Enter. Lines of this kind can appear automatically whenever you type words like `View` or `EditText`. Here's how:

1. **If you have a Windows PC, choose File ➪ Settings. If you have a Mac, choose Android Studio ➪ Preferences.**

   A dialog box appears. (The dialog box's title is either Settings or Preferences. Whatever!)

2. **In the panel on the left side of the dialog box, expand the Editor branch.**

3. **In the subbranch labeled General, select Auto Import.**

   Several options appear in the main body of the dialog box. (See the third sidebar figure.)

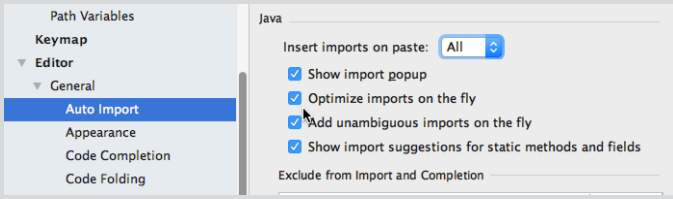
4. **In the drop-down list labeled Insert Imports on Paste, select All.**

5. **Put a check mark in the Optimize Imports on the Fly check box.**

6. **Put a check mark in the Add Unambiguous Imports on the Fly check box.**

7. **Click OK to commit to these changes.**

Now, when you type a line like `TextView textView`, Android Studio automatically adds the required `import android.widget.TextView` line to your code. That's nice.



What All That Java Code Does

You may be curious about the code in Listing 3-2. If so, a few words of explanation are in order.

Finding the EditText and TextView components

In Listing 3-2, the lines

```
EditText editText;
TextView textView;
```

alert Java to the fact that you use the names `editText` and `textView` in your code. The line

```
EditText editText;
```

says that the name `editText` refers to an `EditText` type of component (a place where the user can type some text). This line might seem redundant, but it's not. You can modify the second word on the line this way:

```
EditText userTypesTextHere;
```

But if you make this change, you have to change the name `editText` in other parts of Listing 3-2.


REMEMBER

In Listing 3-2, you can change the name `editText` to another name, but you can't change `EditText` (starting with an uppercase letter *E*) to another name. In an Android program, the name `EditText` (starting with an uppercase letter *E*) stands for a place where the user can type a single line of text. Similarly, the name `Button` stands for a button, and `TextView` stands for a place where Android displays text.

In Listing 3-2, the line

```
editText = (EditText) findViewById(R.id.editText);
```

finds the `EditText` component that you create in the steps in the earlier section "Creating the 'look.'"

Wait a minute! What does it mean to "find" a component, and how does a line of code in Listing 3-2 accomplish that task? Figure 3-16 illustrates the situation.

FIGURE 3-16: Connecting XML code with Java code.

When you follow the directions in the earlier section "Creating the 'look,'" you end up with a file like the one in Listing 3-1. This file contains these lines:

```
    <EditText
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        ...
        android:id="@+id/editText"
        ... />
```

The `EditText` component's XML code contains a cryptic `@+id/editText` attribute. Android Studio sees this `@+id/editText` attribute and takes it as an instruction to add a line to one of your app's Java files:

```
public final class R {
  public static final class id {
    public static final int editText=0x7f0c0051;
```

The file that contains this code is named `R.java`. You don't see the `R.java` file in Android Studio's Project view unless you select Project or Project Files instead of Android in the drop-down list above the Project tool window. Even if you can see the `R.java` file, you should never type any of your own changes in the `R.java` file.

Because of this Java code, the name `R.id.editText` stands for the number `0x7f0c0051`.

So, if you look again at Figure 3-16, you see how a line of Java code says the following:

> Look for something that has id number 2131492945. Treat whatever you find as if it's an EditText component, and from here on, in this Java code, refer to that thing by the name `editText`.

This is how Android connects a component that you create in the Designer tool with a name in your app's Java code.

In Listing 3-2, the line

```
textView = (TextView) findViewById(R.id.textView);
```

serves the same purpose for the `TextView` component that you add when you follow the instructions in the earlier section "Creating the 'look.'"

The characters `0x7f0c0051` might not look much like a number but, in a Java program, the characters `0x7f0c0051` form the hexadecimal representation of what we ordinarily call 2131492945. If this number 2131492945 for a little `EditText` component seems arbitrary, don't worry. It's *supposed* to be arbitrary. Android Studio generates the `R.java` file automatically from the things that you name in places like Listing 3-1. All the numbers in the `R.java` file are arbitrary. There's no reason for them not to be arbitrary.

Responding to a button click

The `onButtonClick` code in Listing 3-2 fulfills the promise that you make in Step 5 of the earlier section "Coding the behavior." Setting the button's `onClick` property to `onButtonClick` gets Android Studio to add the additional line `android:onClick="onButtonClick"` to the code in Listing 3-1. As a result, Android calls the `onButtonClick` code in Listing 3-2 whenever the user clicks the button.

In Listing 3-2, the lines

```
public void onButtonClick(View view) {
  textView.setText(editText.getText());
}
```

form a *method* whose name is `onButtonClick`. The first line is the method's *header:*

```
public void onButtonClick(View view)
```

The header has the method's name — `onButtonClick`. This is the name you typed when you set the button's `onClick` property in Step 5 of the earlier section "Coding the behavior."

Below the header comes the instruction to be performed whenever the user clicks the button. Figure 3-17 describes what the instruction tells Android to do when the user clicks the button.

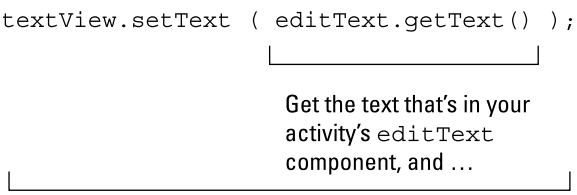


FIGURE 3-17: An instruction to copy text.

REMEMBER

You don't have much leeway in the way you create the button click's method header. Instead of `public void onButtonClick(View view)`, you can write something like `public void whenClicked(View veryNiceView)`, but then you must use the words `whenClicked` and `veryNiceView` consistently throughout your code.

CROSS-REFERENCE

I confess. I'm getting ahead of myself with this section's talk about a Java method. To read more about Java methods, see Chapters 4 and 7.

The rest of the code

Most of the code in Listing 3-2 is standard stuff. Android Studio composes the code automatically, and you use this code in almost every app that you create. Much of the time, you don't pay attention to this code that Android Studio generates. When you stare at Listing 3-2, you concentrate on the boldface lines and not much else. You take the other lines for granted.

Of course, the boilerplate code in Listing 3-2 isn't magic. In later chapters, I describe lots of Java's features and help you to understand the inner workings of the listing's code. But in this section, I provide only a brief description of that code's purpose. The description is in Listing 3-3.

LISTING 3-3: **A Guide to Listing 3-2**

```
package com.allmycode.a03_03; // The code in this file belongs to
                              // a package named com.allmycode.a03_03.

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;         // This code uses things that are coded in
import android.view.View;         // other packages -- packages such as
import android.widget.EditText;   // android.widget.EditText, android.os.View,
import android.widget.TextView;   // and others.

public class MainActivity extends AppCompatActivity {
                          // This code defines a class.
                          // The class's name is MainActivity.
                          // This code inherits all the features described in
                          // Android's built-in AppCompatActivity code.
                          // An AppCompatActivity is a kind of Activity.
                          // An Activity is one screenful of stuff that the
                          // user sees. So, this code describes one screenful
                          // for the user.
    EditText editText;
    TextView textView;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
                                                  // When an Android device
                                                  // creates this screenful
                                                  // of stuff...

        super.onCreate(savedInstanceState);       // ... the device recovers
                                                  // relevant info from the
                                                  // last time this screenful
                                                  // appeared, and ...

        setContentView(R.layout.activity_main);   // ... displays the layout
                                                  // that's described in
                                                  // Listing 3-1.
        editText = (EditText) findViewById(R.id.editText);
        textView = (TextView) findViewById(R.id.textView);
    }

    public void onButtonClick(View view) {
        textView.setText(editText.getText());
    }
}
```

If you go to Android Studio's editor and paste the voluminous code of Listing 3-3 in place of Listing 3-2, your app will still run. That's because Listing 3-3 makes use of Java's *comment* feature. When Android runs this code, Android doesn't act on any text that appears on a line after the double slash (`//`). Text such as `// The code in this file belongs to` is for humans to read and appreciate.

CROSS-REFERENCE

You can find out more about Java comments in Chapter 4.

Going Pro

This chapter's "Coding the behavior" section describes a way to make your app respond when the user clicks a button. The story isn't complicated: You type a name in the button's `onClick` field in the Properties pane, and then you use that name in the app's Java code. That's the easy way.

The problem with the easy way is that hard-core Android developers don't do things that way. Using a button's `onClick` property doesn't work well for more complicated apps. So professional Android developers use a technique that comes from the Java desktop programming world.

In most of this book's examples, I use the easy way to respond to button clicks. But if you want to use the more professional way, read on:

1. **Follow the steps in this chapter's "Creating the 'look'" section.**
2. **Make note of the labels on the branches in the component tree, but don't follow any other instructions in the "Coding the behavior" section.**

   In particular, don't bother setting the button's `onClick` property.
3. **Modify the activity's code, as shown in Listing 3-4.**

   The lines that you type are set in boldface in Listing 3-4. Use the labels that you found in Step 2. For example, if your `TextView` component's id is `textView2`, modify a line in Listing 3-4 as follows:

```
textView = (TextView) findViewById(R.id.textView2);
```

4. **Run the app.**

LISTING 3-4: Event Handling (the Traditional Java Way)

```
package com.allyourcode.a03_04;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity
    implements View.OnClickListener {
  EditText editText;
  Button button;
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    editText = (EditText) findViewById(R.id.editText);
    button = (Button) findViewById(R.id.button);
    textView = (TextView) findViewById(R.id.textView);

    button.setOnClickListener(this);
  }

  @Override
  public void onClick(View view) {
    textView.setText(editText.getText());
  }
}
```

Listing 3-4 uses Java's traditional event-handling pattern. The button registers your activity as its click-event listener. In a sense, the `setOnClickListener` line in Listing 3-4 replaces the button's `onClick` property in this chapter's "Coding the behavior" section. Your activity declares itself to be an `OnClickListener` and makes good on this click-listener promise by implementing the `onClick` method.

The technique that I use in Listing 3-4 involves a callback, and callbacks aren't the easiest things to understand. That's why I wait until Chapter 11 to describe what's going on in Listing 3-4. In the meantime, you can start reading about Java's wonderful features in Chapter 4. Enjoy!

2 Writing Your Own Java Programs

IN THIS PART . . .

Writing your first Java programs

Assembling Java's building blocks

Changing course as your program runs

IN THIS CHAPTER

- Understanding how an Android activity works
- Creating classes and methods
- Adding comments to your code
- Watching the flow in an Android activity

Chapter 4
An Ode to Code

Hello, hello, hello, . . . hello!
—THE THREE STOOGES IN *DIZZY DETECTIVES* AND OTHER SHORT FILMS

In Chapter 3, you create a Hello World app for Android. You do this with the help of Android Studio and, in the process, Android Studio composes some Java code for you. In Chapter 3, you examine a bit of this Java code.

But in Chapter 3, you only scratch the code's surface. In this chapter, you begin to examine the code in depth. When you understand how the code works, you can forge ahead to create bigger and better Android apps.

Hello, Android!

When you create a new Android app and you select Empty Activity in the Add an Activity dialog box, Android Studio creates the Java code shown in Listing 4-1.

LISTING 4-1: **A Small Android Java Program**

```
package com.allyourcode.a04_01;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
  }
}
```

REMEMBER

In Android developer lingo, an *activity* is one "screenful" of components. Each Android application can contain many activities. For example, an app's initial activity might be a login screen. After the user logs on, Android covers the entire login activity with another, more interesting activity.

When you run the app that Android Studio creates automatically, you see the words *Hello World!*, as shown in Figure 4-1. Now, I admit that writing and running a Java program just to make *Hello World!* appear on a device's screen is a lot of work, but every endeavor has to start somewhere.

FIGURE 4-1: Running Android Studio's Blank Activity app.

Figure 4-2 provides hints about the meaning of the code in Listing 4-1.

The next several sections present, explain, analyze, dissect, and otherwise demystify the Java code shown in Listing 4-1.

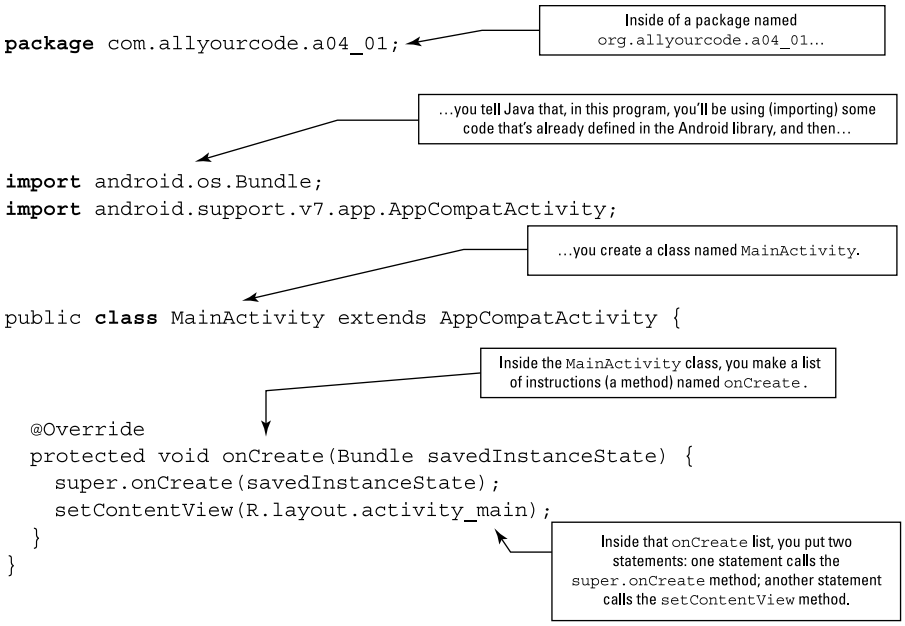


FIGURE 4-2: What you do in Listing 4-1.

The Java Class

Java is an object-oriented programming language. As a Java developer, your primary goal is to describe classes and objects. A *class* is a kind of category, like the category of all customers, the category of all accounts, the category of all geometric shapes, or, less concretely, the category of all `MainActivity` elements, as shown in Listing 4-1. Just as the listing contains the words `class MainActivity`, another piece of code to describe accounts might contain the words `class Account`. The `class Account` code would describe what it means to be (for example) one of several million bank accounts.

CROSS-REFERENCE

The previous paragraph briefly describes what it means to be a *class*. For a more detailed description, see Chapter 9.

The code in Listing 4-1 describes a brand-new Java class. When I create a program like this one, I get to make up a name for my new class. When I created the project, I accepted the default name `MainActivity` in Android Studio's Customize the Activity dialog box. That's why you have the words `class MainActivity` in Listing 4-1. (See Figure 4-3.)

TECHNICAL STUFF

The code inside the larger box in Figure 4-3 is, to be painfully correct, the *declaration* of a class. (This code is a *class declaration*.) I'm being slightly imprecise when I write in the figure that this code *is* a class. In reality, this code *describes* a class.

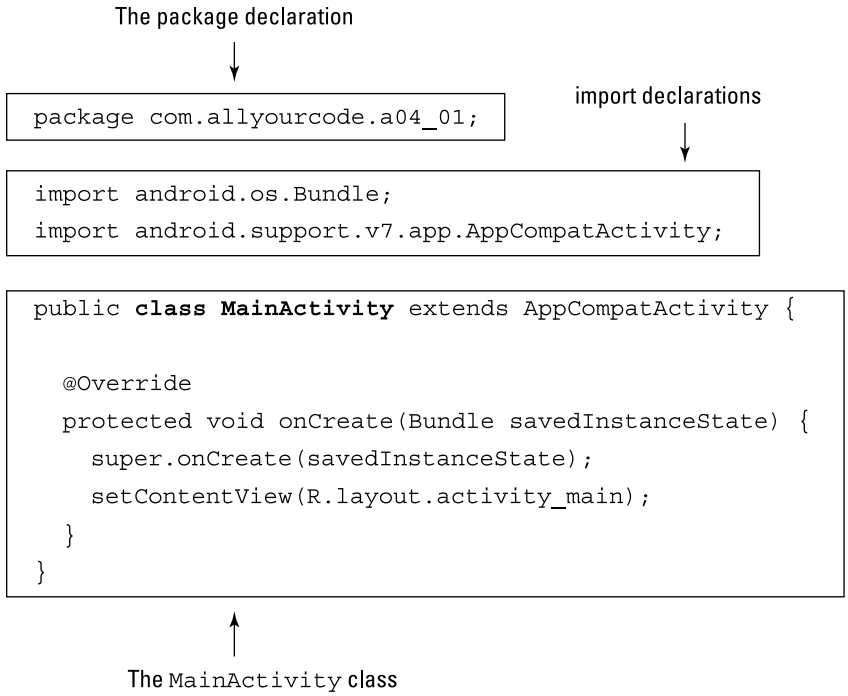


FIGURE 4-3: A simple Android Java program is a class.

The declaration of a class has two parts: The first part is the *header*, and the rest — the part surrounded by curly braces, or {} —is the *class body*, as shown in Figure 4-4.

The word `class` is a Java *keyword*. No matter who writes a Java program, `class` is always used in the same way. On the other hand, `MainActivity` in Listing 4-1 is an *identifier* — a name for something (that is, a name that identifies something). The word `MainActivity`, which Android Studio made up while I was writing a new project, is the name of a particular class — the class that I'm creating by writing this program. When I created the new project, Android Studio gave me the opportunity to type a new name in place of the name `MainActivity`. In place of `MainActivity`, I could have typed `StartHere` or `EatMoreCheese`. It wouldn't have mattered as long as Android Studio had used the new name consistently throughout the project. (The class's name, whatever it is, appears in several places in the new Android project's code.)

WARNING

In the previous paragraph, I raise the possibility of giving the class in Listing 4-1 an unusual name. I do this to call attention to the difference between Java keywords (such as the word `class`), and identifiers (such as the word `MainActivity`). I *don't* mean to suggest that creating strange identifiers (such as `EatMoreCheese`) is — in any way, shape, or form — a good idea. Strange identifiers confuse other programmers. Even slightly nonstandard identifiers, such as `StartHere` in place

of the more commonly used `MainActivity`, make other developers' lives more difficult. So, when you create your own app, use names that other developers will easily recognize. If there's a default name for a particular item in a program, use that default name.

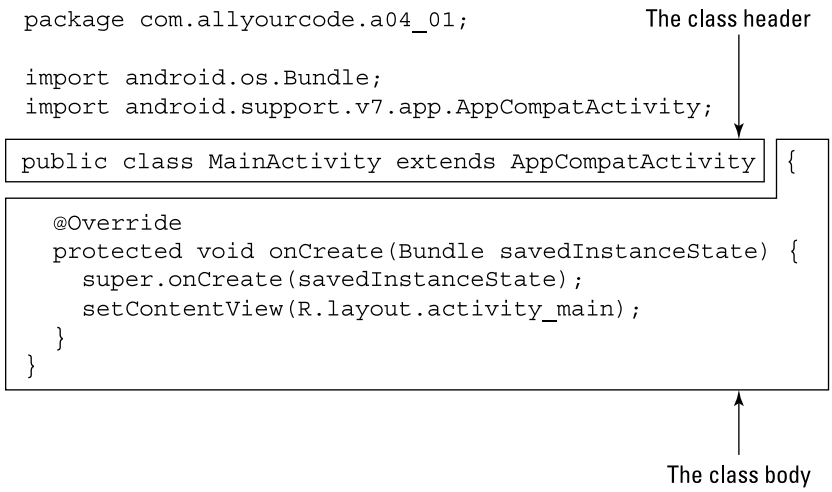


FIGURE 4-4: A class declaration's header and body.

In Listing 4-1, the words `package`, `import`, `public`, `extends`, `protected`, and `super` are also Java keywords. No matter who writes a Java program, `package` and `class` and the other keywords always have the same meaning. For more jabbering about keywords and identifiers, see the nearby sidebar, "Words, words, words."

CROSS-REFERENCE

To find out what the words `public`, `static`, and `void` mean, see Chapters 7 and 9.

WARNING

tHE jAVA PROGRAMMING LANGUAGE IS cASe-sEnsITiVE. FOR EXAMPLE, iF YOU CHANGE A lowercase LETTER IN A WORD TO UPPERCASE OR CHANGE AN UPPERCASE WORD TO lowercase, YOU CHANGE THE WORD'S MEANING AND CAN EVEN MAKE THE WORD MEANINGLESS. iN THE FIRST LINE OF lISTING 4-1, FOR EXAMPLE, IF YOU TRIED TO REPLACE `class` WITH `Class`, THE WHOLE PROGRAM WOULD STOP WORKING.

The same holds true, to some extent, for the name of a file containing a particular class. For example, the name of the class in Listing 4-1 is `MainActivity`, with two uppercase letters and ten lowercase letters. So the code in the listing belongs in a file named `MainActivity.java`, with exactly two uppercase letters and ten lowercase letters in front of `.java`.

WORDS, WORDS, WORDS

The Java language uses two kinds of words: keywords and identifiers. You can tell which words are keywords, because Java has only 50 of them. Here's the complete list:

abstract	continue	for	new	switch
assert	default	goto	package	synchronized
boolean	do	if	private	this
break	double	implements	protected	throw
byte	else	import	public	throws
case	enum	instanceof	return	transient
catch	extends	int	short	try
char	final	interface	static	void
class	finally	long	strictfp	volatile
const	float	native	super	while

As a rule, a *keyword* is a word whose meaning never changes (from one Java program to another). For example, in English, you can't change the meaning of the word *if.* It doesn't make sense to say, "I think that I shall never *if* / A poem lovely as a riff." The same concept holds true in a Java program: You can type `if (x > 5)` to mean "If x is greater than 5," but when you type `if (x > if)`, the computer complains that the code doesn't make sense.

In addition to the keywords, Java has other words that play special roles in the language. You can't make up your own meanings for the words `false`, `null`, and `true`, but, for technical reasons, these words aren't considered keywords. And the words `module`, `requires`, `exports`, `dynamic`, `to`, `uses`, `provides`, and `with` are *restricted keywords*. You can make up meanings for them in some parts of your Java code, but not in other parts.

In Listing 4-1, the words `class`, `package`, `import`, `public`, `extends`, `protected`, and `super` are keywords. Almost every other word in that listing is an *identifier,* which is generally a name for something. The identifiers in the listing include `MainActivity`, `AppCompatActivity`, `onCreate`, and a bunch of other words.

In programming lingo, words such as *Wednesday*, *Barry,* and *university* in the following sentence are identifiers, and the other words (*If*, *it's*, *is*, *at,* and *the*) are keywords:

If it's Wednesday, Barry is at the university.

As in English and most other spoken languages, the names of items are reusable. For example, a recent web search turns up four people in the United States named Barry Burd (with the same uncommon spelling). You can even reuse well-known names. (A fellow student at Temple University had the name *John Wayne*, and in the 1980s two different textbooks were titled *Pascalgorithms*.) The Android API has a prewritten class named `MainActivity`, but that doesn't stop you from defining another meaning for the name `MainActivity`.

Of course, having duplicate names can lead to trouble, so intentionally reusing a well-known name is generally a bad idea. (If you create your own thing named `MainActivity`, you'll find it difficult to refer to the prewritten `MainActivity` class in Android. As for my fellow Temple University student, everyone laughed when the teacher called roll.)

The names of classes

I'm known by several different names. My first name, used for informal conversation, is Barry. A longer name, used on this book's cover, is Barry Burd. The legal name that I use on tax forms is Barry A. Burd, and my passport (the most official document I own) sports the name Barry Abram Burd.

In the same way, elements in a Java program have several different names. For example, the class that's created in Listing 4-1 has the name `MainActivity`. This is the class's *simple name* because, well, it's simple and it's a name.

Listing 4-1 begins with the line `package org.allyourcode.a04_01`. The first line is a *package declaration*. Because of this declaration, the newly created `MainActivity` is inside a package named `org.allyourcode.a04_01`. So `org.allyourcode.a04_01.MainActivity` is the class's *fully qualified name*.

If you're sitting with me in my living room, you probably call me Barry. But if you've never met me and you're looking for me in a crowd of a thousand people, you probably call out the name Barry Burd. In the same way, the choice between a class's simple name and its fully qualified name depends on the context.

In Listing 4-1, the lines

```
import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
```

are two import declarations. An *import declaration* uses a class's fully qualified name. In Android's API, the `Bundle` class is in the `android.os` package, and the `AppCompatActivity` class is in the `android.support.v7.app` package.

Can you do without these import declarations? Yes, you can. Here's how:

```
package com.allyourcode.a04_01_B;

public class MainActivity extends android.support.v7.app.AppCompatActivity {

  @Override
  protected void onCreate(android.os.Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
  }
}
```

This new code is in the `com.allyourcode.a04_01_B` package, but the `Bundle` and `AppCompatActivity` classes aren't in the `com.allyourcode.a04_01_B` package. In a way, the `Bundle` and `AppCompatActivity` classes are foreign to this `com.allyourcode.a04_01_B` package code. This revised code doesn't start with the import declarations. So, to compensate, the code must use `Bundle` and `AppCompatActivity` class's fully qualified names.

If your Java code file doesn't have an `import android.support.v7.app.AppCompatActivity` declaration, and you refer to the `AppCompatActivity` class several times in the file, you must use the fully qualified name `android.support.v7.app.AppCompatActivity` each and every time.

An import declaration, such as

```
import android.support.v7.app.AppCompatActivity;
```

announces that you intend to use the short name `AppCompatActivity` later in the file's code. The declaration clarifies what you mean by the short name `AppCompatActivity`. (You mean `android.support.v7.app.AppCompatActivity`.)


TECHNICAL STUFF

In an import declaration, an asterisk (*) means "all the classes in that package." For example, the `android.support.v7.app` package contains about 20 different classes. You can import all these classes with a single import declaration. Simply write `import android.support.v7.app.*;` near the top of your Java file.


TIP

The details of this import business can be nasty, but (fortunately) Android Studio has features to help you write import declarations. Chapter 3 has the details.

Why Java Methods Are Like Meals at a Restaurant

I'm a fly on the wall at Mom's Restaurant in a small town along Interstate 80. I see everything that goes on at Mom's: Mom toils year after year, fighting against the influx of high-volume, low-quality restaurant chains while the old-timers remain faithful to Mom's menu.

I see you walking into Mom's. Look — you're handing Mom a job application. You're probably a decent cook. If you get the job, you'll get carefully typed copies of every one of the restaurant's recipes. Here's one:

> **Scrambled eggs (serves 2)**
>
> 5 large eggs, beaten
>
> ¼ cup 2% milk
>
> 1 cup shredded mozzarella
>
> Salt and pepper to taste
>
> A pinch of garlic powder
>
> In a medium bowl, combine eggs and milk. Whisk until the mixture is smooth, and pour into preheated frying pan. Cook on medium heat, stirring the mixture frequently with a spatula. Cook for 2 to 3 minutes or until eggs are about halfway cooked. Add salt, pepper, and garlic powder. Add cheese a little at a time, and continue stirring. Cook for another 2 to 3 minutes. Serve.

Before your first day at work, Mom sends you home to study her recipes. But she sternly warns you not to practice cooking. "Save all your energy for your first day," she says.

On your first day, you don an apron. Mom rotates the sign on the front door so that the word *Open* faces the street. You sit quietly by the stove, drumming your fingers. Mom sits by the cash register, trying to look nonchalant. (After 25 years in business, she still worries that the morning regulars won't show up.)

At last! Here comes Joe the barber. Joe orders the breakfast special with two scrambled eggs.

What does Mom's Restaurant have to do with Java?

When you drill down inside the code of a Java class, you find these two important elements:

- **Method declaration:** The "recipe"

  "If anyone ever asks, here's how to make scrambled eggs."

- **Method call:** The "customer's order"

  Joe says, "I'll have the breakfast special with two scrambled eggs." It's time for you to follow the recipe.


TECHNICAL STUFF

Almost every programming language has elements akin to Java's methods. If you've worked with other languages, you may recall terms like *subprogram*, *procedure*, *function*, *subroutine*, *subprocedure*, and `PERFORM` *statement*. Whatever you call a *method* in your favorite programming language, it's a bunch of instructions, collected in one place and waiting to be executed.

A *method declaration* is a plan describing the steps that Java will take if and when the method is called into action. A *method call* is one of those calls to action. As a Java developer, you write both method declarations and method calls. Figure 4-5 shows you a method declaration and some method calls.

Figure 4-5 doesn't contain a complete Java program, so you can't run the figure's code in Android Studio. But the figure illustrates some facts about method declarations and method calls.


TECHNICAL STUFF

If I'm being lazy, I refer to the code in the upper box in Figure 4-5 as a *method*. If I'm not being lazy, I refer to it as a *method declaration*.

Method declaration

Like one of Mom's recipes, a method declaration is a list of instructions: "Do this, then do that, and then do this other thing." And, like each of Mom's recipes, each method has a name. In Figure 4-5, the method declaration's name is `shout`. You won't find the `shout` method in any of Android's API documentation. I made up the `shout` method especially for this chapter.


REMEMBER

Another term for an instruction in a Java program is a *Java statement*, or simply a *statement*. In Figure 4-5, the `shout` method's declaration contains two statements. The first statement tells Java to append a message to the text in a particular component (whatever component the name `textView` refers to). The second statement tells Java to append three asterisks and a blank space to the text in that component.

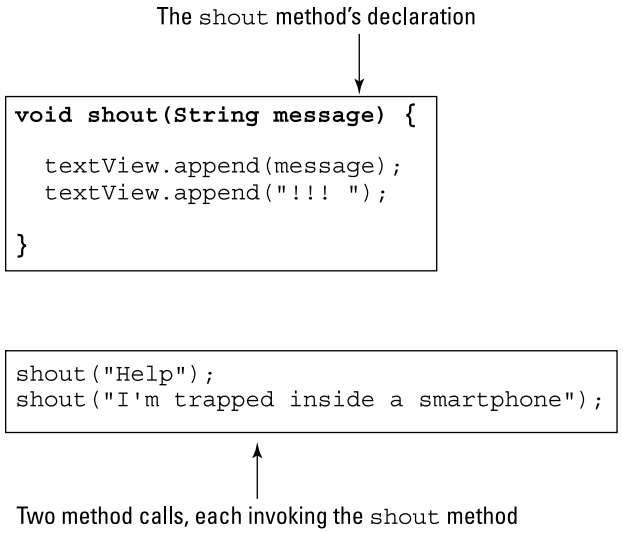


FIGURE 4-5: Declaring and calling the shout method.

A method declaration has two parts: the *method header* and the *method body*, as shown in Figure 4-6.

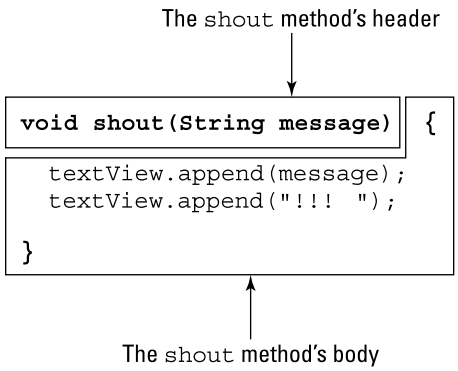


FIGURE 4-6: The shout method's header and body.

The method's header has the name of the method and a parameter list. (See Figure 4-7.)

REMEMBER

Package declarations, import declarations, and method declarations are all called *declarations*, but they don't have much in common. A package declaration is typically one line of code — a line at the very beginning of a program, starting with the word `package`. After one package declaration, a file may contain several import declarations, each consuming one line of code. On the other hand, a typical method declaration is a bunch of lines of code, and those lines don't usually appear at the beginning of a program.

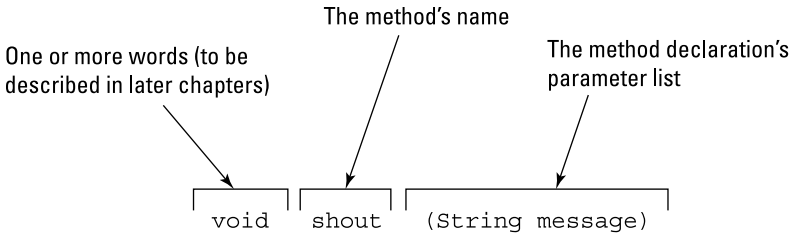


FIGURE 4-7: Anatomy of a method header.

Method call

A method *call* includes the name of the method being called followed by a parameter list. (See Figure 4-8.)

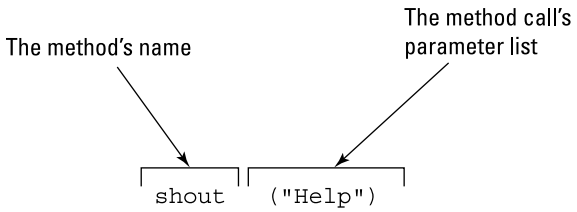


FIGURE 4-8: Anatomy of a method call.

A method call is like a customer order at Mom's Restaurant. The call in Figure 4-8 says, "It's time to execute whatever instructions are inside the `shout` method. And in those instructions, use the string `"Help"`."

Method parameters

A method's declaration has a parameter list, and a method call also has a parameter list. What a coincidence! (Refer to Figures 4-6 and 4-7.)

Of course, it's no coincidence. When Java encounters a method call, Java passes the value in the call's parameter list to the declaration's parameter list. The declaration may use that value in its body's instructions. See Figure 4-9.

A method call parameter conveys specific information — information that may be different from one method call to another. For example, the code shown earlier, in Figure 4-5, contains two method calls. One call conveys the information `"Help"`. The other call conveys different information — namely, `"I'm trapped inside a smartphone"`.

CROSS-REFERENCE

A method call's parameter list doesn't look exactly like a method declaration's parameter list. You can see this by looking at Figure 4-9. The call's parameter list contains one thing — namely, the string `"Help"`. But the declaration's parameter list contains two things: the word `String` and the word `message`. The stuff in the

declaration's parameter list says, "When you call this method, send a `String` of characters. I'll refer to that `String` by the name `message`." The word `String` is the name of a Java *type*. To read more about Java types, see Chapter 5.

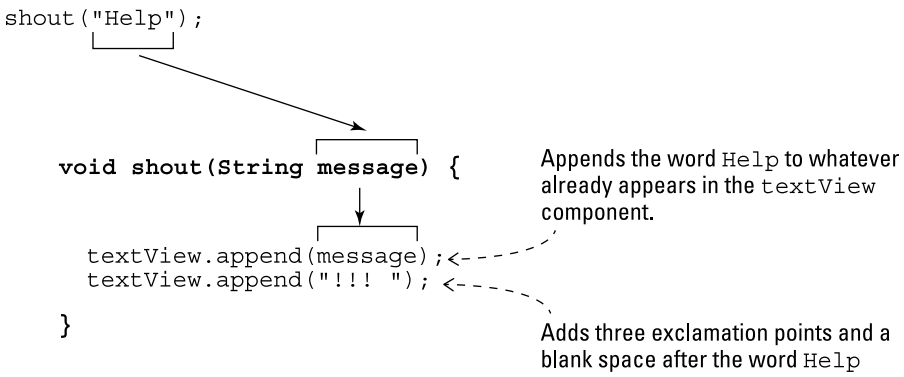


FIGURE 4-9: Passing a value from a call to a declaration.

The chicken or the egg

Which comes first, the method call or the method declaration? Look again at Figure 4-9. The figure contains a call to the `shout` method. The call makes Android execute the statements inside the `shout` method's body.

But the statements inside the `shout` method's body are themselves method calls. They're calls to a method named `append`. In the `shout` method's body, the first `append` call adds the word *Help* to the `textView` component's text. The second `append` call adds three exclamation points and a blank space to the `textView` component's text.

You don't see the `append` method's declaration, because the `append` method is part of Android's built-in API. As an Android developer, you don't deal directly with the method's declaration. All you do is call the method when you need it.

How many parameters?

In Java, double quotation marks denote a string of characters. So the call

```
shout("I'm trapped inside a smartphone")
```

contains one parameter. That single parameter is a string of characters.

Some functions have one parameter. Other functions have more than one parameter. Still other functions have no parameters. Listing 4-2 has an example.

LISTING 4-2: Overloading a Method

```
shout("Help");
shout("I'm trapped inside a smartphone");

shout("Put down the phone and start living life", "*");

shout();


void shout(String message) {
  textView.append(message);
  textView.append("!!! ");
}

void shout(String message, String emphasis) {
  textView.append(message);
  textView.append(emphasis);
  textView.append(emphasis);
  textView.append(emphasis);
}

void shout() {
  textView.append("!!!!!!!");
}
```

Like Figure 4-5, the code in Listing 4-2 doesn't contain a complete Java program, so you can't run the figure's code in Android Studio. But Listing 4-2 illustrates the notion of *method overloading*. When you overload a method, you provide several declarations for the method. Each declaration has its own, unique parameter list.

Listing 4-2 contains three `shout` method declarations — one with a single parameter, another with two parameters, and a third with no parameters.

Listing 4-2 also has four calls to the `shout` method. For each call, Java decides which declaration to use by matching up the call's parameter list with a declaration's parameter list. Here's what happens when Java executes the `shout` method calls in Listing 4-2:

- **The first call, `shout("Help")`, has only one parameter, so Java uses the `shout(String message)` declaration.**

  Java appends *Help!!!* to the text in the `textView` component.

- **The second call, `shout("I'm trapped inside a smartphone")`, also has only one parameter. So, again, Java uses the `shout(String message)` declaration.**

Java adds *I'm trapped inside a smartphone!!!* to the `textView` component.

- **The third call, `shout("Put down the phone and start living life", "*")`, has two parameters. A comma separates the parameters from one another. Java uses the `shout(String message, String emphasis)` declaration because that declaration also has two parameters.**

  Java adds *Put down the phone and start living life**** to the `textView` component.

- **The fourth call, `shout()`, has no parameters. The call has a pair of parentheses, but the pair is empty. Java uses the declaration at the end of Listing 4-2, the `shout()` declaration, because that declaration also has no parameters.**

  Java adds *!!!!!!!* to the `textView` component.

CROSS-REFERENCE

In this section's code, you may wonder why the name `textView` isn't one of the parameters that I pass to the `shout` method. The short answer is, I want the name `textView` to refer to the same component anywhere in my `MainActivity` class's code — not exclusively inside the `shout` method's declaration. So I declare `TextView textView;` outside of any method. For more information about this topic, you can read about *fields* in Chapter 9.

Method declarations and method calls in an Android program

The figures and listing in the previous sections contain `shout` method declarations and `shout` method calls, but they don't contain a complete Java program. Listing 4-3 contains a complete program using these `shout` methods. The program's output is shown in Figure 4-10.

LISTING 4-3: **All the Code That's Fit to Print**

```
package com.allyourcode.a04_03;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
```

(continued)

LISTING 4-3: *(continued)*

```
    textView = (TextView) findViewById(R.id.textView);
    textView.setText("");

    shout("Help");
    shout("I'm trapped inside a smartphone");

    shout();
  }

  void shout(String message) {
    textView.append(message);
    textView.append("!!! ");
  }

  void shout() {
    textView.append("!!!!!!!");
  }
}
```

ON THE WEB

The code in Listing 4-3 belongs in an Android project — a project containing many other files. You can download the entire project from this book's website: `www.allmycode.com/Java4Android`.

FIGURE 4-10: Running the app in Listing 4-3.

The code in Listing 4-3 describes an activity — one screenful of stuff on the Android device's screen. When an activity first appears, Android calls the activity's `onCreate` method. That's why Listing 4-3 declares an `onCreate` method.

REMEMBER

Android's internal code contains a call to an activity's `onCreate` method. You never write a call to the `onCreate` method. In fact, you probably never even see a call to the `onCreate` method.

Here's what happens when Android calls the `onCreate` method in Listing 4-3:

- **If a previous run of this activity was interrupted, the call to `super.onCreate(savedInstanceState)` sets the activity back the way it was immediately before the interruption.**

  Interruptions can occur when the user takes a phone call, when the user switches to a different activity, or even when the user rotates the phone!

  You might wonder why a method named `onCreate` contains an instruction to execute the instructions inside a method named `super.onCreate`. The `onCreate` and `super.onCreate` methods are related to one another, but they're two different methods. For details about the use of the keyword `super`, see Chapter 10.


CROSS-REFERENCE

- **The call to `setContentView` assigns a layout to the activity's screen.**

  To read all about layouts and how layouts are created, refer to Chapter 3.

- **The call to `findViewById` associates the name `textView` with a particular component on the screen.**

  To read more about `findViewById`, see Chapter 3.

- **The call `textView.setText("")` clears the `textView` component of any text that may already appear in it.**

  Two quotation marks with nothing between them is the empty string. This statement puts the empty string in the `textView` component.

- **The `shout("Help")` call makes Java execute the instructions in the first of the two `shout` declarations.**

  This time, the message that's added to the `textView` component is *Help*. In addition, the `shout` method's body adds three exclamation points and a blank space to the stuff in the `textView` component.

- **The `shout("I'm trapped inside a smartphone")` call makes Java execute the instructions in the first of the two `shout` declarations again.**

  This time, the message that's added to the `textView` component is *I'm trapped inside a smartphone*.

- **The `shout()` call makes Java execute the instruction in the second of the two `shout` declarations.**

  This time, there's no particular message — only a bunch of exclamation points.

All in all, the code in Listing 4-3 contains ten (count 'em, ten) method calls. The three `shout` method calls invoke code that's declared right inside Listing 4-3. But the calls to `super.onCreate`, `setContentView`, `findViewById`, `setText`, and `append` invoke methods that aren't declared in Listing 4-3. These methods are declared in Android's standard API.

REMEMBER

Listing 4-3 can be deceiving. In Listing 4-3, every statement contains a method call. But in most Java programs, many statements don't contain method calls. The remaining chapters have many such statements.

In a fit of pedagogical zeal, I started making a diagram to illustrate the flow of control from statement to statement in Listing 4-3. When I finished making the diagram, I realized that the diagram may be quite intimidating. Some pictures are worth a thousand words, but this picture may be worth a thousand screams. Anyway, I leave it up to you. If Figure 4-11 helps you understand what happens in Listing 4-3, spend some time staring at the figure. But if Figure 4-11 makes you want to give up Android app development and learn modern dance instead, ignore Figure 4-11. You can understand Listing 4-3 without bothering about that figure.

REMEMBER

Android programs aren't simple. You're in Chapter 4 and, even if you've read every word up to this point, you haven't yet read enough to understand all the code in Listing 4-3. That's okay. The next several chapters fill in the gaps.

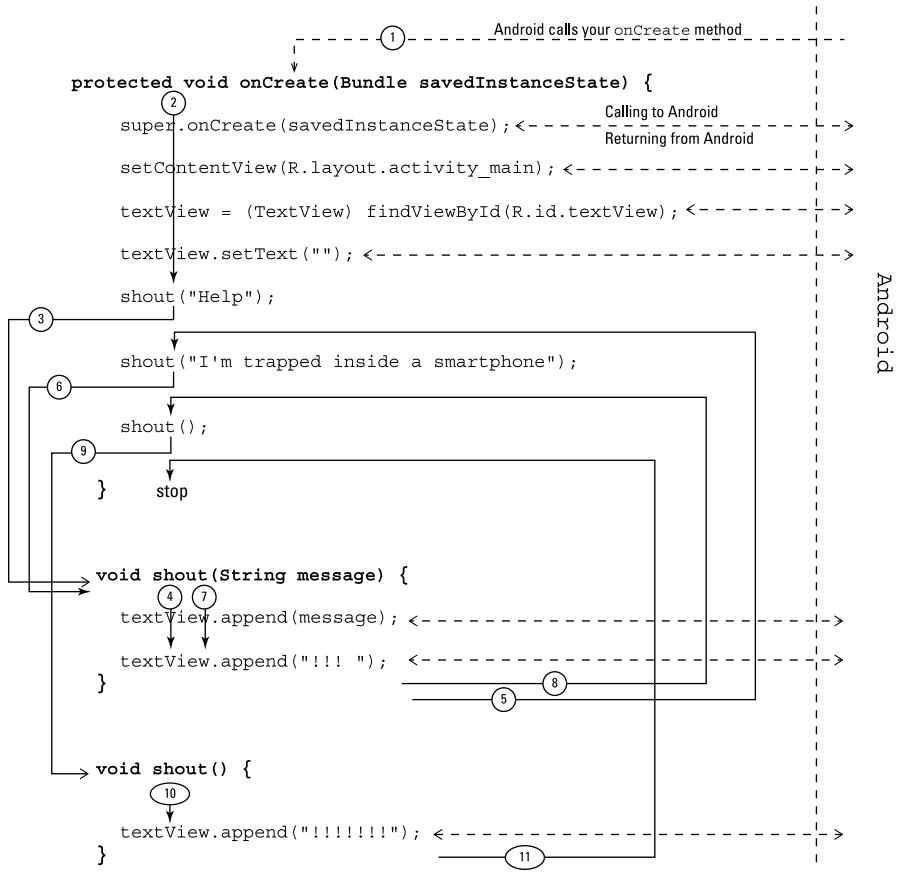


FIGURE 4-11: What happens, and when.

A CHICKEN IN EVERY DOT

If you look back at Listing 4-3, you see statements such as

```
textView.setText("");
```

and

```
textView.append("!!! ");
```

In these statements, what's the dot all about?

Java is an object-oriented programming language. When you write Java code, you deal with things called *classes* and *objects*. I don't start describing classes and objects in detail until Chapter 9, so at this point I have to blur the terminology. I refer to classes and objects as *object-oriented things*.

In Java, every method belongs to an object-oriented thing.

That's important, so I'll type it again:

In Java, every method belongs to an object-oriented thing.

To call a method, you write

```
the_thing_to_which_the_method_belongs . simple_name_of_the_method
```

For example, in Android, each `TextView` component has hundreds of methods. One of them is named `setText`, and another is named `append`. So, in Listing 4-3, the `textView` variable has methods named `setText` and `append`. That's why you use a dot to call the `textView.setText` and `textView.append` methods.

Imagine that your app's screen has two `TextView` components:

```
textView = (TextView) findViewById(R.id.textView);
textView2 = (TextView) findViewById(R.id.textView2);
```

To put *Boo!* in the first of these components, you write

```
textView.setText("Boo!");
```

To put the words *Buy another copy of this book* in the second of these components, you write

```
textView2.setText("Buy another copy of this book");
```

(continued)

(continued)

The first component, `textView`, has a `setText` method, and the second component, `textView2`, has its own `setText` method.

What about the `shout` method in Listing 4-3? Does the `shout` method belong to anything? It does. The enclosing code (the rest of Listing 4-3) defines an object-oriented thing. Because the `shout` method's declaration is in Listing 4-3, the `shout` method belongs to that object-oriented thing.

So now you want to write

```
the_thing_defined_in_all_of_Listing_4-3 . shout
```

But to do that, you have to know the name of the thing defined in all of Listing 4-3. What's the name of the object-oriented thing that's defined in Listing 4-3? You might think that its name is `MainActivity`, but the story is a bit more complicated than that. In Chapter 9, you settle the issue by reading about classes and objects. But in this chapter, you have to gloss over the whole concept.

Here's the quick-and-dirty (and only partly accurate) story: Inside of Listing 4-3, the thing that Listing 4-3 defines goes by the name `this`. And when there's no confusion, you can omit the word `this`.

You can revise these three statements in Listing 4-3:

```
this.shout("Help");
this.shout("I'm trapped inside a smartphone");

this.shout();
```

Alternatively, you can do as I did in Listing 4-3 and omit the word `this`.

Punctuating Your Code

In English, punctuation is vital. If you don't believe me, ask this book's copy editor, who suffered through my rampant abuse of commas and semicolons in the preparation of this manuscript. My apologies to her — I'll try harder in the next edition.

Anyway, punctuation is also important in a Java program. This list lays out a few of Java's punctuation rules:

» **Enclose a class body in a pair of curly braces.**

For example, in Listing 4-3, the `MainActivity` class's body is enclosed in curly braces.

```
public class MainActivity extends AppCompatActivity {
  TextView textView;

  ...

  void shout() {
    textView.append("!!!!!!!");
  }
}
```

REMEMBER

The placement of a curly brace (at the end of a line, at the start of a line, or on a line of its own) is unimportant. The only important aspect of placement is consistency. The consistent placement of curly braces throughout the code makes the code easier for you to understand. And when you understand your own code, you *write* far better code. When you compose a program, Android Studio can automatically rearrange the code so that the placement of curly braces (and other program elements) is consistent. To make it happen, click the mouse anywhere inside the editor and choose Code ➪ Reformat Code.

» **Enclose a method body in a pair of curly braces.**

In Listing 4-3, the `onCreate` method's body is enclosed in curly braces, and the bodies of the two `shout` methods are enclosed in curly braces.

```
public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    ...
  }

  void shout(String message) {
    ...
  }

  void shout() {
    ...
  }
}
```

» **A Java statement ends with a semicolon.**

Notice the semicolons in this excerpt from Listing 4-3:

```
super.onCreate(savedInstanceState);
setContentView(R.layout.activity_main);

textView = (TextView) findViewById(R.id.textView);
textView.setText("");
```

» **A package declaration ends with a semicolon. An import declaration also ends with a semicolon.**

In Listing 4-3 each of the first four lines ends with a semicolon.

```
package com.allyourcode.methoddemo;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;
```

» **In spite of the previous two rules, don't place a semicolon immediately after a closing curly brace (}).**

In Listing 4-3, there's no semicolon after any of the close curly braces.

» **Use parentheses to enclose a method's parameters, and use commas to separate the parameters.**

Listing 4-2 has some examples:

```
shout("Help");
shout("I'm trapped inside a smartphone");

shout("Put down the phone and start living life", "*");

shout();
```

» **Use double quotation marks ("") to denote strings of characters.**

The previous bullet contains four strings — namely, `"Help"`, `"I'm trapped inside a smartphone"`, `"Put down the phone and start living life"`, and, finally, `"*"`.

» **Use dots to separate the parts of a qualified name.**

The fully qualified name of the class in Listing 4-3 is `com.allyourcode.a04_03.MainActivity`.

The `setText` and `append` methods belong to a component named `textView`. So, in Listing 4-3, you write `textView.setText` and `textView.append`.

For details, refer to the earlier section "The names of classes" and the earlier sidebar named "A chicken in every dot."

» **Use dots within a package name.**

The most blatant consequence of a package name's dots is to determine a file's location on the hard drive. For example, because of its package name, the code in Listing 4-3 must be in a folder named `a04_03`, which must be in a folder named `allyourcode`, which in turn must be in a folder named `com`, as shown in Figure 4-12. Fortunately, Android Studio creates all these folders for you and puts the code in the right place. You don't have to worry about a thing.

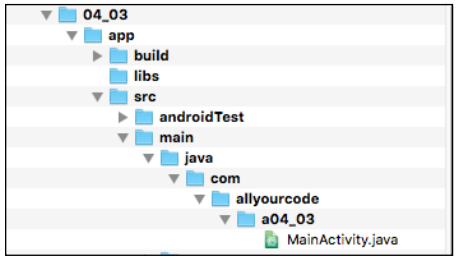


FIGURE 4-12: The folders containing a Java program.

Comments are your friends

Listing 4-4 has an enhanced version of the code in Listing 4-1. In addition to all the keywords, identifiers, and punctuation, Listing 4-4 has text that's meant for human beings (like you and me) to read.

LISTING 4-4: **Three Kinds of Comments**

```
/*
 * Listing 4-4 in
 *   "Java Programming for Android Developers For Dummies, 2nd Edition"
 *
 * Copyright 2016 Wiley Publishing, Inc.
 * All rights reserved.
 */
```

(continued)

LISTING 4-4: ***(continued)***

```
package com.allyourcode.a04_04;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

/**
 * MainActivity displays Hello World! on the screen.
 *
 * @author  Barry Burd
 * @version 1.0 07/07/16
 */
public class MainActivity extends AppCompatActivity {

  /**
   * Called when Android creates this activity.
   *
   * @param savedInstanceState
   *
   */
  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);       // Restores any previous state
    setContentView(R.layout.activity_main);   // Makes activity_main.xml be
  }                                           //   the layout file
}
```

A *comment* is a special section of text inside a program whose purpose is to help people understand the program. A comment is part of a good program's documentation.

The Java programming language has three kinds of comments:

- **Block comments:** The first seven lines in Listing 4-4 form one *block* comment. The comment begins with `/*` and ends with `*/`. Everything between the opening `/*` and the closing `*/` is for human eyes only. No information about `"Java Programming for Android Developers For Dummies"` or `Wiley Publishing, Inc.` is translated by the compiler.

  To read about compilers, see Chapter 1.

CROSS-REFERENCE

Lines 2 through 6 in Listing 4-4 have extra asterisks (*). I call them *extra* because these asterisks aren't required when you create a comment. They only make the comment look pretty. I include them in the listing because, for some reason that I don't entirely understand, most Java programmers insist on adding these extra asterisks.

- **Line comments:** The text `// Restores any previous state` in Listing 4-4 is a *line* comment — it starts with two slashes and goes to the end of a line of type. Once again, the compiler doesn't translate the text inside a line comment.

  In Listing 4-4, the text `// Makes activity_main.xml be` is a second line comment, and the text `// the layout file` is a third.

- **Javadoc comments:** A *Javadoc* comment begins with a slash and two asterisks (/**). Listing 4-4 has two Javadoc comments — one with the text `MainActivity displays Hello ...` and another with the text `Called when Android creates...`.

  A *Javadoc* comment is a special kind of block comment: It's meant to be read by people who never even look at the Java code.

  Wait — that doesn't make sense. How can you see the Javadoc comments in Listing 4-4 if you never look at the listing?

  Well, with a few points and clicks, you can find all the Javadoc comments in Listing 4-4 and turn them into a nice-looking web page, as shown in Figure 4-13.

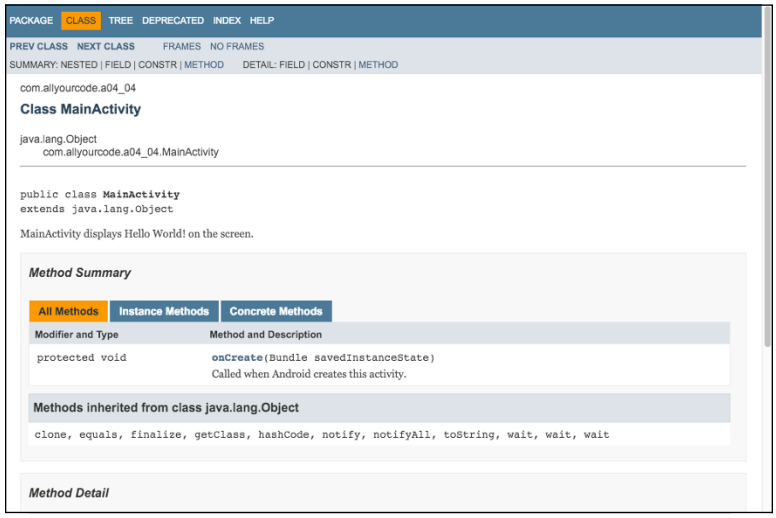


FIGURE 4-13: Javadoc comments, generated from the code in Listing 4-4.

To make documentation pages for your own code, follow these steps:

1. **Put Javadoc comments in your code.**
2. **From the main menu in Android Studio, choose Tools ➪ Generate JavaDoc.**

   As a result, a dialog box with an awkward title appears. The title is Specify Generate JavaDoc Scope.
3. **In the Specify Generate JavaDoc Scope dialog box, browse to select an Output directory.**

   The computer puts the newly created documentation pages in that directory.
4. **Click OK.**

   As a result, the computer creates the documentation pages.

If you visit the Destination directory and double-click the new `index.html` file's icon, you see your beautiful (and informative) documentation pages.


REMEMBER

You can find the documentation pages for Android's built-in API classes by visiting `https://developer.android.com/reference/packages.html`. Android's API contains thousands of classes, so don't memorize the names of the classes and their methods. Instead, you simply visit these online documentation pages.

What's Barry's excuse?

For years, I've been telling my students to put all kinds of comments in their code, and for years, I've been creating sample code (such as the code in Listing 4-3) containing few comments. Why?

Three little words: "Know your audience." When you write complicated, real-life code, your audience consists of other programmers, information technology managers, and people who need help deciphering what you've done. But when I write simple samples of code for this book, my audience is you — the novice Java programmer. Rather than read my comments, your best strategy is to stare at my Java statements — the statements that Java's compiler deciphers. That's why I put so few comments in this book's listings.

Besides, I'm a little lazy.

All About Android Activities

If you look in the app/manifests branch in Android Studio's Project tool window, you see an AndroidManifest.xml file. The file isn't written in Java; it's written in XML. I don't write much about XML files in this book. Still, I have to write something about an app's manifest file.

Listing 4-5 contains some code from an AndroidManifest.xml file to accompany Listing 4-1. With minor tweaks, this same code could accompany almost any example in this book.

LISTING 4-5: **The activity Element in an AndroidManifest.xml File**

```
<activity android:name=".MainActivity">
    <intent-filter>
        <action android:name="android.intent.action.MAIN"/>

        <category android:name="android.intent.category.LAUNCHER"/>
    </intent-filter>
</activity>
```

CROSS-REFERENCE

For a quick introduction to the niceties of XML code, refer to Chapter 3.

Here's what the code in Listing 4-5 "says" to your Android device:

- **The code's action element indicates that the activity that's set forth in Listing 4-1 (the MainActivity class) is MAIN.**

  Being MAIN means that the program in Listing 4-1 is the starting point of an app's execution. When a user launches the app described in Listing 4-1, the Android device reaches inside the Listing 4-1 code and executes the code's onCreate method. In addition, the device executes several other methods that don't appear in Listing 4-1.

- **The code's category element adds an icon to the device's Application Launcher screen.**

  On most Android devices, the user sees the Home screen. Then, by touching one element or another on the Home screen, the user gets to see the Launcher screen, which contains several apps' icons. By scrolling this screen, the user can find an appropriate app's icon. When the user taps the icon, the app starts running.

  In Listing 4-5, the category element's LAUNCHER value makes an icon for running the MainActivity class available on the device's Launcher screen.

So there you have it. With the proper secret sauce (namely, the `action` and `category` elements in the `AndroidManifest.xml` file), an Android activity's `onCreate` method becomes an app's starting point of execution.

Extending a class

In Listing 4-1, and in other listings throughout this book, the words `extends` and `@Override` tell an important story — a story that applies to all Java programs, not only to Android apps.

Most of this book's examples contain the lines

```
import android.support.v7.app.AppCompatActivity;


public class MainActivity extends AppCompatActivity {
```

When you *extend* the `android.support.v7.app.AppCompatActivity` class, you create a new kind of Android activity. In Listing 4-1, and in so many other listings, the words `extends AppCompatActivity` tells Java that a `MainActivity` is, in fact, an example of an Android `AppCompatActivity`. That's good because an `AppCompatActivity` is a certain kind of Android activity. The folks at Google have already written thousands of lines of Java code to describe what an Android `AppCompatActivity` can do. Being an example of an `AppCompatActivity` in Android means that you can take advantage of all the `AppCompatActivity` class's prewritten code.


REMEMBER

When you extend an existing Java class (such as the `AppCompatActivity` class), you create a new class with the existing class's functionality. For details of this important concept, see Chapter 10.

Overriding methods

In Listing 4-1, and in many other listings, a `MainActivity` is a kind of Android `AppCompatActivity`. So a `MainActivity` is automatically a screenful of components with lots and lots of handy, prewritten code.

Of course, in some apps, you might not want all that prewritten code. After all, being a Republican or a Democrat doesn't mean believing everything in your party's platform. You can start by borrowing most of the platform's principles but then pick and choose among the remaining principles. In the same way, the code in Listing 4-1 declares itself to be an Android `AppCompatActivity`, but then *overrides* one of the `AppCompatActivity` class's existing methods.

If you bothered to look at the code for Android's built-in `AppCompatActivity` class, you'd see the declaration of an `onCreate` method. In Listing 4-1, the word `@Override` indicates that the listing's `MainActivity` doesn't use the `AppCompatActivity` class's prewritten `onCreate` method. Instead, the `MainActivity` contains a declaration for its own `onCreate` method, as shown in Figure 4-14.

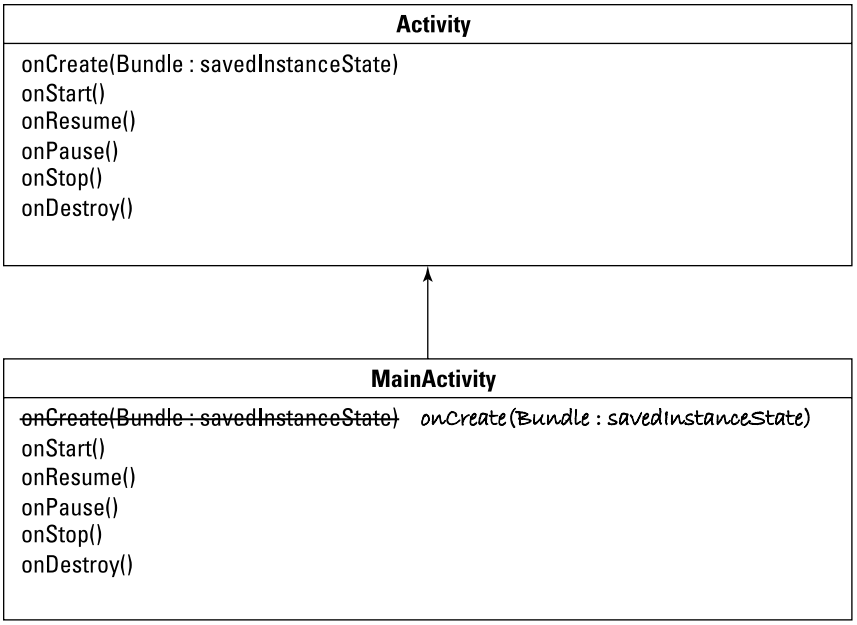


FIGURE 4-14: I don't like the prewritten `onCreate` method.

In particular, Listing 4-1's `onCreate` method calls `setContentView(R.layout.activity_main)`, which displays the material described in the `res/layout/activity_main.xml` file. The `AppCompatActivity` class's built-in `onCreate` method doesn't do those things.

CROSS-REFERENCE

For an introduction to the `res/layout/activity_main.xml` file, see Chapter 3.

An activity's workhorse methods

Every Android activity has a *lifecycle* — a set of stages that the activity undergoes from birth to death to rebirth, and so on. In particular, when your Android device launches an activity, the device calls the activity's `onCreate` method. The device also calls the activity's `onStart` and `onResume` methods. See Figure 4-15.

In most of this book's listings, I choose to declare my own `onCreate` method, but I don't bother declaring my own `onStart` and `onResume` methods. Rather than override the `onStart` and `onResume` methods, I silently use the `AppCompat Activity` class's prewritten `onStart` and `onResume` methods.

CROSS-REFERENCE

To find out why you'd choose to override `onResume`, see Chapter 14.

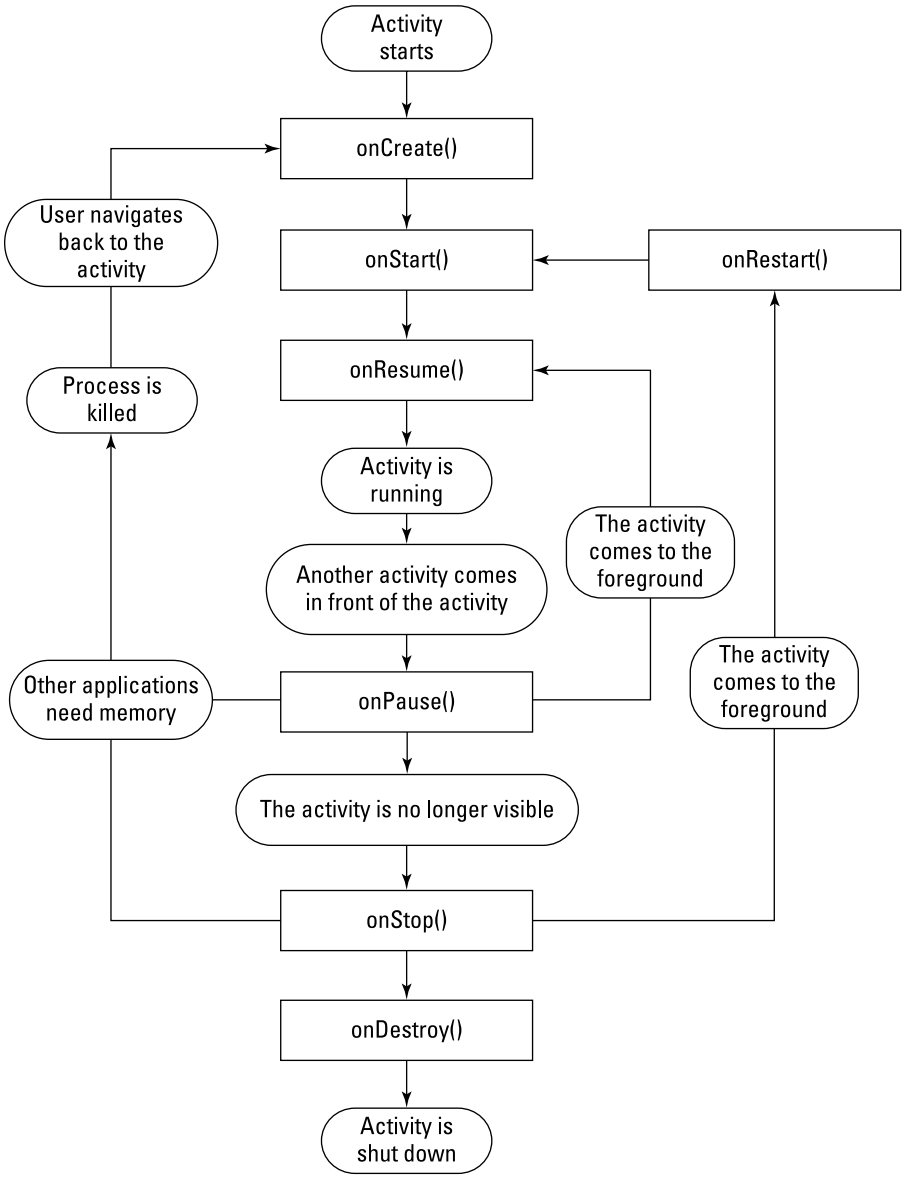


FIGURE 4-15: The life, death, and rebirth of an Android activity.

When an Android device ends an activity's run, the device calls three additional methods: the activity's `onPause`, `onStop`, and `onDestroy` methods. So, one complete sweep of your activity, from birth to death, involves the run of at least six methods: `onCreate`, then `onStart`, and then `onResume`, and later `onPause`, and then `onStop`, and, finally, `onDestroy`. As it is with all life forms, "ashes to ashes, dust to dust."

Don't despair. For an Android activity, reincarnation is a common phenomenon. For example, if you're running several apps at a time, the device might run low on memory. In this case, Android can kill some running activities. As the device's user, you have no idea that any activities have been destroyed. When you navigate back to a killed activity, Android re-creates the activity for you and you're none the wiser. A call to `super.onCreate(savedInstanceState)` helps bring things back to the way they were before Android destroyed the activity.

Here's another surprising fact. When you turn a phone from Portrait mode to Landscape mode, the phone destroys the *current* activity (the activity that's in Portrait mode) and re-creates that same activity in Landscape mode. The phone calls all six of the activity's lifecycle methods (`onPause`, `onStop`, and so on) in order to turn the activity's display sideways. It's similar to starting on the transporter deck of the *Enterprise* and being a different person after being beamed down to the planet (except that you act like yourself and think like yourself, so no one knows that you're a completely different person).

Indeed, methods like `onCreate` in this book's examples are the workhorses of Android development.

IN THIS CHAPTER

- Assigning values to things
- Making things store certain types of values
- Applying operators to get new values

Chapter 5
Java's Building Blocks

I've driven cars in many cities, and I'm ready to present my candid reviews:

- Driving in New York City is a one-sided endeavor. A New York City driver avoids hitting another car but doesn't avoid being hit by another car. In the same way, New York pedestrians do nothing to avoid being hit. Racing into the path of an oncoming vehicle is commonplace. Anyone who doesn't behave this way is either a New Jersey driver or a tourist from the Midwest. In New York City, safety depends entirely on the car that's moving toward a potential target.
- A driver in certain parts of California will stop on a dime for a pedestrian who's about to jaywalk. Some drivers stop even before the pedestrian is aware of any intention to jaywalk.
- Boston's streets are curvy and irregular, and accurate street signs are rare. Road maps are outdated because of construction and other contingencies. So driving in Boston is highly problematic. You can't find your way around Boston unless you already know your way around Boston, and you don't know your way around Boston unless you've already driven around Boston. Needless to say, I can't drive in Boston.
- London is quite crowded, but the drivers are polite (to foreigners, at least). Several years ago, I caused three car accidents in one week on the streets of London. And after each accident, the driver of the other car apologized to me!

I was particularly touched when a London cabby expressed regret that an accident (admittedly, my fault) might stain his driving record. Apparently, the rules for London cabbies are quite strict.

This brings me to the subject of the level of training required to drive a taxicab in London. The cabbies start their careers by memorizing the London street map. The map has over 25,000 streets, and the layout has no built-in clues. Rectangular grids aren't the norm, and numbered streets are quite uncommon. Learning all the street names takes several years, and the cabbies must pass a test in order to become certified drivers.

This incredibly circuitous discussion about drivers, streets, and my tendency to cause accidents leads me to the major point of this section: Java's built-in types are easy to learn. In contrast to London's 25,000 streets, and the periodic table's 100-some elements, Java has only eight built-in types. They're Java's *primitive types*, and this chapter describes them all.

Info Is As Info Does

Reality! To Sancho, an inn; to Don Quixote, a castle; to someone else, whatever!

—MIGUEL DE CERVANTES, *AS UPDATED FOR "MAN OF LA MANCHA"*

When you think a computer or some other kind of processor is storing the letter J, the processor is, in reality, storing 01001010. For the letter K, the processor stores 01001011. Everything inside the processor is a sequence of 0s and 1s. As every computer geek knows, a 0 or 1 is a *bit.*

As it turns out, the sequence 01001010, which stands for the letter J, can also stand for the number 74. The same sequence can also stand for $1.0369608636003646 \times 10^{-43}$. In fact, if the bits are interpreted as screen pixels, the same sequence can be used to represent the dots shown in Figure 5-1. The meaning of 01001010 depends on the way the software interprets this sequence of 0s and 1s.

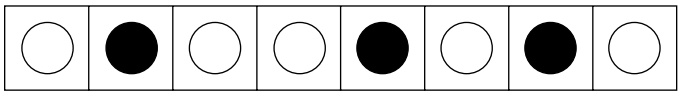


FIGURE 5-1: An extreme close-up of eight black-and-white screen pixels.

So how do you tell Java what 01001010 stands for? The answer is in the concept of *type*.

The *type* of a variable is the range of values that the variable is permitted to store. Listing 5-1 illustrates this idea.

LISTING 5-1: **Goofing Around with Java Types**

```
package com.allmycode.a05_01;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    int anInteger = 74;
    char aCharacter = 74;

    System.out.println(anInteger);
    System.out.println(aCharacter);
  }
}
```

CROSS-REFERENCE

You can download the Android Studio project for Listing 5-1, or you can create it yourself from scratch. To find out how to download the project — as well as how to open the project in Android Studio — see Chapter 2. For info on creating the project from scratch, see Chapter 3.

When you run the code in Listing 5-1, you don't see anything interesting on the emulator screen. But if you scroll around in Android Studio's Logcat pane, you see two interesting lines: one containing the text *I/System.out: 74* and another containing the text *I/System.out: J*. (Refer to Figure 5-2.)

In Java, `System.out.println` is the name of a method. The `System.out.println` method tells your development computer to display something in Android Studio's Logcat pane. Someone holding an Android device (a phone, a tablet, a watch, or whatever) doesn't see the stuff in Android Studio's Logcat pane, so this output isn't useful in a finished app. But the output can be useful while you're developing a new app to help you see how well the app is running.

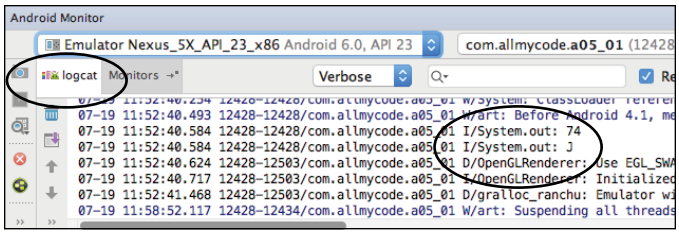


FIGURE 5-2: Some output from the code in Listing 5-1.

TECHNICAL STUFF

The words `System.out.println` tell Java to display something in a text-only pane. In Android Studio, this text-only pane happens to be the Logcat pane, but in other situations, your text-only pane might be something different. For example, if a Java program is meant to run on a desktop or laptop computer, the text-only pane might be the command prompt in Windows or the Terminal application on a Mac.

CROSS-REFERENCE

To read about Android Studio's Logcat pane, check out Chapter 2.

WARNING

If you visit `https://source.android.com/source/code-style.html`, you find guidelines describing the kind of code that can and cannot be published on Google Play. The guidelines specifically prohibit the use of `System.out.println` in any code that's distributed on the store. So, for professional Android developers, the code in Listing 5-1 is an anathema. If you show Listing 5-1 on a PowerPoint slide at an Android developers' conference, you'll be booed off the stage. But `System.out.println` is part of Java's API. And apps that can sell on Google Play aren't necessarily the best learning tools. In this chapter, `System.out.println` allows me to describe certain ideas about Java types — ideas that would be hopelessly muddled if I stuck to Google's guidelines. So bear with me and examine the `System.out.println` examples in this chapter. When you finish this chapter, you can rip out the chapter's pages and burn them, if you like. Just remember to read the guidelines mentioned above (yes, available at `https://source.android.com/source/code-style.html`) and never use `System.out.println` in code that you publish on Google Play.

In Figure 5-2, Java interprets 01001010 two different ways. On one line, Java interprets 01001010 as a whole number. And on the next line, Java interprets the same 01001010 bits as the representation of the character `J`. The difference stems from the two *type declarations* in Listing 5-1:

```
int anInteger = 74;
char aCharacter = 74;
```

Each of these declarations consists of three parts: a variable name, a type name, and an initialization. The next few sections describe these parts.

Variable names

The identifiers `anInteger` and `aCharacter` in Listing 5-1 are variable names, or simply variables. A *variable name* is a nickname for a value (like the value `74`).

I made up both variable names for the example in Listing 5-1, and I intentionally made up *informative* variable names. Instead of `anInteger` and `aCharacter` in Listing 5-1, I could have chosen `flower` and `goose`. But I use `anInteger` and `aCharacter` because informative names help other people read and understand my code. (In fact, informative names help me read and understand my own code!)

Like most of the names in a Java program, variable names can't have blank spaces. The only allowable punctuation symbol is the underscore character (_). Finally, you can't start a variable's name with a digit. For example, you can name your variable `close2Call`, but you can't name it `2Close2Call`.


TIP

If you want to look like a seasoned Java programmer, start every variable name with a lowercase letter and use uppercase letters to separate words within the name. For example, `numberOfBunnies` starts with a lowercase letter and separates words by using the uppercase letters `O` and `B`. This mixing of upper- and lowercase letters is called *camel case* because of its resemblance to a camel's humps.


CROSS-REFERENCE

Experienced Android programmers begin many variable names with the lowercase letter `m`. For more info on that, refer to Chapter 9.

Type names

In Listing 5-1, the words `int` and `char` are *type names*. The word `int` (in the first type declaration) tells Java to interpret whatever value `anInteger` has as a "whole number" value (a value with no digits to the right of the decimal point). And the word `char` (in the second type declaration) tells Java to interpret whatever value `aCharacter` has as a character value (a letter, a punctuation symbol, or maybe even a single digit). So in Listing 5-1, the line

```
System.out.println(anInteger);
```

tells Android to display the value of `anInteger`, and Android displays the number `74`. (Refer to Figure 5-2.) And then the line

```
System.out.println(aCharacter);
```

tells Android to display the value of `aCharacter`, and Android displays the letter `J`.

REMEMBER

In Listing 5-1, the words `int` and `char` tell Java what types my variable names have. The names `anInteger` and `aCharacter` remind me, the programmer, what kinds of values these variables have, but the names `anInteger` and `aCharacter` provide no type information to Java. The declarations `int rocky = 74` and `char bullwinkle = 74` would be fine, as long as I used the variable names `rocky` and `bullwinkle` consistently throughout Listing 5-1.

Assignments and initializations

Both type declarations in Listing 5-1 end with an initialization. As the name suggests, an *initialization* sets a variable to its initial value. In both declarations, I initialize the variable to the value `74`.

You can create a type declaration without an initialization. For example, I can turn two of the lines in Listing 5-1 into four lines:

```
int anInteger;
char aCharacter;
anInteger = 74;
aCharacter = 74;
```

A line like

```
int anInteger;
```

is a declaration without an initialization. A line like

```
anInteger = 74;
```

is called an *assignment*. An assignment changes a variable's value. An assignment isn't part of a type declaration. Instead, an assignment is separate from its type declaration (maybe many lines after the type declaration).

You can initialize a variable with one value and then, in an assignment statement, change the variable's value.

```
int year = 2008;
System.out.println(year);
System.out.println("Global financial crisis");
year = 2009;
System.out.println(year);
System.out.println("Obama sworn in as US president");
year = 2010;
System.out.println(year);
System.out.println("Oil spill in the Gulf of Mexico");
```

Sometimes, you need a name for a value that doesn't change during the program's run. In such situations, the keyword `final` signals a variable whose value can't be reassigned.

```
final int NUMBER_OF_PLANETS = 9;
```

A `final` variable is a variable whose value doesn't vary. (As far as I know, no one has ever seriously suggested calling these things *invariables*.)

You can initialize a `final` variable's value, but after the initialization, you can't change the variable's value with an assignment statement. In other words, after you declare `final int NUMBER_OF_PLANETS = 9`, this assignment statement isn't legal:

```
NUMBER_OF_PLANETS = 8;
```

If Pluto is no longer a planet, you can't accommodate the change without changing the `9` in the `final int NUMBER_OF_PLANETS = 9` declaration.

In Java, the word `final` is one of Java's modifiers. A *modifier* is like an adjective in English. A modifier causes a slight change in the meaning of a declaration. For example, in this section, the word `final` modifies the `NUMBER_OF_PLANETS` declaration, making the value of `NUMBER_OF_PLANETS` unchangeable.

CROSS-REFERENCE

For more information about Java's modifiers, see Chapters 9 and 10.

You use `final` variables, as a rule, to give friendly names to values that never (or rarely) change. For example, in a Java program, `6.626068e-34` stands for 6.626068×10^{-34}, which is the same as this:

```
0.00000000000000000000000000000000006626068
```

In a quantum physics application, you probably don't want to retype the number `6.626068e-34` several times in your code. (You can type the number wrong or even make a mistake when you copy-and-paste.) To keep errors from creeping into your code, you declare

```
final double PLANCK_CONSTANT = 6.626068e-34;
```

From that point on, rather than type `6.626068e-34` multiple times in your code, you can type only the name `PLANCK_CONSTANT` when needed.

TIP

You can use lowercase letters in any variable, including `final` variables. But Java programmers seldom write code this way. To keep from looking like a complete newbie, use only uppercase letters and digits in a `final` variable's name. Use underscores to separate words.

TECHNICAL STUFF

A loophole in the Java language specification allows you, under certain circumstances, to use an assignment statement to give a variable its initial value. For a variable, such as `amount`, declared inside of a method's body, you can write `final int amount;` on one line and then write `amount = 0;` on another line. Want my advice? Ignore this loophole. Don't even read this Technical Stuff icon!

Expressions and literals

In a Java program, an *expression* is a bunch of text that has a value. In Listing 5-1 each occurrence of `74` is an expression, each occurrence of `anInteger` is an expression, and each occurrence of `aCharacter` is an expression. Listing 5-1 is unusual in that all six of these expressions have the same value, namely, the numeric value 74.

If I use the name `anInteger` in ten different places in my Java program, then I have ten expressions, and each expression has a value. If I decide to type `anInteger + 17` somewhere in my program, then `anInteger + 17` is an expression because `anInteger + 17` has a value.

A *literal* is a kind of expression whose value doesn't change from one Java program to another. For example, the expression `74` means "the numeric value 74" in every Java program. Likewise, the expression `'J'` means "the tenth uppercase letter in the Roman alphabet" in every Java program, and the word `true` means "the opposite of `false`" in every Java program. The expressions `true`, `74`, and `'J'` are literals. Similarly, the text `"Global financial crisis"` is a literal because, in any Java program, the text `"Global financial crisis"` stands for the same three words.

In Java, single quotation marks stand for a character. You can change the second declaration in Listing 5-1 this way:

```
char aCharacter = 'J';
```

With this change, the program's run doesn't change. The second `I/System.out` line in Figure 5-2 still contains the letter `J`.

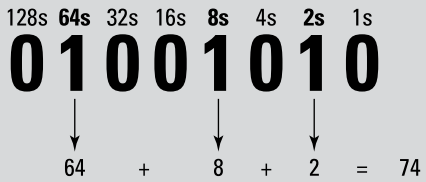
REMEMBER

In Java, a `char` value is a number in disguise. In Listing 5-1, you get the same result if the second type declaration is `char aCharacter = 'J'`. You can even do arithmetic with `char` values. For example, in Listing 5-1, if you change the second declaration to `char aCharacter = 'J' + 2`, you get the letter `L`.

THE 01000001 01000010 01000011S

What does 01001010 have to do with the number 74 or with the letter J?

The answer for 74 involves the binary number representation. The familiar base-10 (decimal) system has a 1s column, a 10s column, a 100s column, a 1000s column, and so on. But the base-2 (binary) system has a 1s column, a 2s column, a 4s column, an 8s column, and so on. The figure shows how you get 74 from 01001010 using the binary column values.



The connection between 01001010 and the letter J might seem more arbitrary. In the early 1960s, a group of professionals devised the American Standard Code for Information Interchange (ASCII). In the ASCII representation, each character takes up 8 bits. You can see the representations for some of the characters in the sidebar table. For example, our friend 01001010 (which, as a binary number, stands for 74) is also the way Java stores the letter J. The decision to make A be 01000001 and to make J be 01001010 has roots in the 20th century's typographic hardware. (To read all about this, visit `http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.96.678`.)

In the late 1980s, as modern communications led to increasing globalization, a group of experts began work on an enhanced code with up to 32 bits for each character. The lower 8 Unicode bits have the same meanings as in the ASCII code, but with so many more bits, the Unicode standard has room for languages other than English. A Java `char` value is a 16-bit Unicode number, which means that, depending on the way you interpret it, a `char` is either a number between 0 and 65535 or a character in one of the many Unicode languages.

In fact, you can use non-English characters for identifiers in a Java program. The sidebar figure shows an Android program with identifiers in Yiddish.

(continued)

(continued)

```
package com.allmycode.yiddish;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    int איינס = 1;
    int צוויי = 2;
    int דריי = איינס + צוויי;
    System.out.print("ענטפער : ");
    System.out.println(דריי);
  }

}
```

Bits	When Interpreted As an int	When Interpreted As a char	Bits	When Interpreted As an int	When Interpreted As a char
00100000	32	space	00111111	63	?
00100001	33	!	01000000	64	@
00100010	34	"	01000001	65	A
00100011	35	#	01000010	66	B
00100100	36	$	01000011	67	C
00100101	37	%	.	.	.
00100110	38	&	.	.	.
00100111	39	'	*etc.*	*etc.*	*etc.*
00101000	40	(	01011000	88	X
00101001	41	)	01011001	89	Y
00101010	42	*	01011010	90	Z
00101011	43	+	01011011	91	[

Bits	When Interpreted As an int	When Interpreted As a char	Bits	When Interpreted As an int	When Interpreted As a char
00101100	44	,	01011100	92	\
00101101	45	-	01011101	93	]
00101110	46	.	01011110	94	^
00101111	47	/	01011111	95	_
00110000	48	0	01100000	96	`
00110001	49	1	01100001	97	a
00110010	50	2	01100010	98	b
00110011	51	3	01100011	99	c
00110100	52	4	.	.	.
00110101	53	5	.	.	.
00110110	54	6	*etc.*	*etc.*	*etc.*
00110111	55	7	01111000	120	x
00111000	56	8	01111001	121	y
00111001	57	9	01111010	122	z
00111010	58	:	01111011	123	{
00111011	59	;	01111100	124	|
00111100	60	<	01111101	125	}
00111101	61	=	01111110	126	~
00111110	62	>	01111111	127	Delete

How to string characters together

In Java, a single character isn't the same as a string of characters. Compare the character `'J'` with the string `"Bullwinkle J. Moose"`. A *character* literal has single quotation marks; a *string* literal has double quotation marks.

In Java, a string of characters may contain more than one character, but a string of characters doesn't necessarily contain more than one character. (Surprise!) You can write

```
char aCharacter = 'J';
```

because a character literal has single quotation marks. And because `String` is one of Java's types, you can also write

```
String myFirstName = "Barry";
```

initializing the `String` variable `myFirstName` with the `String` literal `"Barry"`. Even though `"A"` contains only one letter, you can write

```
String myMiddleInitial = "A";
```

because `"A"`, with its double quotation marks, is a `String` literal.

But in Java, a single character isn't the same as a one-character string, so you can't write

```
//Don't do this:
char theLastLetter = "Z";
```

Even though it contains only one character, the expression `"Z"` is a `String` value, so you can't initialize a `char` variable with the expression `"Z"`.

Java's primitive types

Java has two kinds of types: primitive and reference. *Primitive types* are the atoms — the basic building blocks. In contrast, *reference types* are the things you create by combining primitive types (and by combining other reference types).

CROSS-REFERENCE

This chapter covers (mostly) Java's primitive types. Chapter 9 introduces Java's reference types.

TECHNICAL STUFF

Throughout this chapter, I give some attention to Java's `String` type. The `String` type in reality belongs in Chapter 9 because Java's `String` type is a reference type, not a primitive type. But I can't wait until Chapter 9 to use strings of characters in my examples. So consider this chapter's `String` material to be an informal (but useful) preview of Java's `String` type.

Table 5-1 describes all eight primitive Java types.

TABLE 5-1 Java's Primitive Types

Type Name	What a Literal Looks Like	Range of Values
Integral types		
`byte`	`(byte)42`	–128 to 127
`short`	`(short)42`	–32768 to 32767
`int`	`42`	–2147483648 to 2147483647
`long`	`42L`	–9223372036854775808 to 9223372036854775807
Character type (which is, technically, an Integral type)		
`char`	`'A'`	Thousands of characters, glyphs, and symbols
Floating-point types		
`float`	`42.0F`	-3.4×10^{38} to 3.4×10^{38}
`double`	`42.0` or `0.314159e1`	-1.8×10^{308} to 1.8×10^{308}
Logical type		
`boolean`	`true`	true, false

You can divide Java's primitive types into three categories:

- **Integral**

  The *integral* types represent whole numbers — numbers with no digits to the right of the decimal point. For example, the number `42` in a Java program represents the `int` value 42, as in 42 cents or 42 clowns or 42 eggs. A family can't possibly have 2.5 children, so an `int` variable is a good place to store the number of kids in a particular family.

  The thing that distinguishes one integral type from another is the range of values you can represent with each type. For example, a variable of type `int` represents a number from –2147483648 to +2147483647.

  When you need a number with no digits to the right of the decimal point, you can almost always use the `int` type. Java's `byte`, `short`, and `long` types are reserved for special range needs (and for finicky programmers).

- **Floating-point**

  The *floating-point* types represent numbers with digits to the right of the decimal point, even if those digits are all zeroes. For example, an old wooden measuring stick might be 1.001 meters long, and a precise measuring stick might be 1.000 meters long.

  The `double` type has a much larger range than the `float` type and is much more accurate.

  In spite of their names, Java programmers almost always use `double` rather than `float`, and when you write an ordinary literal (such as `42.0`), that literal is a `double` value. (On the off chance that you want to create a `float` value, write `42.0F`.)

- **Logical**

  A `boolean` variable has one of two values: `true` or `false`. You can assign `74` to an `int` variable, and you can assign `true` (for example) to a `boolean` variable:

```
int numberOfPopsicles;
boolean areLemonFlavored;
numberOfPopsicles = 22;
areLemonFlavored = true;
```

  You can do arithmetic with numeric values, and you can do a kind of "arithmetic" with `boolean` values. For more information, see the next section.

Things You Can Do with Types

You can do arithmetic with Java's *operators*. The most commonly used arithmetic operators are `+` (addition), `-` (subtraction), `*` (multiplication), `/` (division), and `%` (remainder upon division).

- **When you use an arithmetic operator to combine two `int` values, the result is another `int` value.**

  For example, the value of `4 + 15` is 19. The value of `14 / 5` is 2 (because 5 "goes into" 14 two times, and even though the remainder is bigger than ½, the remainder is omitted). The value of `14 % 5` is 4 (because 14 divided by 5 leaves a remainder of 4).

  The same kinds of rules apply to the other integral types. For example, when you add a `long` value to a `long` value, you get another `long` value.

- **When you use an arithmetic operator to combine two `double` values, the result is another `double` value.**

  For example, the value of `4.0 + 15.0` is 19.0. The value of `14.0 / 5.0` is 2.8.

  The same kind of rule applies to `float` values. For example, a `float` value plus a `float` value is another `float` value.

- **When you use an arithmetic operator to combine an `int` value with a `double` value, the result is another `double` value.**

  Java *widens* the `int` value in order to combine it with the `double` value. For example, `4 + 15.0` is the same as `4.0 + 15.0`, which is 19.0. And `14 / 5.0` is the same as `14.0 / 5.0`, which is 2.8.

  This widening also happens when you combine two different kinds of integral values or two different kinds of floating-point values. For example, the number 9000000000000000000 is too large to be an `int` value, so

  ```
  9000000000000000000L + 1
  ```

  is the same as

  ```
  9000000000000000000L + 1L
  ```

  which is

  ```
  9000000000000000001L
  ```

Two other popular operators are increment `++` and decrement `--`. The most common use of the increment and decrement operators looks like this:

```
x++;
y--;
```

But you can also place the operators before the variables:

```
++x;
--y;
```

Placing the operator after the variable is called *postincrementing* (or *postdecrementing*). Placing the operator before the variable is called *preincrementing* (or *predecrementing*).

Both forms (before and after the variable) have the same effect on the variable's value; namely, the increment `++` operator always adds `1` to the value, and the decrement `--` operator always subtracts `1` from the value. The only difference is what happens if you dare to display (or otherwise examine) the value of something like `x++`. Figure 5-3 illustrates this unsettling idea.

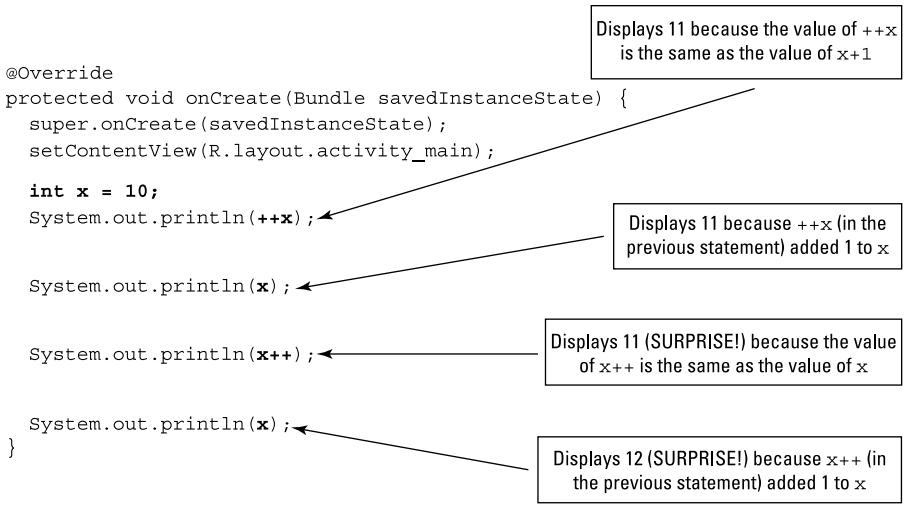


FIGURE 5-3: Preincrement and postincrement.

TIP

In practice, if you remember only that `x++` adds 1 to the value of `x`, you're usually okay.

TECHNICAL STUFF

The curious behavior shown in Figure 5-3 was inspired by assembly languages of the 1970s. These languages have instructions that perform increment and decrement operations on a processor's internal registers.

Add letters to numbers (Huh?)

You can add `String` values and `char` values to other elements and to each other. Listing 5-2 has some examples.

LISTING 5-2: **Java's Versatile Plus Sign**

```
package com.allmycode.a05_02;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
```

```
    int x = 74;
    System.out.println("Hello, " + "world!");
    System.out.println("The value of x is " + x + ".");
    System.out.println("The second letter of the alphabet is " + 'B' + ".");
    System.out.println("The fifth prime number is " + 11 + '.');
    System.out.println
        ("The sum of 18 and 21 is " + 18 + 21 + ". Oops! That's wrong.");
    System.out.println
        ("The sum of 18 and 21 is " + (18 + 21) + ". That's better.");
  }
}
```

REMEMBER

The `String` type more appropriately belongs in Chapter 9 because Java's `String` type isn't a primitive type. Even so, I start covering the `String` type in this chapter.

When you run the code in Listing 5-2, you see the output shown in Figure 5-4.

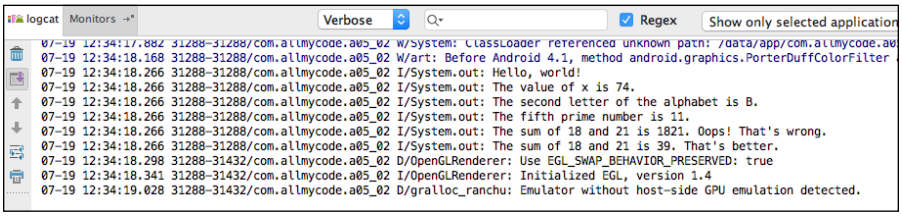


FIGURE 5-4: A run of the code in Listing 5-2.

Here's what's happening in Figure 5-4:

- **When you use the plus sign to combine two strings, it stands for string concatenation.**

  String concatenation is a fancy name for what happens when you display one string immediately after another. In Listing 5-2, the act of concatenating `"Hello, "` and `"world!"` yields the string

  ```
  "Hello, world!"
  ```

- **When you add a string to a number, Java turns the number into a string and concatenates the strings.**

  In Listing 5-2, the `x` variable is initialized to 74. The code displays `"The value of x is " + x` (a string plus an `int` variable). When adding the string `"The value of x is "` to the number 74, Java turns the `int` 74 into the string `"74"`.


TECHNICAL STUFF

So `"The value of x is " + x` becomes `"The value of x is " + "74"`, which (after string concatenation) becomes `"The value of x is 74"`.

This automatic conversion of a number into a string is handy whenever you want to display a brief explanation along with a numeric value.

Java's internal representation of the number 74 is 00000000000000000000000001001010 (with 1 in the 64s place, 1 in the 8s place, and 1 in the 2s place). In contrast, Java's internal representation of the string `"74"` is 0000000000110111000000000110100. (For some clues to help you understand why these bits represent the `"74"` string, see the table accompanying this chapter's earlier sidebar, "The 01000001 01000010 01000011s.") The bottom line, as far as Java is concerned, is that the number 74 and the string `"74"` aren't the same.

- **When you add a string to any other kind of value, Java turns the other value into a string and concatenates the strings.**

  The third `System.out.println` call in Listing 5-2 adds the `char` value `'B'` to a string. The result, as you can see in Figure 5-4, is a string containing the letter `B`.

- **The order in which Java performs operations can affect the outcome.**

  The last two `System.out.println` calls in Listing 5-2 illustrate this point. In the next-to-last call, Java works from left to right. Java starts by combining `"The sum of 18 and 21 is "` with `18`, getting `"The sum of 18 and 21 is 18"`. Then, working its way rightward, Java combines `"The sum of 18 and 21 is 18"` with `21` getting the screwy string `"The sum of 18 and 21 is 1821"`.

  In the last `System.out.println` call, I fix these problems by grouping `18` and `21` in parentheses. As a result, Java starts by adding 18 and 21 to get 39. Then Java combines `"The sum of 18 and 21 is "` with `39`, getting the more sensible string `"The sum of 18 and 21 is 39"`.

Java's exotic assignment operators

In a Java program, you can add `2` to a variable with a statement like this:

```
numberOfCows = numberOfCows + 2;
```

To a seasoned Java developer, a statement of this kind is horribly *gauche.* You might as well wear white after Labor Day or talk seriously about a "nucular" reactor. Why?

Because Java has a fancy *compound assignment operator* that performs the same task in a more concise way. The statement

```
numberOfCows += 2;
```

adds 2 to `numberOfCows` and lets you easily recognize the programmer's intention. For a silly example, imagine having several similarly named variables in the same program:

```
int numberOfCows;
int numberOfCrows;
int numberOfCries;
int numberOfCrays;
int numberOfGrays;
```

Then the statement

```
numberOfCrows += 2;
```

doesn't force you to check both sides of an assignment. Instead, the `+=` operator makes the statement's intent crystal-clear.

Java's other compound assignment operators include `-=`, `*=`, `/=`, `%=`, and others. For example, to multiply `numberOfCows` by `numberOfDays`, you can write

```
numberOfCows *= numberOfDays;
```

A compound assignment, like `numberOfCrows += 2`, might take a tiny bit less time to execute than the cruder `numberOfCows = numberOfCows + 2`. But the main reason for using a compound assignment statement is to make the program easier for other developers to read and understand. The savings in computing time, if any, is usually minimal.

True bit

A `boolean` value is either `true` or `false`. Those are only two possible values, compared with the thousands of values an `int` variable can have. But these two values are quite powerful. (When someone says "You've won the lottery" or "Your shoe is untied," you probably care whether these statements are true or false. Don't you?)

When you compare things with one another, the result is a `boolean` value. For example, the statement

```
System.out.println(3 > 2);
```

puts the word `true` in Android Studio's Logcat pane. In addition to Java's `>` (greater than) operator, you can compare values with `<` (less than), `>=` (greater than or equal), and `<=` (less than or equal).

You can also use a double-equal sign (`==`) to find out whether two values are equal to one another. The statement

```
System.out.println(15 == 9 + 9);
```

puts the word `false` in the Logcat pane. You can also test for inequality. For example, the statement

```
System.out.println(15 != 9 + 9);
```

puts the word `true` in the Logcat pane. (A computer keyboard has no ≠ sign. To help you remember the `!=` operator, think of the exclamation point as a work-around for making a slash through the equal sign.)

An expression whose value is either `true` or `false` is a *condition*. In this section, expressions such as `3 > 2` and `15 != 9 + 9` are examples of conditions.


REMEMBER

The symbol to compare for equality isn't the same as the symbol that's used in an assignment or an initialization. Assignment or initialization uses a single equal sign (`=`), and comparison for equality uses a double equal sign (`==`). Everybody mistakenly uses the single equal sign to compare for equality several times in their programming careers. The trick is not to avoid making the mistake; the trick is to catch the mistake whenever you make it.


CROSS-REFERENCE

It's nice to display the word `true` or `false` in Android Studio's Logcat pane, but `boolean` values aren't just for pretty displays. To find out how `boolean` values can control the sequence of steps in your program, see Chapter 8.

Java isn't like a game of horseshoes

When you use a double equal sign, you have to be careful. Figure 5-5 shows you what happens in a paper-and-pencil calculation to convert 21 degrees Celsius to Fahrenheit. You get exactly 69.8.

But when you add the following statement to a Java program, you see `false`, not `true`:

```
System.out.println(9.0 / 5.0 * 21 + 32.0 == 69.8);
```

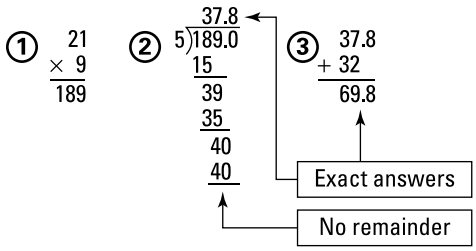


FIGURE 5-5: An exact Celsius-to-Fahrenheit conversion.

Why isn't `9.0 / 5.0 * 21 + 32.0` the same as `69.8`? The answer is that Java's arithmetic operators don't use the decimal system — they use the *binary* system. And in binary arithmetic, things don't go as well as they do in Figure 5-5.

Figure 5-6 shows you how Java divides 189.0 by 5. You might not understand (and you might not want to understand) how Java computes the value 100101.110011001100110011 . . ., but when you stop after 64 bits or so, this answer isn't exactly 37.8. It's more like 37.800000000000004, which is slightly inaccurate. In a Java program, when you ask whether `9.0 / 5.0 * 21 + 32.0` is exactly equal to `69.8`, Java says "No, that's false."

REMEMBER

Avoid comparing `double` values or `float` values for equality (using `==`) or for inequality (using `!=`). Comparing strings for equality (as in the expression `"passw0rd" == "passw0rd"`) is also unadvisable.

CROSS-REFERENCE

For details about comparing strings, see Chapter 8.

```
      100101.110011001100110011 ... etc.
101)10111101.000000000
    101
     0111
     0101
       1001
       0101
        100 0
        010 1
          1 10
          1 01
            1000
            0101
              110
              101
                1000
```

FIGURE 5-6: A division problem that never ends.

Use Java's logical operators

Real-life situations might involve complicated chains of conditions. To illustrate that fact, look at the kinds of real-life prose I find myself forced to read late on the evening of April 14 almost every year:

Household income for the purpose of premium tax credit is the sum of [IRC 36B(d)(2); Reg. 1.36B-1(e)]:

1. *The individual's modified adjusted gross income (MAGI) and the aggregate MAGI of all other individuals taken into account for determining family size who are required to file a tax return. Individuals not required to file, but filing to claim a refund are not included in the calculation.*
2. *MAGI for this purpose is the adjusted gross income as reported on Line 37 of Form 1040 increased by the foreign earned income exclusion, tax-exempt income received or accrued and that portion of an individual's social security benefits not included in income.*

The good news is that an app's conditions are not formulated by the same folks who came up with the U.S. tax code — the conditions can be expressed using Java's `&&`, `||` and `!` operators. The story begins in Listing 5-3. Here, the listing's code computes the price of a movie theater ticket.

LISTING 5-3: **Pay the Regular Ticket Price?**

```
package com.allmycode.a05_03;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    int age;
    boolean chargeRegularPrice;

    age = 17;
    chargeRegularPrice = 18 <= age && age < 65;
    System.out.println(chargeRegularPrice);
```

```
        age = 18;
        chargeRegularPrice = 18 <= age && age < 65;
        System.out.println(chargeRegularPrice);

        age = 75;
        chargeRegularPrice = 18 <= age && age < 65;
        System.out.println(chargeRegularPrice);
    }
}
```

Figure 5-7 shows part of the Logcat pane when you run the code in Listing 5-3. At first, with the value of `age` set to 17, the value of `chargeRegularPrice` is `false`. So the first `I/System.out` line says that `chargeRegularPrice` is `false`. Then the value of `age` becomes 18, and `chargeRegularPrice` becomes `true`. So the second `I/System.out` line says that `chargeRegularPrice` is `true`. Finally, the code sets the value of `age` to 75, and once again `chargeRegularPrice` becomes `false`.

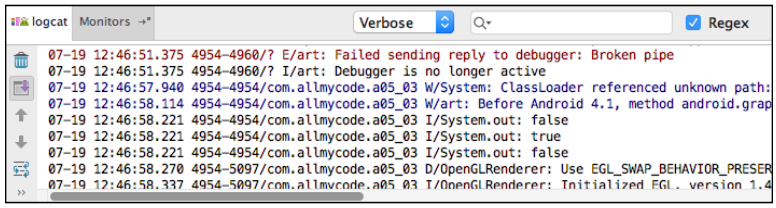


FIGURE 5-7: Three people go to the movies.

CROSS-REFERENCE

This section's example might look peculiar because the code sets the value of `age` and then tests something about the value of `age`. Maybe the program's output should be "If you already know the value of age, why are you asking me if it's between 18 and 65?" The answer to that smart-aleck question is that the code for having the user type an `age` value isn't the world's simplest stuff. I don't want to muddy my discussion of logical operators with lots of user input code. If you want to know how to get input from the user, see Chapter 6.

In Listing 5-3, the value of `chargeRegularPrice` is `true` or `false` depending on the outcome of the `18 <= age && age < 65` condition test. The `&&` operator stands for a logical *and* combination, so `18 <= age && age < 65` is `true` as long as `age` is greater than or equal to 18 *and* `age` is less than 65.

REMEMBER

To create a condition like `18 <= age && age < 65`, you have to use the `age` variable twice. You can't write `18 <= age < 65`. Other people might understand what `18 <= age < 65` means, but Java doesn't understand it.

TIP

In the earlier section "Java isn't like a game of horseshoes," I warn against using the == operator to compare two `double` values with one another. If you absolutely must compare `double` values with one another, give yourself a little leeway. Rather than write `fahrTemp == 69.8`, write something like this:

```
(69.7779 < fahrTemp) && (fahrTemp < 69.8001)
```

Listing 5-4 illustrates Java's || operator. (In case you're not sure, you type the || operator by pressing the | key twice.) The || operator stands for a logical *or* combination, so `age < 18 || 65 <= age` is `true` as long as `age` is less than 18 *or* `age` is greater than or equal to 65.

LISTING 5-4: **Pay the Discounted Ticket Price?**

```
package com.allmycode.a05_04;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    int age;
    boolean chargeDiscountPrice;

    age = 17;
    chargeDiscountPrice = age < 18 || 65 <= age;
    System.out.println(chargeDiscountPrice);

    age = 18;
    chargeDiscountPrice = age < 18 || 65 <= age;
    System.out.println(chargeDiscountPrice);

    age = 75;
    chargeDiscountPrice = age < 18 || 65 <= age;
    System.out.println(chargeDiscountPrice);

  }
}
```

A run of the code from Listing 5-4 is shown in Figure 5-8. A run of Listing 5-4 looks a lot like a run of Listing 5-3. But where Listing 5-3 outputs `true`, Listing 5-4 outputs `false`. And where Listing 5-3 outputs `false`, Listing 5-4 outputs `true`.

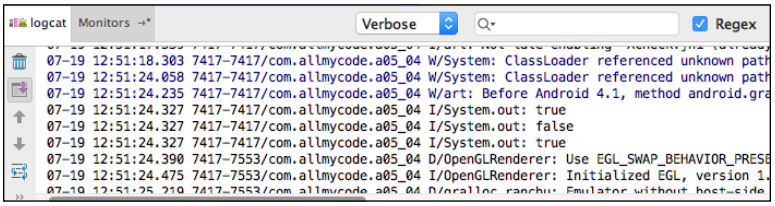


FIGURE 5-8: To be young again! To be old at last!

Listing 5-5 adds Java's `!` operator to the logical stew. If you're unfamiliar with languages like Java, you have to stop thinking that the exclamation point means "Yes, definitely." Instead, Java's `!` operator means *not*. In Listing 5-5, where `isSpecialShowing` is `true` or `false`, the expression `!isSpecialShowing` stands for the opposite of `isSpecialShowing`. That is, when `isSpecialShowing` is `true`, `!isSpecialShowing` is `false`. And when `isSpecialShowing` is `false`, `!isSpecialShowing` is `true`.

LISTING 5-5: **What about Special Showings?**

```
package com.allmycode.a05_05;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    int age;
    boolean isSpecialShowing;
    boolean chargeDiscountPrice;

    age = 13;

    isSpecialShowing = false;
    chargeDiscountPrice = (age < 18 || 65 <= age) && !isSpecialShowing;
    System.out.println(chargeDiscountPrice);
```

(continued)

LISTING 5-5: *(continued)*

```
        isSpecialShowing = true;
        chargeDiscountPrice = (age < 18 || 65 <= age) && !isSpecialShowing;
        System.out.println(chargeDiscountPrice);
    }
}
```

A run of the code from Listing 5-5 is shown in Figure 5-9.

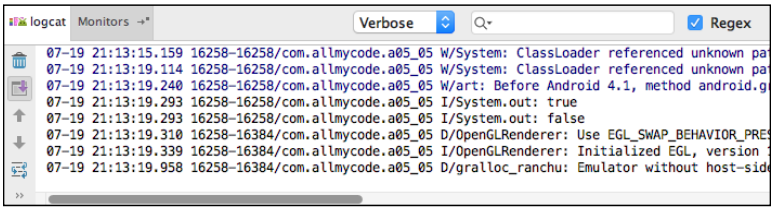


FIGURE 5-9: Ticket prices for two movie showings.

In Listing 5-5, the assignment of a value to `chargeDiscountPrice` grants the discount price to kids and to seniors as long as the current feature isn't a "special showing" — one that the management considers to be a hot item, such as the first week of the run of a highly anticipated movie. When there's a special showing, no one gets the discounted price. Figure 5-10 shows you in detail how `chargeDiscountPrice` gets its values.

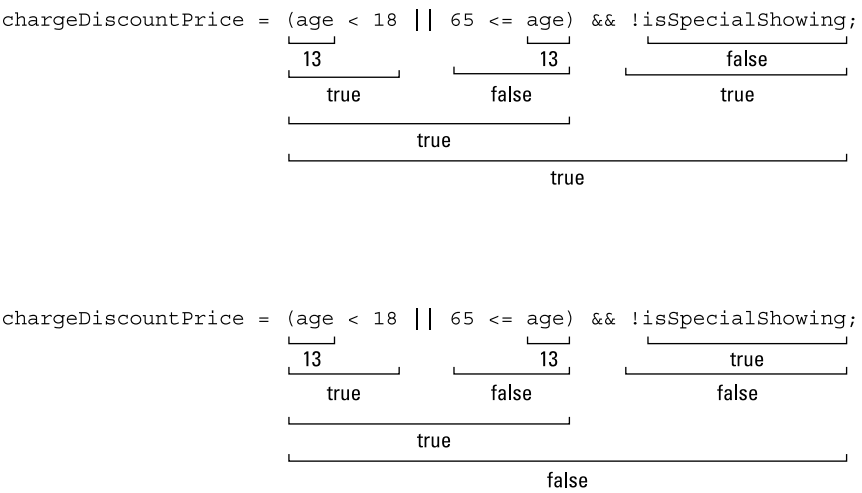


FIGURE 5-10: Finding the value of a boolean expression.

TIP

For any condition you want to express, you always have several ways to express it. For example, rather than test `numberOfCats != 3`, you can be more long-winded and test `!(numberOfCats == 3)`. Rather than test `myAge < yourAge`, you can get the same answer by testing `yourAge > myAge` or `!(myAge >= yourAge)`. Rather than type `a != b && c != d`, you can get the same result with `!(a == b || c == d)`. (A guy named Augustus DeMorgan told me about this last trick.)

Parenthetically speaking . . .

The big condition in Listing 5-5 (the condition `(age < 18 || 65 <= age) && !isSpecialShowing`) illustrates the need for (and the importance of) parentheses (but only when parentheses are needed (or when they help people understand your code)).

When you don't use parentheses, Java's *precedence rules* settle arguments about the meaning of the expression. They tell you whether the line

```
age < 18 || 65 <= age && !isSpecialShowing
```

stands for the expression

```
(age < 18 || 65 <= age) && !isSpecialShowing
```

or for this one:

```
age < 18 || (65 <= age && !isSpecialShowing)
```

According to the precedence rules, in the absence of parentheses, Java evaluates `&&` before evaluating `||`. If you omit the parentheses, Java first checks to find out whether `65 <= age && !isSpecialShowing`. Then Java combines the result with a test of the `age < 18` condition. Imagine a 16-year-old kid buying a movie ticket on the day of a special showing. The condition `65 <= age && !isSpecialShowing` is `false`, but the condition `age < 18` is `true`. Because one of the two conditions on either side of the `||` operator is `true`, the whole nonparenthesized condition is `true` — and, to the theater management's dismay, the 16-year-old kid gets a discount ticket.

Sometimes, you can take advantage of Java's precedence rules and omit the parentheses in an expression. But I have a problem: I don't like memorizing precedence rules, and when I visit Java's online language specifications document (`https://docs.oracle.com/javase/specs/jls/se8/html`), I don't like figuring out how the rules apply to a particular condition.

When I create an expression like the one in Listing 5-5, I almost always use parentheses. In general, I use parentheses if I have any doubt about the way Java behaves without them. I also add parentheses when doing so makes the code easier to read.

Sometimes, if I'm not sure about stuff and I'm in a curious frame of mind, I write a quick Java program to test the precedence rules. For example, I run Listing 5-5 with and without the condition's parentheses. I send a 16-year-old kid to the movie theater when there's a special showing and see whether the kid ever gets a discount ticket. This little experiment shows me that the parentheses aren't optional.

IN THIS CHAPTER

- Getting input from the user
- Displaying all kinds of values
- Converting from one type of value to another

Chapter 6
Working with Java Types

"You can't fit a square peg into a round hole," or so the saying goes. In Java programming, the saying goes one step further: "Like all other developers, you sometimes make a mistake and try to fit a square peg into a round hole. Java's type system alerts you to the mistake and prevents you from running the flawed code."

Working with Strings

Chapter 5 introduces `int` values, `double` values, `String` values, and other kinds of values. Android doesn't let you mix these values willy-nilly. You can't plop an `int` value into a `TextView` component and expect things to go smoothly. `TextView` components want their contents to be `String` values.

But values don't live in vacuums. Sometimes you want to display a number such as an `int` value on the user's screen. So what can you do?

You can check some of the ideas in this section. That's what you can do.

Going from primitive types to strings

Chapter 5 gives you one way to get a `String` value from a numeric value: Put a plus sign between the numeric value and some other `String` value. For example, the expression

```
"" + 81
```

doesn't stand for the numeric value 81 (the amount eighty-one). Instead, it stands for the string `"81"` — a string consisting of the two digit characters, `'8'` followed by `'1'`.

Another way to go from a primitive type to a string is with one of Java's `toString` methods. Imagine that, in your code, the variable `amountTextView` refers to a `TextView` component that appears on the user's screen and that the variable `howMany` refers to an `int` value such as 21 or 456. To display the number `howMany` in the `TextView` component, you write

```
amountTextView.setText(Integer.toString(howMany));
```

If `howMany` refers to the number 21, the expression `Integer.toString(howMany)` refers to the Java `String` value `"21"`, and you can set a `TextView` component's text to the `String` value `"21"`.

CROSS-REFERENCE

For an introduction to `TextView` components, see Chapter 3.

The same kind of thing works for other primitive type values. For example, if the `double` variable `howMuch` refers to the value `32.785`, then the expression `Double.toString(howMuch)` refers to the `String` value `"32.785"`. If the `boolean` variable `isGood` refers to the value `true`, then `Boolean.toString(isGood)` refers to the `String` value `"true"`. If the `char` variable `oneLetter` refers to the single letter `'x'`, then the expression `Character.toString(oneLetter)` refers to the `String` value `"x"`.

The words `Integer`, `Double`, `Boolean`, and `Character` are the names of *wrapper types*. These types wrap the primitive types in additional functionality. For more information about wrapper types, see Chapter 12.

REMEMBER

Java's `System.out.println` displays just about any kind of value, including `String` values, `int` values, `double` values, and others. But the display doesn't appear on an Android device's screen. To display a value on a device's screen, you have to put the value into something like a `TextView` component or an `EditText` component. And Android's components can't directly display `int` values or `double` values. Fortunately, Android's components can directly display `String` values.

REMEMBER

To turn an `int` value into a `String`, you don't use `int.toString`. Instead, you use `Integer.toString`. Similarly, you don't use `double.toString`, `boolean.toString`, or `char.toString`. Instead, you use `Double.toString`, `Boolean.toString`, and `Character.toString`.

WARNING

Java's calculations with `double` values isn't always dead-on accurate. When you think your double variable `howMuch` refers to the value 32.785, the expression `Double.toString(howMuch)` might yield a string like `"32.78500001"`.

Going from strings to primitive types

In the previous section, you put an `int` value, a `double` value, or some other primitive type value into a `TextView` component. What about going in the opposite direction? You want to add 10 to some number that the user types in an `EditText` component. How do you get the value from the `EditText` component and turn it into an `int` value? You do it with a `toString` method and with one of Java's `parse` methods.

For example, imagine that the variable `amountEditText` refers to an `EditText` component that appears on the user's screen, and that `howMany` is an `int` variable. As long as the `amountEditText` contains a whole number, you can make `howMany` refer to that number with the following code:

```
howMany = Integer.parseInt(amountEditText.getText().toString());
```

Figure 6-1 shows you what kinds of values you have when you obtain an `int` value from an `EditText` component.

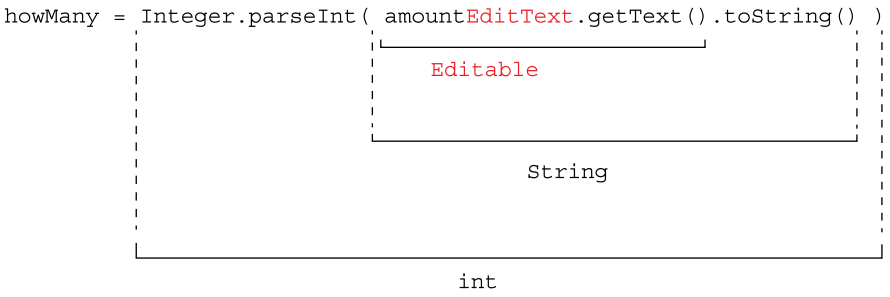


FIGURE 6-1: Getting an int value from a text field.

If the user types `21` into the `amountEditText`, the expression `amountEditText.getText()` refers to those two digits, `21`. Unfortunately, `amountEditText.getText()` isn't quite a Java `String` value. It's an `Editable` value (whatever that

means). To get a `String` value from an `Editable` value, you apply `toString`. So the expression `amountEditText.getText().toString()` is the `String` value `"21"`. Then, to get an `int` value from a `String`, you apply `Integer.parseInt`. The expression

```
Integer.parseInt(amountEditText.getText().toString())
```

refers to an `int` value, and if you want, you can add 10 to that `int` value.

The same kind of thing works for other primitive type values. For example, if the user types `105.796` into the `sizeEditText`, the expression

```
Integer.parseDouble(sizeEditText.getText().toString())
```

refers to the `double` value `105.796`.


TIP

If the user types `3.14159` or `cat` into an `EditText` component and you hit that component with the statement in Figure 6-1, your program crashes. Unfortunately, neither 3.14159 nor cat is a whole number, so the `Integer.parseInt` part of the statement simply explodes. Oops! You can prevent this calamity by using the Number and Number (Signed) items from the palette of Android Studio's Designer tool. (See Figure 6-2.) The *Number* item is an `EditText` component that accepts whole numbers with no sign. The *Number (Signed)* item is an `EditText` component that accepts positive, negative, and zero whole numbers. There's also a Number (Decimal) item for `double` values. Of course, it's a good idea for your code to do some extra checking to make sure that the stuff the user types in the `EditText` component is something that `Integer.parseInt` or `Double.parseInt` can handle. For this, you need Java's `if` statements or Java's exception handling features. To find out about `if` statements, see Chapter 8. And for some good reading about exception handling, see Chapter 13.

Getting input from the user

In Chapter 5, I promise that I can make meaningful use of Java's logical operators. With some information from the previous section, I can fulfill that promise. In Listing 6-1, the app gets two pieces of information from the user. The app gets a person's age, and gets a check or no-check, indicating a movie's special showing status.

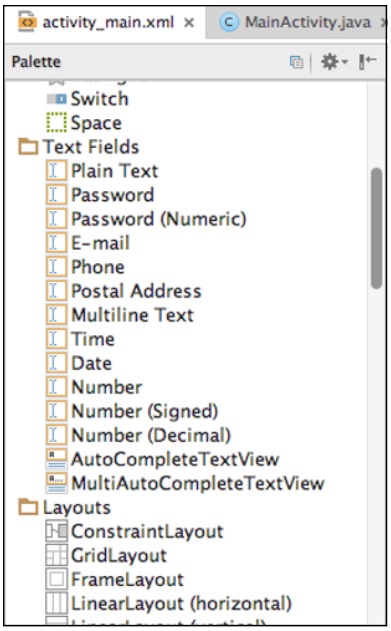


FIGURE 6-2: Some special text fields.

LISTING 6-1: **Going Back and Forth Between Strings and Primitives**

```
package com.allmycode.a06_01;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.CheckBox;
import android.widget.EditText;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  EditText ageEditText;
  CheckBox specialShowingCheckBox;
  TextView outputTextView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    ageEditText = (EditText) findViewById(R.id.ageEditText);
    specialShowingCheckBox =
                        (CheckBox) findViewById(R.id.specialShowingCheckBox);
```

(continued)

LISTING 6-1: *(continued)*

```
    outputTextView = (TextView) findViewById(R.id.outputTextView);
  }

  public void onButtonClick(View view) {
    int age = Integer.parseInt(ageEditText.getText().toString());
    boolean isSpecialShowing = specialShowingCheckBox.isChecked();

    boolean chargeDiscountPrice = (age < 18 || 65 <= age) && !isSpecialShowing;
    outputTextView.setText(Boolean.toString(chargeDiscountPrice));
  }
}
```

CROSS-REFERENCE

There's more to the app in Listing 6-1 than the code in Listing 6-1. To create this app, you have to design the layout with its text fields, its check box, and its button. You also have to set the button's `onClick` property to `"onButtonClick"`. I've described the steps for designing layouts and setting properties in Chapter 3.

Figures 6-3 and 6-4 show runs of the code in Listing 6-1.

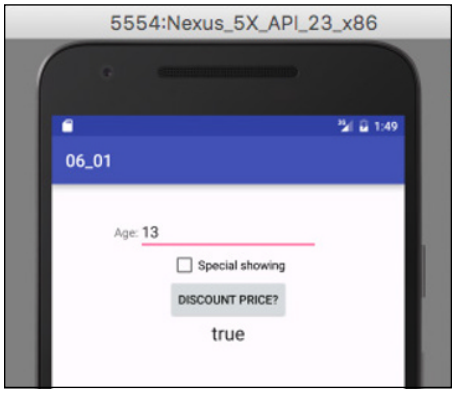


FIGURE 6-3: Getting a discounted movie ticket.

In Listing 6-1, the `age` variable gets its value using the tricks that I describe earlier in this chapter, in the "Going from strings to primitive types" section. And the `String` value for the `outputTextView` comes from the techniques earlier in this chapter, in the "Going from primitive types to strings" section.

Every check box has an `isChecked` method, and, in Listing 6-1, the `isSpecialShowing` variable gets its value from a call to the `isChecked` method. In Figure 6-3, the user hasn't selected the check box. So, when Android executes the code in Listing 6-1, the expression `specialShowingCheckBox.isChecked()` has the value `false`. But, in Figure 6-4, the user has selected the check box. So for

Figure 6-4, when Android executes the code in Listing 6-1, the expression `specialShowingCheckBox.isChecked()` has the value `true`.

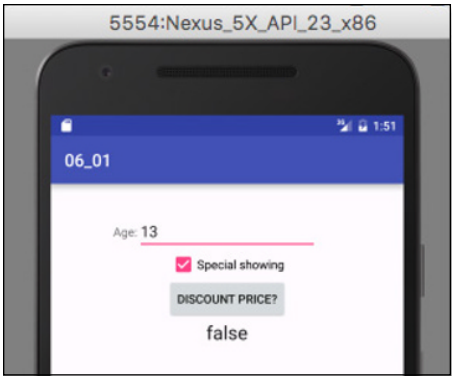


FIGURE 6-4: Paying the full price for a movie ticket.

CROSS-REFERENCE

To make the code in Listing 6-1 work, you have to associate the variable names `ageEditText`, `specialShowingCheckBox`, and `outputTextView` with the correct thingamajigs on the device's screen. The `findViewById` statements in Listing 6-1 help you do that. For details, refer to Chapter 3.

Practice Safe Typing

In the previous section, you convert primitive values to `String` values and `String` values to primitive values. It's very useful, but the story about converting values doesn't end there. Java is *fussy* about the types of its values. In Java, you can't even move seamlessly among the different kinds of primitive values. Here's an example:

By one measure, the average number of children per family in the United States in 2010 was 1.16. But by 2010, the Duggar family (featured on a well-known cable television show in the United States) had 19 children. Measuring the average family size in a population of 300 million people is tricky. But, no matter how you measure it, the average number of children has digits to the right of the decimal point. In my Java program, the average number of children is a `double` value. In contrast, the number of children in a particular family is an `int` value.

In Figure 6-5, I try to calculate the Duggar family's divergence from the national average. I don't even show you a run of this program, because the program doesn't work. It's defective. It's damaged goods. As cousin Jeb would say, "This program is a dance party on a leaky raft in a muddy river."

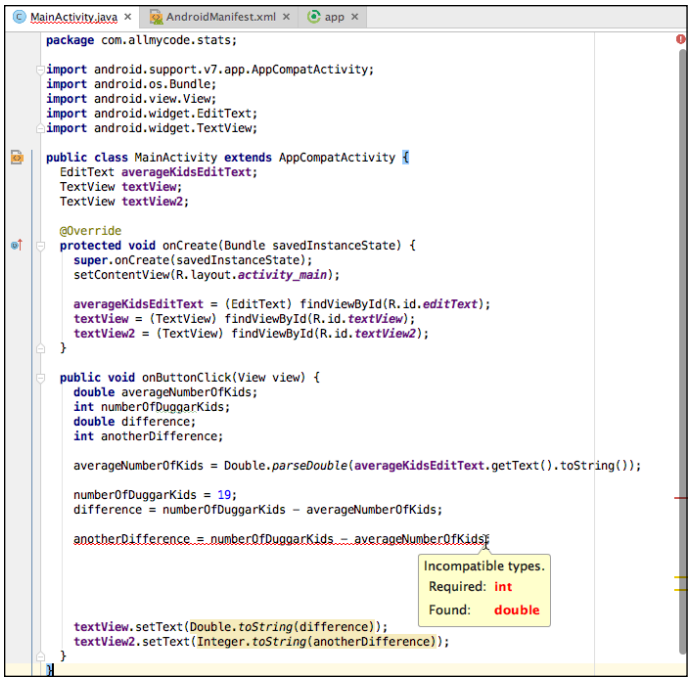


FIGURE 6-5: Trying to fit a square peg into a round hole.

The code in Figure 6-5 deals with `double` values (such as the `averageNumberOfKids` variable) and `int` values (such as the `numberOfDuggarKids` variable). You might plan to type `1` in the app's `averageKidsEditText`. But, because of the declaration

```
double averageNumberOfKids;
```

the value stored in the `averageNumberOfKids` variable is of type `double`. The user's typing `1` instead of `1.0` doesn't scare Java into storing anything but a `double` in the `averageNumberOfKids` variable.

The expression `numberOfDuggarKids - averageNumberOfKids` is an `int` minus a `double`, so (according to my sage advice in Chapter 5) the value of `numberOfDuggarKids - averageNumberOfKids` is of type `double`. Sure, if you type `1` in the `averageKidsEditText`, then `numberOfDuggarKids - averageNumberOfKids` is `18.0`, and `18.0` is sort of the same as the `int` value `18`. But Java doesn't like things to be "sort of the same."

Java's *strong typing* rules say that you can't assign a `double` value (like `18.0`) to an `int` variable (like `anotherDifference`). You don't lose any accuracy when you chop the *.0* off *18.0*. But with digits to the right of the decimal point (even with *0* to the right of the decimal point), Java doesn't trust you to stuff a `double` value

into an `int` variable. After all, rather than type `1.0` in the `averageKidsEditText`, you can type `0.9`. Then you'd definitely lose accuracy, from stuffing *18.1* into an `int` variable.

You can try to assure Java that things are okay by using a plain, old assignment statement, like this:

```
double averageNumberOfKids;
averageNumberOfKids = 1;
```

When you do, `numberOfDuggarKids – averageNumberOfKids` is always 18.0. Even so, Java doesn't like assigning 18.0 to the `int` variable `anotherDifference`. This statement is still illegal:

```
anotherDifference = numberOfDuggarKids – averageNumberOfKids;
```


WARNING

When you put numbers in your Java code (such as `1` in the previous paragraph or the number `19` in Figure 6-5), you *hardcode* the values. In this book, my liberal use of hardcoding keeps the examples simple and (more importantly) concrete. But in real applications, hardcoding is generally a bad idea. When you hardcode a value, you make it difficult to change. In fact, the only way to change a hardcoded value is to tinker with the Java code, and all code (written in Java or not) can be brittle. It's much safer to input values in a dialog box than to change a value in a piece of code. If getting a value from a dialog box doesn't suit your needs, you can create a name for the value using Java's `final` keyword. (See Chapter 5.) You can even read the value from the device's SD card.

Remember to do as I say and not as I do. Avoid hardcoding values in your programs.

Widening is good; narrowing is bad

Java prevents you from making any assignment that potentially *narrows* a value, as shown in Figure 6-6. For example, with the declarations

```
int numberOfDuggarKids = 19;
long lotsAndLotsOfKids;
```

the following attempt to narrow from a `long` value to an `int` value is illegal:

```
numberOfDuggarKids = lotsAndLotsOfKids; //Don't do this!
```

An attempt to *widen* from an `int` value to a `long` value, however, is fine:

```
lotsAndLotsOfKids = numberOfDuggarKids;
```

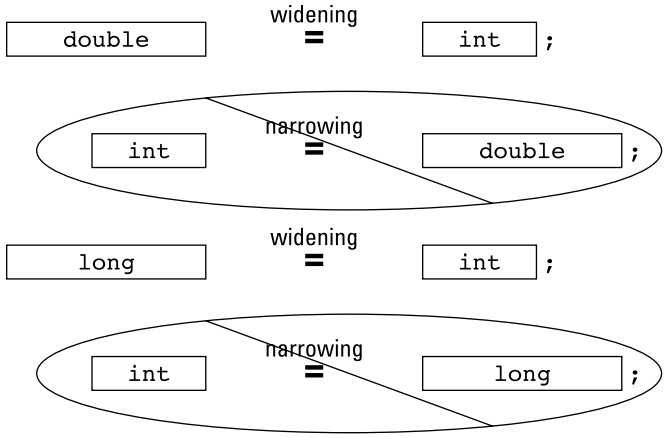


FIGURE 6-6: Widening and narrowing.

Earlier, in fact, in Figure 6-5, I subtract a `double` value from an `int` value with no trouble at all:

```
double averageNumberOfKids;
int numberOfDuggarKids;
double difference;

difference = numberOfDuggarKids - averageNumberOfKids;
```

Combining a `double` value with an `int` value is legal because Java automatically widens the `int` value.

Incompatible types

Aside from the technical terms *narrowing* and *widening*, there's another possibility — plain, old incompatibility — trying to fit one element into another when the two have nothing in common and have no hope of ever being mistaken for one another. You can't assign an `int` value to a `boolean` value or assign a `boolean` value to an `int` value:

```
int numberOfDuggarKids;
boolean isLarge;
numberOfDuggarKids = isLarge; //Don't do this!
isLarge = numberOfDuggarKids; //Don't do this!
```

You can't do either assignment, because `boolean` values aren't numeric. In other words, neither of these assignments makes sense.

REMEMBER

Java is a *strongly typed* programming language. It doesn't let you make assignments that might result in a loss of accuracy or in outright nonsense.

Using a hammer to bang a peg into a hole

In some cases, you can circumvent Java's prohibition against narrowing by *casting* a value. For example, you can create the `long` variable `lotsAndLotsOfKids` and make the assignment `numberOfDuggarKids = (int) lotsAndLotsOfKids`, as shown in Listing 6-2.

LISTING 6-2: Casting to the Rescue

```
package com.allmycode.a06_02;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  TextView numberTextView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
    numberTextView = (TextView) findViewById(R.id.numberTextView);
  }

  public void onButtonClick(View view) {
    long lotsAndLotsOfKids = 2147483647;
    int numberOfDuggarKids;

    numberOfDuggarKids = (int) lotsAndLotsOfKids;

    numberTextView.setText(Integer.toString(numberOfDuggarKids));
  }
}
```

In Listing 6-2, the type name `(int)` in parentheses is a *cast operator.* It tells Java that you're aware of the potential pitfalls of stuffing a `long` value into an `int` variable and that you're willing to take your chances.

When you run the code in Listing 6-2, the value of `lotsAndLotsOfKids` might be between –2147483648 and 2147483647. If so, the assignment `numberOfDuggarKids = (int) lotsAndLotsOfKids` is just fine. (***Remember:*** An `int` value can be between –2147483648 and 2147483647. Refer to Table 5-1 in Chapter 5.)

But if the value of `lotsAndLotsOfKids` isn't between –2147483648 and 2147483647, the assignment statement in Listing 6-2 goes awry. When I run the code in Listing 6-2 with the different initialization

```
long lotsAndLotsOfKids = 2098797070970970956L;
```

the value of `numberOfDuggarKids`. becomes –287644852 (a negative number!).

When you use a casting operator, you're telling Java, "I'm aware that I'm doing something risky but (trust me) I know what I'm doing." And if you don't know what you're doing, you get a wrong answer. That's life!

IN THIS CHAPTER

- Matching Java types
- Calling methods effectively
- Understanding method parameters

Chapter 7

Though These Be Methods, Yet There Is Madness in't

In Chapter 4, I compare a method declaration to a recipe for scrambled eggs. In this chapter, I compute the tax and tip for a meal in a restaurant. And in Chapter 9 (spoiler alert!), I compare a Java class to the inventory in a cheese emporium. These comparisons aren't far-fetched. A method's declaration is a lot like a recipe, and a Java class bears some resemblance to a blank inventory sheet. But instead of thinking about methods, recipes, and Java classes, you might be reading between the lines. You might be wondering why I use so many food metaphors.

The truth is, my preoccupation with food is a recent development. Like most men my age, I've been told that I should shed my bad habits, lose a few pounds, exercise regularly, and find ways to reduce the stress in my life. (I've argued to my Wiley editors that submission deadlines are a source of stress, but so far the editors aren't buying a word of it. I guess I don't blame them.)

Above all, I've been told to adopt a healthy diet: Skip the chocolate, the cheeseburgers, the pizza, the fatty foods, the fried foods, the sugary snacks, and everything else that I normally eat. Instead, eat small portions of vegetables, carbs, and

protein, and eat these things only at regularly scheduled meals. Sounds sensible, doesn't it?

I'm making a sincere effort. I've been eating right for about two weeks. My feelings of health and well-being are steadily improving. I'm only slightly hungry. (Actually, by "slightly hungry," I mean "extremely hungry." Yesterday I suffered a brief hallucination, believing that my computer keyboard was a giant Hershey's bar. And this morning I felt like gnawing on my office furniture. If I start trying to peel my mouse, I'll stop writing and go out for a snack.)

One way or another, the gustatory arena provides many fine metaphors for Java programming. A method's declaration is like a recipe. A declaration sits quietly, doing nothing, waiting to be executed. If you create a declaration but no one ever calls your declaration, then — like a recipe for worm stew — your declaration goes unexecuted.

On the other hand, a method call is a call to action — a command to follow the declaration's recipe. When you call a method, the method's declaration wakes up and follows the instructions inside the body of the declaration.

In addition, a method call may contain parameters. You call

```
textEdit.setText("Don't vote for that narcissist!");
```

with the parameter `"Don't vote for that narcissist!"`. The parameter, `"Don't vote for that narcissist!"` tells Android exactly what to display in the `textEdit` component on the user's screen. In the world of food, you might call `meatLoaf(6)`, which means, "Follow the meatloaf recipe, and make enough to serve six people."

Minding Your Types When You Call a Method

In Chapter 4, I introduce method parameters. And in Chapters 5 and 6, I make a big fuss about Java types. In this section, I pull those two ideas together.

A method call involves values going both ways — from the call to the running method and from the running method back to the call. Consider the code in Listing 7-1.

LISTING 7-1: **Parameter Types and Return Types**

```
package com.allmycode.a07_01;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.view.View;
import android.widget.TextView;

import java.text.NumberFormat;

public class MainActivity extends AppCompatActivity {
  TextView paymentView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    paymentView = (TextView) findViewById(R.id.paymentView);
  }

  public void onButtonClick(View view) {
    double principal = 100000.00, ratePercent = 5.25;
    double payment;
    int years = 30;
    String paymentString;

    payment = monthlyPayment(principal, ratePercent, years);

    NumberFormat currency = NumberFormat.getCurrencyInstance();
    paymentString = currency.format(payment);
    paymentView.setText(paymentString);
  }

  double monthlyPayment(double dPrincipal, double dRatePercent, int dYears) {
    double rate, effectiveAnnualRate;
    int paymentsPerYear = 12, numberOfPayments;

    rate = dRatePercent / 100.00;
    numberOfPayments = paymentsPerYear * dYears;
    effectiveAnnualRate = rate / paymentsPerYear;
```

(continued)

LISTING 7-1: *(continued)*

```
    return dPrincipal * (effectiveAnnualRate /
        (1 - Math.pow(1 + effectiveAnnualRate, -numberOfPayments)));
  }

}
```

Figure 7-1 shows a run of the code in Listing 7-1.

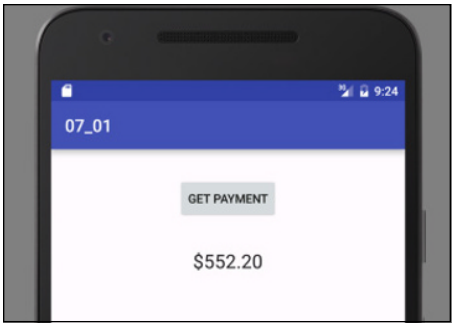


FIGURE 7-1: Pay it and weep.

In Listing 7-1, I choose the parameter names `principal` and `dPrincipal`, `ratePercent` and `dRatePercent`, and `years` and `dYears`. I use the letter `d` to distinguish a declaration's parameter from a call's parameter. I do this to drive home the point that the names in the call aren't automatically the same as the names in the declaration. In fact, there are many variations on this call/declaration naming theme, and they're all correct. For example, you can use the same names in the call as in the declaration:

```
//In the call:
payment = monthlyPayment(principal, ratePercent, years);

//In the declaration:
double monthlyPayment(double principal, double ratePercent, int years) {
```

You can use expressions in the call that aren't single variable names:

```
//In the call:
payment = monthlyPayment(amount + fees, rate * 100, 30);

//In the declaration:
double monthlyPayment(double dPrincipal, double dRatePercent, int dYears) {
```

When you call a method from Java's API, you don't even know the names of parameters used in the method's declaration. And you don't care. The only things that matter are the positions of parameters in the list and the compatibility of the parameters. The value of the call's leftmost parameter becomes the value of the declaration's leftmost parameter, no matter what name the declaration's leftmost parameter has. The value of the call's second parameter becomes the value of the declaration's second parameter, no matter what name the declaration's second parameter has. And so on.

REMEMBER

In this section's example, I hardcode the values of the variables `principal`, `ratePercent`, and `years`, making Listing 7-1 useless for anything except one particular calculation. The only people who hardcode values are book authors and bad programmers. In a real app, you'd probably get values for these variables from `EditText` components on the user's screen. If you didn't have `EditText` components, you'd manage to get the values for `principal`, `ratePercent`, and `years` some other way.

Method parameters and Java types

Listing 7-1 contains both the declaration and a call for the `monthlyPayment` method. Figure 7-2 illustrates the type matches between these two parts of the program.

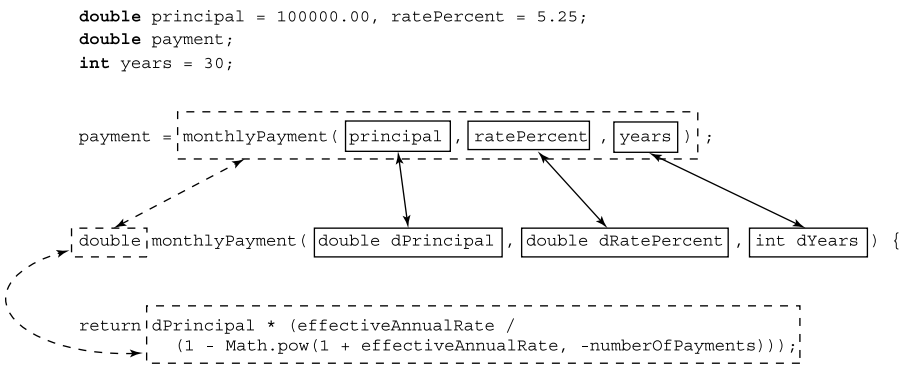


FIGURE 7-2: Each value fits like a glove.

In Figure 7-2, the `monthlyPayment` method call has three parameters, and the `monthlyPayment` declaration's header has three parameters. The call's three parameters have the types `double` and then `double` and then `int`:

```
double principal = 100000.00, ratePercent = 5.25;
...
int years = 30;

payment = monthlyPayment(principal, ratePercent, years);
```

And sure enough, the declaration's three parameters have the types `double` and then `double` and then `int`:

```
double monthlyPayment(double dPrincipal, double dRatePercent, int dYears) {
```

The expressions in the call must have types that are compatible with the corresponding parameters in the method's declaration. But "compatible" doesn't necessarily mean "exactly the same." You can take advantage of widening, which I describe in Chapter 6. For example, in Listing 7-1, the following call would be okay:

```
payment = monthlyPayment(100000, 5, years);
```

You can pass an `int` value (like `100000`) to the `dPrincipal` parameter, because the `dPrincipal` parameter is of type `double`. Java widens the values `100000` and `5` to the values `100000.0` and `5.0`. But, once again, Java doesn't narrow your values. The following call causes a squiggly red underline in Android Studio's editor:

```
payment = monthlyPayment(principal, ratePercent, 30.0);
```

You can't stuff a `double` value (like `30.0`) into the `dYears` parameter, because the `dYears` parameter is of type `int`.

If at first you don't succeed . . .

If you don't like the types of the parameters in a method declaration, you can take matters into your own hands. You can create another method declaration with the same name but with different parameter types. For example, in Listing 7-1, you can add a method with the following header:

```
double monthlyPayment(String lenderName, String borrowerName, double amount) {
```

In other words, you can overload a method name. Java figures out which method declaration to use by looking for a match with the types of parameters in the method call. For more information about overloading, refer to Chapter 4.

Return types

A method declaration's header normally looks like this:

```
maybeSomeWords returnType methodName(parameters) {
```

For example, Listing 7-1 contains a method declaration with the following header:

```
double monthlyPayment(double dPrincipal, double dRatePercent, int dYears) {
```

In this header, the *returnType* is `double`, the *methodName* is `monthlyPayment`, and the *parameters* are `double dPrincipal, double dRatePercent, int dYears`.

An entire method call can have a value, and the declaration's `returnType` tells Java what type that value has. In Listing 7-1, the `returnType` is `double`, so the call

```
monthlyPayment(principal, ratePercent, years)
```

has a value of type `double`. (Refer to Figure 7-2.)

I hardcoded the values of `principal`, `ratePercent`, and `years` in Listing 7-1. So when you run Listing 7-1, the value of the `monthlyPayment` method call is always 552.20. The call's value is whatever comes after the word `return` when the method is executed. And in Listing 7-1, the expression

```
return dPrincipal * (effectiveAnnualRate /
        (1 - Math.pow(1 + effectiveAnnualRate, -numberOfPayments)));
```

always comes out to be 552.20. Also, in keeping with the theme of type safety, the expression after the word `return` is of type `double`.

In summary, a call to the `monthlyPayment` method has the *return value* 552.20 and has the *return type* `double`.

The great void

A method to compute a monthly mortgage payment naturally returns a value. But some methods have no reason to return a value. Consider, for example, the `onButtonClick` method in Listing 7-1. This method's purpose is to make text appear in the `paymentView`. That's not what you'd call a calculation, and it's not the kind of work that ends up with an answer of some kind. So, in Listing 7-1, the `onButtonClick` method doesn't return a value of any kind.

In Listing 7-1, the `onButtonClick` method doesn't return a value, so the method's body has no `return` statement. And, in place of a return type, the header in the method's declaration contains the word `void`.

To be painfully precise, you can put a `return` statement in a method that doesn't return a value. When you do, the `return` statement has no expression. It's just one word, `return`, followed by a semicolon. When Java executes this `return` statement, Java ends the run of the method and returns to the code that called the method. This form of the `return` statement works well in a situation in which you want to end the execution of a method before you reach the last statement in the method's declaration.

Displaying numbers

Here are a few lines that are scattered about in Listing 7-1:

```
import java.text.NumberFormat;

NumberFormat currency = NumberFormat.getCurrencyInstance();
paymentString = currency.format(payment);
```

Taken together, these statements format numbers into local currency amounts. On my phone, when I call `getCurrencyInstance()` with no parameters, I get a number (like `$552.20`) formatted for United States currency. (Refer to Figure 7-1.) But if your phone is set to run in Germany, you see the payment amount shown in Figure 7-3.

FIGURE 7-3: Displaying the euro symbol and a comma for the decimal separator.

A country, its native language, or a variant of the native language is a *locale*. And by adding a parameter to the `getCurrencyInstance` call, you can format for locales other than your own. For example, by calling

```
NumberFormat.getCurrencyInstance(Locale.GERMANY)
```

anyone in any country can get the message box shown in Figure 7-3.

You can even cobble together a locale from a bunch of pieces. For example, one variant of the Thai language uses its own, special digit symbols. (See Figure 7-4.) To form a number with Thai digits, you write

```
NumberFormat.getCurrencyInstance(new Locale("th", "TH", "TH"))
```

In the list `("th", "TH", "TH")`, the lowercase `"th"` stands for the Thai language. The first uppercase `"TH"` stands for the country Thailand. The last uppercase `"TH"` indicates the language variant that uses its own digit symbols.

FIGURE 7-4: Thai digit symbols.

Primitive Types and Pass-by Value

Java has two kinds of types: primitive and reference. The eight primitive types are the atoms — the basic building blocks. In contrast, the reference types are the things you create by combining primitive types (and by combining other reference types).

CROSS-REFERENCE

I cover Java's primitive types in Chapter 5, and my coverage of Java's reference types begins in Chapter 9.

Here are two concepts you should remember when you think about primitive types and method parameters:

- **When you assign a value to a variable with a primitive type, you're identifying that variable name with the value.**

  The same is true when you initialize a primitive type variable to a particular value.

- **When you call a method, you're *making copies* of each of the call's parameter values and initializing the declaration's parameters with those copied values.**

This scheme, in which you make copies of the call's values, is named *pass by value*. Listing 7-2 shows you why you should care about any of this.

LISTING 7-2: **Rack Up Those Points!**

```
package com.allmycode.a07_02;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;
```

(continued)

LISTING 7-2: *(continued)*

```
public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
    textView = (TextView) findViewById(R.id.textView);

    int score = 50000;
    int points = 1000;
    addPoints(score, points);
    textView.setText(Integer.toString(score));
  }

  void addPoints(int score, int points) {
    score += points;
  }

}
```

In Listing 7-2, the `addPoints` method uses Java's compound assignment operator to add 1000 (the value of `points`) to the existing `score` (which is 50000). To make things as cozy as possible, I've used the same parameter names in the method call and the method declaration. (In both, I use the names `score` and `points`.)

So what happens when I run the code in Listing 7-2? I get the result shown in Figure 7-5.

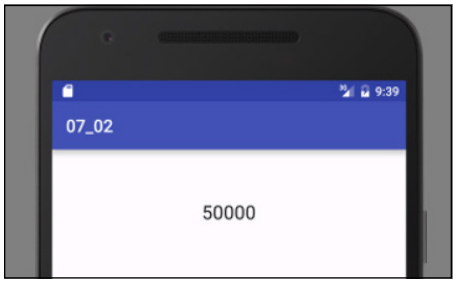


FIGURE 7-5: Getting 1000 more points?

But wait! When you add 1000 to 50000, you don't normally get 50000. What's wrong?

With Java's pass-by value feature, you *make a copy* of each parameter value in a call. You initialize the declaration's parameters with the copied values. So, immediately after making the call, you have two pairs of variables: the original `score` and `points` variables in the `onCreate` method and the new `score` and `points` variables in the `addPoints` method. The new `score` and `points` variables have copies of values from the `onCreate` method. (See Figure 7-6.)

PERILS AND PITFALLS OF PARAMETER PASSING

How would you like to change the value of 2 + 2? What would you like 2 + 2 to be? Six? Ten? Three hundred? In certain older versions of the FORTRAN programming language, you could make 2 + 2 be almost anything you wanted. For example, the following chunk of code (translated to look like Java code) would display 6 for the value of 2 + 2:

```
void increment(int score) {
  score++;
}
...
increment(2);
print(2 + 2);
```

When computer languages were first being developed, their creators didn't realize how complicated parameter passing can be. They weren't as careful about specifying the rules for copying parameters' values or for doing whatever else they wanted to do with parameters. As a result, some versions of FORTRAN indiscriminately passed memory addresses rather than values. Though address-passing alone isn't a terrible idea, things become ugly if the language designer isn't careful.

In some early FORTRAN implementations, the computer automatically (and without warning) turned the literal `2` into a variable named `two`. (In fact, the newly created variable probably wasn't named `two`. But in this story, the actual name of the variable doesn't matter.) FORTRAN would substitute the variable name `two` in any place where the programmer typed the literal value `2`. But then, while running this sidebar's code, the computer would send the address of the `two` variable to the `increment` method. The method would happily add 1 to whatever was stored in the `two` variable and then continue its work. Now the `two` variable stored the number 3. By the time you reached the `print` call, the computer would add to itself whatever was in `two`, getting 3 + 3, which is 6.

If you think parameter passing is a no-brainer, think again. Different languages use all different kinds of parameter passing. And in many situations, the minute details of the way parameters are passed makes a big difference.

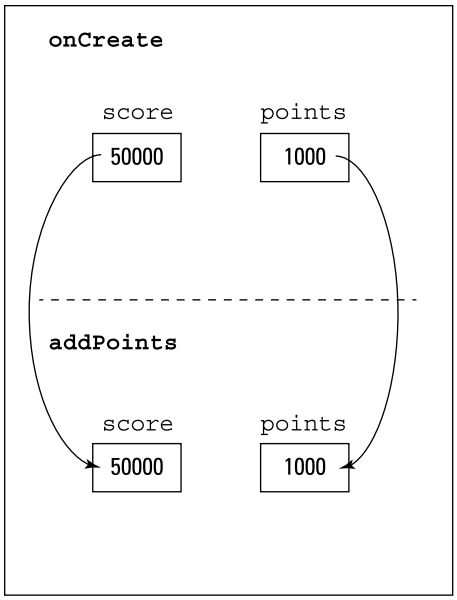


FIGURE 7-6: Java makes copies of the values of variables.

The statement in the body of the `addPoints` method adds 1000 to the value stored in its `score` variable. After adding 1000 points, the program's variables look like the stuff shown in Figure 7-7.

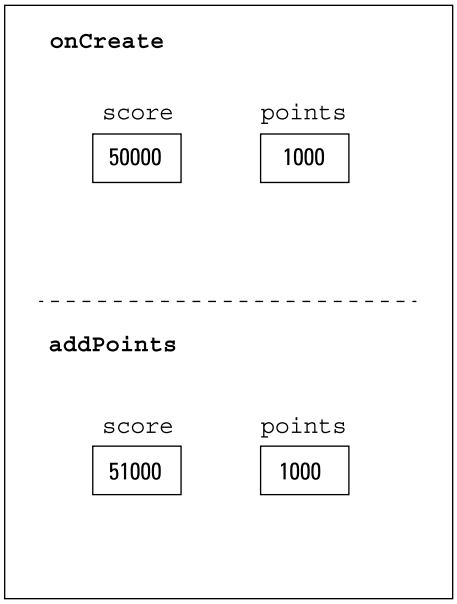


FIGURE 7-7: Java adds 1000 to only one of the two score variables.

Notice how the value of the `onCreate` method's `score` variable remains unchanged. After returning from the call to `addPoints`, the `addPoints` method's variables disappear. All that remains is the original `onCreate` method and its variables. (See Figure 7-8.)

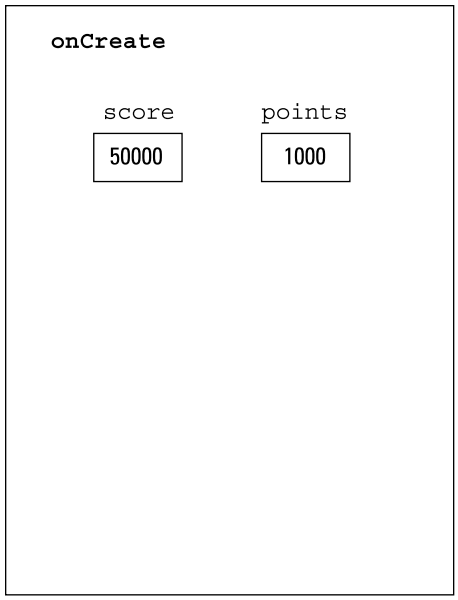


FIGURE 7-8: The variable with value 51000 no longer exists.

Finally, in Listing 7-2, Java calls `textView.setText` to display the value of the `onCreate` method's `score` variable. And (sadly, for the game player) the value of `score` is still 50000.

What's a developer to do?

The program in Listing 7-2 has a big, fat bug. The program doesn't add 1000 to a player's score. That's bad.

You can squash the bug in Listing 7-2 in several different ways. For example, you can avoid calling the `addPoints` method by inserting `score += points` along with the other code in the `onCreate` method.

```
int score = 50000;
int points = 1000;
score += points;
textView.setText(Integer.toString(score));
```

But that's not a satisfactory solution. Methods such as `addPoints` are useful for dividing work into neat, understandable chunks. And avoiding problems by skirting around them is no fun at all.

A better way to get rid of the bug is to make the `addPoints` method return a value. Listing 7-3 has the code.

LISTING 7-3: A New-and-Improved Scorekeeper Program

```
package com.allmycode.a07_03;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
    textView = (TextView) findViewById(R.id.textView);

    int score = 50000;
    int points = 1000;
    score = addPoints(score, points);
    textView.setText(Integer.toString(score));
  }

  int addPoints(int score, int points) {
    return score + points;
  }

}
```

In Listing 7-3, the new-and-improved `addPoints` method returns an `int` value — namely, the value of `score + points`. So the value of the `addPoints(score, points)` call is 51000. Finally, I change the value of `score` by assigning the method call's value, 51000, to the `score` variable.

TECHNICAL STUFF

Java's nitpicky rules ensure that the juggling of the `score` variable's values is reliable and predictable. In the statement `score = addPoints(score, points)`, there's no conflict between the old value of `score` (50000 in the `addPoints` parameter list) and the new value of `score` (51000 on the left side of the assignment statement).

A run of the code in Listing 7-3 is shown in Figure 7-9. You probably already know what the run looks like. (After all, 50000 + 1000 is 51000.) But I can't bear to finish this example without showing the correct answer.

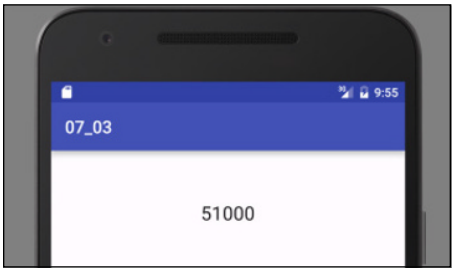


FIGURE 7-9: At last, a higher score!

CROSS-REFERENCE

Making `addPoints` return a value isn't the only way to correct the problem in Listing 7-2. At least two other ways (using member variables and passing objects) are among the subjects of discussion in Chapter 9.

A final word

The program in Listing 7-4 displays the total cost of a $100 meal.

LISTING 7-4: **Yet Another Food Example**

```
package com.allmycode.a07_04;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.TextView;

import java.text.NumberFormat;

public class MainActivity extends AppCompatActivity {
  TextView totalView;
```

(continued)

LISTING 7-4: *(continued)*

```
  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
    totalView = (TextView) findViewById(R.id.totalView);
  }

  public void onButtonClick(View view) {
    NumberFormat currency = NumberFormat.getCurrencyInstance();
    totalView.setText(currency.format(addAll(100.00, 0.05, 0.20)));
  }

  double addAll(double bill, double taxRate, double tipRate) {
    bill *= 1 + taxRate;
    bill *= 1 + tipRate;
    return bill;
  }

}
```

A run of the program in Listing 7-4 is shown in Figure 7-10.

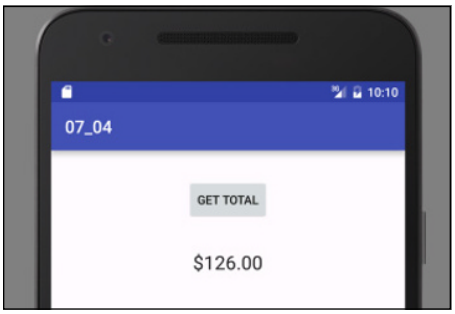


FIGURE 7-10: Support your local eating establishment.

Listing 7-4 is nice, but this code computes the tip after the tax has been added to the original bill. Some of my less generous friends believe that the tip should be based on only the amount of the original bill. (Guys, you know who you are!) They believe that the code should compute the tax but that it should remember and reuse the original $100.00 amount when calculating the tip. Here's my friends' version of the `addAll` method:

```
double addAll(double bill, double taxRate, double tipRate) {
  double originalBill = bill;
  bill *= 1 + taxRate;
  bill += originalBill * tipRate;
  return bill;
}
```

The new (stingier) total is shown in Figure 7-11.

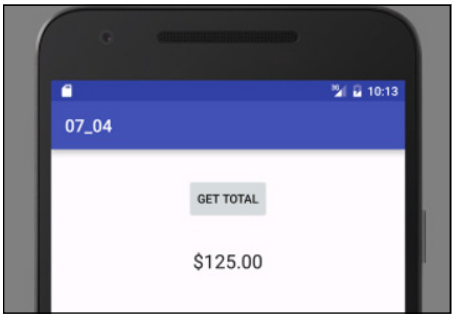


FIGURE 7-11: A dollar saved is a dollar earned.

The revised `addAll` method is overly complicated. (In fact, in creating this example, I got this little method wrong two or three times before getting it right.) Wouldn't it be simpler to insist that the `bill` parameter's value never changes? Rather than mess with the `bill` amount, you make up new variables named `tax` and `tip` and total everything in the `return` statement:

```
double addAll(double bill, double taxRate, double tipRate) {
  double tax = bill * taxRate;
  double tip = bill * tipRate;
  return bill + tax + tip;
}
```

When you have these new `tax` and `tip` variables, the `bill` parameter always stores its original value — the value of the untaxed, untipped meal.

After developing this improved code, you make a mental note that the `bill` variable's value shouldn't change. Months later, when your users are paying big bucks for your app and demanding many more features, you might turn the program into a complicated, all-purpose meal calculator with localized currencies and tipping etiquette from around the world. Whatever you do, you always want easy access to that original `bill` value.

After your app has gone viral, you're distracted by the need to count your earnings, pay your servants, and maintain the fresh smell of your private jet's leather

seats. With all these pressing issues, you accidentally forget your old promise not to change the `bill` variable. You change the variable's value somewhere in the middle of your 1000-line program. Now you've messed everything up.

But wait! You can have Java remind you that the `bill` parameter's value doesn't change. To do this, you add the keyword `final` (one of Java's modifiers) to the method declaration's parameter list. And while you're at it, you can add `final` to the other parameters (`taxRate` and `tipRate`) in the `addAll` method's parameter list:

```
double addAll (final double bill, final double taxRate, final double tipRate) {
  double tax = bill * taxRate;
  double tip = bill * tipRate;
  return bill + tax + tip;
}
```

With this use of the word `final`, you're telling Java not to let you change a parameter's value. If you plug the newest version of `addAll` into the code in Listing 7-4, `bill` becomes 100.00 and `bill` stays 100.00 throughout the execution of the `addAll` method. If you accidentally add the statement

```
bill += valetParkingFee;
```

to your code, Android Studio flags that line as an error because a `final` parameter's value cannot be changed. Isn't it nice to know that, with servants to manage and your private jet to maintain, you can still rely on Java to help you write a good Android app?

IN THIS CHAPTER

- Making decisions with Java statements
- Repeating actions with Java statements

Chapter 8
What Java Does (and When)

Human thought centers around nouns and verbs. Nouns are the "stuff," and verbs are the stuff's actions. Nouns are the pieces, and verbs are the glue. Nouns are, and verbs do. When you use nouns, you say "book," "room," or "stuff." When you use verbs, you say "do this," "do that," "tote that barge," or "lift that bale."

Java also has nouns and verbs. Java's nouns include `int` and `String`, along with Android-specific terms such as `AppCompatActivity`, `EditText`, and `TextView`. Java's verbs involve assigning values, choosing among alternatives, repeating actions, and taking other courses of action.

This chapter covers some of Java's verbs. (In the next chapter, I bring in the nouns.)

Making Decisions

When you're writing Java programs, you're continually hitting forks in roads. Did the user type the correct password? If the answer is yes, let the user work; if it's no, kick the bum out. The Java programming language needs a way to make a program branch in one of two directions. Fortunately, the language has a way: It's the `if` statement. The use of the `if` statement is illustrated in Listing 8-1.

LISTING 8-1: **Using an if Statement**

```
package com.allmycode.a08_01;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.CheckBox;
import android.widget.EditText;
import android.widget.TextView;

import java.text.NumberFormat;

public class MainActivity extends AppCompatActivity {
  EditText ageEditText;
  CheckBox specialShowingCheckBox;
  TextView outputView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    ageEditText = (EditText) findViewById(R.id.ageEditText);
    specialShowingCheckBox =
        (CheckBox) findViewById(R.id.specialShowingCheckBox);
    outputView = (TextView) findViewById(R.id.outputView);
  }

  public void onButtonClick(View view) {
    int age = Integer.parseInt(ageEditText.getText().toString());
    boolean isSpecialShowing = specialShowingCheckBox.isChecked();
    double price;
    NumberFormat currency = NumberFormat.getCurrencyInstance();

    if ((age < 18 || 65 <= age) && !isSpecialShowing) {
      price = 7.00;
    } else {
      price = 10.00;
    }

    outputView.setText(currency.format(price));
  }
}
```

Listing 8-1 revives a question that I pose in Chapters 5 and 6: How much should a person pay for a movie ticket? Most people pay $10. But when the movie has no special showings, youngsters (under 18) and seniors (65 and older) pay only $7.

In Listing 8-1, a Java `if` statement determines a person's eligibility for the discounted ticket. If this condition is true:

```
(age < 18 || 65 <= age) && !isSpecialShowing
```

the `price` becomes `7.00`; otherwise, the `price` becomes `10.00`. In either case, the code displays the `price` in a `TextView` component. (See Figure 8-1.)

FIGURE 8-1: Checking the ticket price.

Java if statements

An `if` statement has this form:

```
if (condition) {
    statements to be executed when the condition is true
} else {
    statements to be executed when the condition is false
}
```

In Listing 8-1, the condition being tested is

```
(age < 18 || 65 <= age) && !isSpecialShowing
```

The condition is either `true` or `false` — `true` for youngsters and seniors when there's no special showing and `false` otherwise.

Conditions in if statements

The condition in an `if` statement must be enclosed in parentheses. The condition must be a `boolean` expression — an expression whose value is either `true` or `false`. For example, the following condition is okay:

```
if (numberOfTries < 17) {
```

But the strange kind of condition that you can use in other (non-Java) languages — languages such as C++ — is not okay:

```
if (17) { //This is incorrect.
```

CROSS-REFERENCE

See Chapter 5 for information about Java's primitive types, including the `boolean` type.

Omitting braces

You can omit an `if` statement's curly braces when only one statement appears between the condition and the word `else`. You can also omit braces when only one statement appears after the word `else`. For example, the following chunk of code is right and proper:

```
if ((age < 18 || 65 <= age) && !isSpecialShowing)
  price = 7.00;
else
  price = 10.00;
```

The code is correct because only one statement (`price = 7.00`) appears between the condition and the `else`, and only one statement (`price = 10.00`) appears after the word `else`.

An `if` statement can also enjoy a full and happy life without an `else` part. The following code snippet contains an assignment statement followed by a complete `if` statement:

```
price = 10.00;
if ((age < 18 || 65 <= age) && !isSpecialShowing)
  price = 7.00;
```

Compound statements

An `if` statement is one of Java's *compound* statements because an `if` statement normally contains other Java statements. For example, the `if` statement in Listing 8-1 contains the two assignment statements `price = 7.00` and `price = 10.00`.

A compound statement might even contain other compound statements. In this example:

```
price = 10.00;
if (age < 18 || 65 <= age) {
  if (!isSpecialShowing) {
    price = 7.00;
  }
}
```

one `if` statement (with the condition `age < 18 || 65 <= age`) contains another `if` statement (with the condition `!isSpecialShowing`).

Choosing among many alternatives

A Java `if` statement creates a fork in the road: Java chooses between two alternatives. But some problems lend themselves to forks with many prongs. What's the best way to decide among five or six alternative actions?

For me, multipronged forks are scary. In my daily life, I hate making decisions. (If a problem crops up, I would rather have it be someone else's fault.) So, writing the previous sections (on making decisions with Java's `if` statement) knocked the stuffing right out of me. That's why my mind boggles as I begin this section on choosing among many alternatives.

This section's example is a tiny calculator. The user types in two numbers and then presses one of four buttons. I label the buttons with the symbols of the four common arithmetic operations. See Figure 8-2.

FIGURE 8-2: Running a tiny calculator app.

When I create the four buttons, I give each button an `id` value. How about the names `buttonAdd`, `buttonSubtract`, `buttonMultiply`, and `buttonDivide` for the buttons' `id` values? That sounds good.

CROSS-REFERENCE

For a reminder about `id` values, refer to Chapter 3.

I also give each button an `onClick` attribute. In fact, I set each button's `onClick` attribute to the name `onButtonClick`. So if the user clicks one of the buttons, Android calls my activity's `onButtonClick` method.

But wait! Any of the four buttons sends Android to my activity's `onButtonClick` method. How does my code know which of the buttons the user clicked? Listing 8-2 has the answer.

LISTING 8-2: **Switching from One Button to Another**

```
package com.allmycode.a08_02;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.EditText;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  EditText numberLeftEditText, numberRightEditText;
  TextView operatorView, resultView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    numberLeftEditText = (EditText) findViewById(R.id.numberLeftEditText);
    numberRightEditText = (EditText) findViewById(R.id.numberRightEditText);
    operatorView = (TextView) findViewById(R.id.operatorView);
    resultView = (TextView) findViewById(R.id.resultView);
  }

  public void onButtonClick(View view) {
    double numberLeft =
        Double.parseDouble(numberLeftEditText.getText().toString());
    double numberRight =
        Double.parseDouble(numberRightEditText.getText().toString());
```

```
    String operatorSymbol = "";
    double result;

    switch (view.getId()) {
      case R.id.buttonAdd:
        operatorSymbol = "+";
        result = numberLeft + numberRight;
        break;
      case R.id.buttonSubtract:
        operatorSymbol = "-";
        result = numberLeft - numberRight;
        break;
      case R.id.buttonMultiply:
        operatorSymbol = "x";
        result = numberLeft * numberRight;
        break;
      case R.id.buttonDivide:
        operatorSymbol = "/";
        result = numberLeft / numberRight;
        break;
      default:
        operatorSymbol = "?";
        result = 0;
        break;
    }

    operatorView.setText(operatorSymbol);
    resultView.setText(Double.toString(result));
  }
}
```

In Figure 8-2, the user enters the numbers 16.5 and 10.0 in the two `EditText` components. Then the user clicks the button that has a plus sign on its face. As a result, Android calls the `onButtonClick` method in Listing 8-2. What happens next?

The program enters the `switch` statement in Listing 8-2. The `switch` statement starts with the line

```
switch (view.getId()) {
```

That line contains the expression `view.getId()`. The name `view` (a parameter of the `onButtonClick` method) refers to whatever component the user clicked. That component's `getId` method returns the component's `id`. For example, if the user clicks the plus-sign button, the value of `view.getId()` is the same as the

value of `R.id.buttonAdd`. If the user clicks the times-sign button, the value of `view.getId()` is the same as the value of `R.id.buttonMultiply`. And so on.

A `switch` statement contains `case` clauses, followed (optionally) by a `default` clause. In Listing 8-2, Java compares the value of `view.getId()` with `R.id.buttonAdd` (the value in the first of the `case` clauses). If the user clicked the plus-sign button, the value of `view.getId()` is the same as the value of `R.id.buttonAdd`, and the program executes the statements after the words `case R.id.buttonAdd`.

In Listing 8-2, the statements immediately after `case R.id.buttonAdd` are

```
operatorSymbol = "+";
result = numberLeft + numberRight;
break;
```

The first two statements set the values of `operatorSymbol` and `result` in preparation for displaying these values on the user's screen. The third statement (the `break` statement) jumps out of the entire `switch` statement, skipping past all the other `case` clauses and past the `default` clause to get to the last part of the program.

After the `switch` statement, the statements

```
operatorView.setText(operatorSymbol);
resultView.setText(Double.toString(result));
```

display the `operatorSymbol` and `result` values in `TextView` components on the user's screen. (Refer to Figure 8-2.)

Take a break

This news might surprise you: The end of a `case` clause (the beginning of another `case` clause) doesn't automatically make the program jump out of the `switch` statement. If you forget to add a `break` statement at the end of a `case` clause, the program finishes the statements in the `case` clause *and then continues executing the statements in the next* `case` *clause*. Imagine that I write the following code (and omit the `R.id.buttonAdd` case's `break` statement):

```
case R.id.buttonAdd:
  operatorSymbol = "+";
  result = numberLeft + numberRight;
case R.id.buttonSubtract:
  operatorSymbol = "-";
  result = numberLeft - numberRight;
  break;
... etc.
```

With this modified code (and with `view.getId()` equal to `R.id.buttonAdd`), the program sets `operatorSymbol` to `"+"`, sets `result` to `numberLeft + numberRight`, sets `operatorSymbol` to `"-"`, sets `result` to `numberLeft - numberRight`, and, finally, breaks out of the `switch` statement (skipping past all other `case` clauses and the `default` clause). The upshot of the whole thing is that `operatorSymbol` has the value `"-"` (not `"+"`) and that `result` is `numberLeft - numberRight` (not `numberLeft + numberRight`).

This phenomenon of jumping from one `case` clause to another (in the absence of a `break` statement) is called *fall-through*, and, sometimes, it's useful. Imagine a dice game in which 7 and 11 are instant wins; 2, 3, and 12 are instant losses; and any other number (from 4 to 10) tells you to continue playing. The code for such a game might look like this:

```
switch (roll) {
  case 7:
  case 11:
    message = "win";
    break;
  case 2:
  case 3:
  case 12:
    message = "lose";
    break;
  case 4:
  case 5:
  case 6:
  case 8:
  case 9:
  case 10:
    message = "continue";
    break;
  default:
    message = "not a valid dice roll";
    break;
}
```

If you roll a 7, you execute all statements immediately after `case 7` (of which there are none), and then you fall-through to `case 11`, executing the statement that assigns `"win"` to the variable `message`.


REMEMBER

Every beginning Java programmer forgets to put a `break` statement at the end of a `case` clause. When you make this mistake, don't beat yourself up about it. Just remember what's causing your program's unexpected behavior, add `break` statements to your code, and move on. As you gain experience in writing Java

programs, you'll make this mistake less and less frequently. (You'll still make the mistake occasionally, but not as often.)

In this section, I harp on the use of the `break` statement as if it's the only way to avoid fall-through. But in truth, there are other ways. You can see another way in this chapter's later section "Take a break from using the break statement." With or without these other ways, reminding yourself about fall-through by thinking "break, break, break!" is a good idea.

Java selects a case clause

When you run the code in Listing 8-2, you can click any of the four buttons. If you click the times-sign button, Java looks for a match between the times-sign button's `id` and the values in the `case` expressions. Java skips past the statements in the `case R.id.buttonAdd` clause and then skips past the statements in the `R.id.buttonSubtract` clause. The program hits pay dirt when it reaches the `case R.id.buttonMultiply` clause and executes that clause's statements, making `operatorSymbol` be `"x"` and making `result` be `numberLeft * numberRight`. Then the `case R.id.buttonMultiply` clause's `break` statement makes the program skip the rest of the stuff in the `switch` statement.

The default clause

A `switch` statement's optional `default` clause is a catchall for values that don't match any of the `case` clauses' values. You might enhance the calculator app by adding a square root button to the activity's screen but then forget to create a `case` clause for the new button. Then, if you run the app and click the square root button, Java doesn't fix on any of the `case` clauses. Java skips past all the `case` clauses and executes the code in the `default` clause, making `operatorSymbol` be `"?"` and making `result` be `0`.

When you create a `switch` statement, your `switch` statement doesn't have to have a `default` clause. But if it doesn't, you probably haven't planned for all possible contingencies. You should always plan for contingencies. Good planning makes a good, sturdy app, and a good, sturdy app gets high ratings on Google Play.

The last `break` statement in Listing 8-2 tells Java to jump to the end of the `switch` statement, skipping any statements after the `default` clause. But look again. Nothing comes after the `default` clause in the `switch` statement! Which statements are being skipped? The answer is none. I put a `break` at the end of the `default` clause for good measure. This extra `break` statement doesn't do anything, but it doesn't do any harm, either.

Oops!

Figures 8-3 and 8-4 show you what happens when the app in Listing 8-2 divides a number by zero.

FIGURE 8-3: Dividing almost any number by zero.

FIGURE 8-4: Dividing zero by zero.

Dividing a number by zero might give you *Infinity* — an inspiring value. But dividing zero by zero gives you *NaN*, which stands for *Not a Number*. In general, you probably don't want the user to divide by zero, so you can add code that makes dividing by zero a "no-no." Here's the code:

```
if (Double.isInfinite(result) || Double.isNaN(result)) {
  resultView.setText("Bad value!");
} else {
  resultView.setText(Double.toString(result));
}
```

The `Double.isInfinite` and `Double.isNaN` methods do what their names advertise. If the user becomes frisky and tries to crash your app with a zero divisor, your app tells the user to behave.

TIP

In this book, I create examples with the novice developer in mind. In some cases, I break with recommended Android coding guidelines to keep the code simple and readable. For example, in an industrial-strength Android program, you should avoid statements such as

```
resultView.setText("Bad value!");
```

This statement displays the English language phrase *Bad value!* on every device, even if the device's language setting is for German or Chinese. To create an app that adapts to non-English languages, you don't put `String` values in the app's `setText` method calls. Instead, you put references to string resources in the `setText` method calls.

At this point, you may ask "What's a reference to string resource?" To that question I reply "See Chapter 11."

Some formalities concerning Java switch statements

A `switch` statement has the following form:

```
switch (expression) {
case constant1:
    statements to be executed when the
    expression has value constant1
case constant2:
    statements to be executed when the
    expression has value constant2
case ...

default:
    statements to be executed when the
    expression has a value different from
    any of the constants
}
```

You can't put any old expression in a `switch` statement. The expression that's tested at the start of a `switch` statement must have

- One of these primitive types: `char`, `byte`, `short`, or `int`

  or

- One of these wrapper types: `Character`, `Byte`, `Short`, or `Integer`

  or

- The `String` type

  or

- An `enum` type

CROSS-REFERENCE

For some words of wisdom concerning Java's wrapper types, see Chapter 12.

An `enum` type is a type whose values are limited to the few that you declare. For example, the line

```
enum TrafficSignal {GREEN, YELLOW, RED};
```

defines a type whose only values are `GREEN`, `YELLOW`, and `RED`. Elsewhere in your code, you can write

```
TrafficSignal signal;
signal = TrafficSignal.GREEN;
```

to make use of the `TrafficSignal` type.

Repeating Instructions Over and Over Again

In 1966, the company that brings you Head & Shoulders shampoo made history. On the back of the bottle, the directions for using the shampoo read, "Lather, rinse, repeat." Never before had a complete set of directions (for doing anything, let alone shampooing hair) been summarized so succinctly. People in the direction-writing business hailed it as a monumental achievement. Directions like these stood in stark contrast to others of the time. (For instance, the first sentence on a can of bug spray read, "Turn this can so that it points away from your face." Duh!)

Aside from their brevity, the characteristic that made the Head & Shoulders directions so cool was that, with three simple words, they managed to capture a notion that's at the heart of all step-by-step instruction-giving, namely, the notion of repetition. That last word, *repeat,* turned an otherwise bland instructional drone into a sophisticated recipe for action.

When you follow directions, you usually don't just follow one instruction after another. Instead, you make turns in the road. You make decisions ("If HAIR IS DRY, then USE CONDITIONER,") and you repeat steps ("LATHER-RINSE, and then LATHER-RINSE again."). In application development, you use decision-making and repetition all the time.

Check, and then repeat

In this chapter's earlier "Take a break" section, I describe a simplified version of the dice game called Craps. Keep rolling the dice until you roll 2, 3, 7, 11, or 12. If you finish with 7 or 11, you win. But if you finish with 2, 3, or 12, you lose.

The program in Listing 8-3 uses Java's `Random` class to simulate a round of play.

LISTING 8-3: **Look Before You Leap**

```
package com.allmycode.a08_03;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.view.View;
import android.widget.TextView;

import java.util.Random;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);
  }

  public void onButtonClick(View view) {
    Random random = new Random();
    String message = "continue";

    textView.setText("");

    while (message.equals("continue")) {
      int numberA = random.nextInt(6) + 1;
      int numberB = random.nextInt(6) + 1;
      int total = numberA + numberB;
      message = getMessage(total);
```

```
        textView.append(numberA + " + " + numberB + " = " + total +
                                                    " " + message + "\n");
    }
  }

  String getMessage(int total) {
    switch (total) {
      case 7:
      case 11:
        return "win";
      case 2:
      case 3:
      case 12:
        return "lose";
      case 4:
      case 5:
      case 6:
      case 8:
      case 9:
      case 10:
        return "continue";
      default:
        return "not a valid dice roll";
    }
  }
}
```

A run of the code in Listing 8-3 is shown in Figure 8-5.

FIGURE 8-5: Try, try, try again.

Take your chances

In Listing 8-3, I spread the statements

```
import java.util.Random;

Random random = new Random();

int numberA = random.nextInt(6) + 1;
int numberB = random.nextInt(6) + 1;
```

across the code to produce two randomly chosen `int` values. A single call to `random.nextInt(6)` returns a randomly chosen `int` value from 0 to 5 inclusive. (Yes, you read it correctly. The number `6` means "return 0, 1, 2, 3, 4, or 5.") By adding 1 to the value returned by `random.nextInt(6)`, you get a randomly chosen `int` value from 1 to 6 — exactly the kind of value you get when you roll a single die. Calling `random.nextInt(6) +1` twice is like rolling two dice.


TECHNICAL STUFF

Java's `Random` class generates sequences of numbers that, by the most stringent technical standards, are "almost random." To use the correct terminology, the `Random` class creates *pseudo-random* sequences of numbers. You wouldn't use Java's `Random` class for a multimillion-dollar, government-sponsored lottery game. But you can use the `Random` class to help demonstrate loops in an introductory programming book.

Testing String values for equality

Java has several ways to test for equality: "Is this value the same as that value?" None of these ways is the first one you'd consider. In particular, to find out whether someone's age is 35, you *don't* write `if (age = 35)`. Instead, you use a double equal sign (==): `if (age == 35)`. In Java, the single equal sign (=) is reserved for *assignment.* So `age = 35` means "Let `age` stand for the value `35`", and `age == 35` means "True or false: Does `age` stand for the value `35`"?

Comparing two strings is a different story. When you compare two strings, you don't use the double equal sign. Using a double equal sign would ask a question that's usually not what you want to ask: "Is this string stored in exactly the same place in memory as that other string?" Instead, you want to ask, "Does this string have the same characters in it as that other string?" To ask the second question (the more appropriate one), use Java's `equals` method. To call this `equals` method, follow one of the two strings with a dot and the word `equals`, and then with a parameter list containing the other string:

```
while (message.equals("continue")) {
```

The `equals` method compares two strings to see whether they have the same characters in them. In Listing 8-3, the variable `message` refers to a string, and the text `"continue"` refers to a string. The condition `message.equals("continue")` is `true` if `message` refers to a string whose characters are the letters in the `"continue"` string.

Repeat, repeat, repeat

A `while` statement tells Java to do things repeatedly. In plain language, the `while` statement in Listing 8-3 says:

```
while ( message is "continue" ) {

  roll the dice and add new information to the textView

}
```

The `while` statement is one of Java's compound statements. It's also one of Java's *looping* statements because, when executing a `while` statement, Java can go into a loop, spinning around and around, executing a certain chunk of code over and over again.

In a looping statement, each go-around is an *iteration*.

TIP

In Listing 8-3, notice how the string that I append to the `textView` component's text ends with `"\n"`. The `\n` says "go to a new line before adding more text after this." That's why, in Figure 8-5, each simulated dice roll appears on its own, separate line. The `\n` business is an example of an *escape sequence*. Other escape sequences include `\t` for tab, `\b` for backspace, `\"` for a double quotation mark, and `\\` for the backslash itself.

Some formalities concerning Java while statements

A `while` statement has this form:

```
while (condition) {
    statements inside the loop
}
```

Java repeats the *statements inside the loop* over and over again as long as the condition in parentheses is true:

```
Check to make sure that the condition is true;
Execute the statements inside the loop.

Check again to make sure that the condition is true;
Execute the statements inside the loop.

Check again to make sure that the condition is true;
Execute the statements inside the loop.

And so on.
```

For Listing 8-3, the repetition looks like this:

```
Check to make sure that the message is "continue";
Roll the dice, get a message, and display stuff on the screen.

Check again to make sure that the message is "continue";
Roll the dice, get a message, and display stuff on the screen.

Check again to make sure that the message is "continue";
Roll the dice, get a message, and display stuff on the screen.

And so on.
```

At some point, the `while` statement's condition becomes `false`. (Generally, this happens because one of the statements in the loop changes one of the program's values.) When the condition becomes `false`, Java stops repeating the statements in the loop. (That is, Java stops *iterating*.) Instead, Java executes whatever statements appear immediately after the end of the `while` statement:

```
Check again to make sure that the condition is true;
Execute the statements inside the loop.

Check again to make sure that the condition is true;
Execute the statements inside the loop.

Check again to make sure that the condition is true;
Oops! The condition is no longer true!
Execute any code that comes immediately after the while statement.
```

For Listing 8-3, the repetition looks like this:

```
Check to make sure that the message is "continue";
Roll the dice, get a message, and display stuff on the screen.

Check again to make sure that the message is "continue";
Roll the dice, get a message, and display stuff on the screen.

Check again to make sure that the message is "continue";
Oops! The message is no longer "continue"!
Execute any code that comes immediately after the while statement.
```

In Listing 8-3, the `onButtonClick` method has no code after the `while` statement. So, when the `message.equals("continue")` condition is no longer true, the code in Listing 8-3 doesn't do anything. The code sits and waits for the user to click another button, for the user to back away from the activity, or for some other interesting event to happen.

Take a break from using the break statement

In this chapter's earlier section "Take a break," I promise to show you an alternative way of avoiding unwanted fall-through. The `switch` statement in Listing 8-3 avoids fall-through by jumping clear out of `getMessage` method.

For example, if the value of `total` is `7`, the `switch` statement matches `total` with the first `case 7` clause. The `case 7` clause has no statements to execute. But because of fall-through, Java marches onward into the `case 11` clause. Inside that `case 11` clause, Java encounters the `return "win"` statement. With this `return "win"` statement, Java ends execution of anything inside the `getMessage` method and returns to the statements in `while` loop. It all works very nicely!

Variations on a theme

A `while` statement's condition might become `false` in the middle of an iteration, before all the iteration's statements have been executed. When this happens, Java doesn't stop the iteration dead in its tracks. Instead, Java executes the rest of the loop's statements. After executing the rest of the loop's statements, Java checks the condition (finding the condition to be `false`) and marches on to whatever code comes immediately after the `while` statement.

The previous paragraph should come with some fine print. To be painfully accurate, I should point out a few ways for you to stop abruptly in the middle of a loop iteration. You can execute a `break` statement to jump out of a `while` statement immediately. (It's the same `break` statement that you use in a `switch` statement.) Alternatively, you can execute a `continue` statement (the word `continue`,

followed by a semicolon) to jump abruptly out of an iteration. When you jump out with a `continue` statement, Java ends the current iteration immediately and then checks the `while` statement's condition. A `true` condition tells Java to begin the next loop iteration. A `false` condition tells Java to go to whatever code comes after the `while` statement.

Many of the `if` statement's tricks apply to `while` statements as well. A `while` statement is a compound statement, so it might contain other compound statements. Also, when a `while` statement contains only one statement, you can omit curly braces. Here's an example:

```
int newNumber = 1;

while (newNumber < 4)
  newNumber = random.nextInt(6) + 1;
```

This code repeatedly fetches randomly generated values for `newNumber` as long as `newNumber` is less than 4.

Priming the pump

Java's `while` statement uses the policy "Look before you leap." Java always checks a condition before executing the statements inside the loop. Among other things, this forces you to prime the loop. When you prime a loop, you create statements that affect the loop's condition before the beginning of the loop. (Think of an old-fashioned water pump and how you have to prime the pump before water comes out.) In Listing 8-3, the initialization in

```
String message = "continue";
```

primes the loop. This initialization — the `=` part — gives `message` its first value so that when you check the condition `message.equals("continue")` for the first time, the variable `message` refers to a value that's worth checking.

Here's something you should consider when you create a `while` statement: Java can execute a `while` statement without ever executing the statements inside the loop. For example, in Listing 8-3, change the `message` variable's initialization to

```
String message = "win";
```

The code checks the condition `message.equals("continue")` before performing any loop iterations. But before performing any loop iterations, the condition `message.equals("continue")` is `false`. Java skips past the statements inside the loop and goes immediately to a place after `while` statement. In this situation, Java never rolls the dice and never displays any info about a roll.

Repeat, and then check

The `while` statement (which I describe in the previous section) is the workhorse of repetition in Java. Using `while` statements, you can do any kind of looping that you need to do. But sometimes it's convenient to have other kinds of looping statements. For example, occasionally you want to structure the repetition so that the first iteration takes place without checking a condition. In that situation, you use Java's `do` statement. Listing 8-4 is almost the same as Listing 8-3. But in Listing 8-4, I replace a `while` statement with a `do` statement.

LISTING 8-4: **Leap before You Look**

```
package com.allmycode.a08_04;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.view.View;
import android.widget.TextView;

import java.util.Random;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);
  }

  public void onButtonClick(View view) {
    Random random = new Random();
    String message;

    textView.setText("");

    do {
      int numberA = random.nextInt(6) + 1;
      int numberB = random.nextInt(6) + 1;
      int total = numberA + numberB;
      message = getMessage(total);
```

(continued)

LISTING 8-4: *(continued)*

```
        textView.append(numberA + " + " + numberB + " = " + total +
                                                    " " + message + "\n");

      } while (message.equals("continue"));

    }

    String getMessage(int total) {
      switch (total) {
        case 7:
        case 11:
          return "win";
        case 2:
        case 3:
        case 12:
          return "lose";
        case 4:
        case 5:
        case 6:
        case 8:
        case 9:
        case 10:
          return "continue";
        default:
          return "not a valid dice roll";
      }
    }
}
```

With a `do` statement, Java jumps right in, takes action, and then checks a condition. If the condition is true, Java goes back to the top of the loop for another go-round. If the condition is `false`, execution of the loop is done.

REMEMBER

A `do` statement contains the `while` keyword, but a `while` statement never contains the `do` keyword. If it helps, think of Java's `do` statement as a `do...while` statement.

Walls built with braces

Unlike a `while` statement, a `do` statement generally doesn't need to be primed. In Listing 8-4, I don't even bother to give `message` an initial value.

Because `message` isn't checked until the last line of the `do` statement, you might be tempted to declare `message` inside the `do` statement.

```
// Don't "do" this... (ha ha!)
do {
  int numberA = random.nextInt(6) + 1;
  int numberB = random.nextInt(6) + 1;
  int total = numberA + numberB;

  String message;
  message = getMessage(total);

  textView.append(numberA + " + " + numberB + " = " + total +
      " " + message + "\n");

} while (message.equals("continue"));
```

Unfortunately, declaring `message` inside of the `do` statement doesn't work. In Figure 8-6, the shaded area marks the code where the declaration of `message` is in play.

```
public void onButtonClick(View view) {
   Random random = new Random();

   textView.setText("");

   do {
     int numberA = random.nextInt(6) + 1;
     int numberB = random.nextInt(6) + 1;
     int total = numberA + numberB;
     String message = getMessage(total);

     textView.append(numberA + " + " + numberB + " = " + total +
         " " + message + "\n");
   } while (message.equals("continue"));
}
```

FIGURE 8-6: A declaration inside of a do statement's block.

In this incorrect code snippet, you can use the variable `message` only between the `do` statement's open curly brace and the `do` statement's close curly brace. But the words `while (message.equals("continue"))` aren't between the two curly braces. With this snippet, Android Studio displays an error message and refuses to run your code. Too bad!

The stuff between an open curly brace and its corresponding close curly brace is called a *block*. Here's the story:

- **Every block, whether it's part of a method declaration, a `do` statement, an `if` statement, a `while` statement, or any other Java construct, traps any of its variable declarations for use only inside the block.**

  If you declare a variable inside a block, you can't use that variable outside the block.

  But if you go from outside a block to the inside of a block, the opposite is true. . . .

- **If a variable's declaration is in force immediately before the start of a block, you can use that variable inside the block, and you can use that variable in the code that comes after the block.**

  In Figure 8-7, I declare `message` before the `do` statement's block. The shaded area marks the code where this declaration of `message` is in play.

  This second bullet explains why it's okay to declare `message` before the start of the `do` statement in Listing 8-4. For the same reason, in Listing 8-4, I'm able to declare `textView` before any of the method declarations, and then use the `textView` variable in two of those method declarations.

```
public void onButtonClick(View view) {
    Random random = new Random();
    String message;

    textView.setText("");

    do {
      int numberA = random.nextInt(6) + 1;
      int numberB = random.nextInt(6) + 1;
      int total = numberA + numberB;
      message = getMessage (total);

      textView.append(numberA + " + " + numberB + " = " + total +
          " " + message + "\n");

     } while (message.equals("continue"));

}
```

FIGURE 8-7: A declaration outside of a do statement's block.

TECHNICAL STUFF

If you want, you can use a name such as `message` in two different declarations. You can put one declaration outside the `do` statement's block, and a second declaration inside the `do` statement's block. But if you try this, you've declared two different variables, both with the same name `message`. It's like having two people named "Barry Burd" living in the same town. They have the same name, but

they're not the same person. The two `message` variables don't share any values. Except for coincidentally having the same spelling, the two variable names bear no relation to one another.

Some formalities concerning Java do statements

A `do` statement has the following form:

```
do {
    statements inside the loop
} while (condition)
```

Java executes the *`statements inside the loop`* and then checks to see whether the condition in parentheses is `true`. If the condition in parentheses is `true`, Java executes the *`statements inside the loop`* again. And so on.

Java's `do` statement uses the policy "Leap before you look." The statement checks a condition immediately *after* each iteration of the statements inside the loop.

A `do` statement is good for situations in which you know for sure that you should perform the loop's statements at least once. But in practice, you see many more `while` statements than `do` statements. In the lion's share of your processing scenarios, you check a condition before you start repeating things.

Count, count, count

Java's `while` and `do` statements check conditions to decide whether to keep repeating things. That's great but, sometimes, the condition is mundane. You don't check for a special showing or a `"continue"` message. You simply want to repeat something a certain number of times. To do that, you should use Java's `for` statement.

Suppose that you want to estimate how many times a player wins or loses in this chapter's simplified dice game. You can use mathematics to calculate probabilities, but you can also experiment by rolling the dice 100 times. To do that, you put the dice-rolling statements inside a Java `for` statement. Listing 8-5 shows you what to do.

LISTING 8-5: A Loop That Counts

```
package com.allmycode.a08_05;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
```

(continued)

LISTING 8-5: ***(continued)***

```
import android.view.View;
import android.widget.TextView;

import java.util.Random;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);
  }

  public void onButtonClick(View view) {
    Random random = new Random();
    String message;
    int winCount = 0, loseCount = 0;

    for (int i = 1; i <= 100; i++) {
      int numberA = random.nextInt(6) + 1;
      int numberB = random.nextInt(6) + 1;
      int total = numberA + numberB;
      message = getMessage(total);

      if (message.equals("win")) {
        winCount++;
      } else if (message.equals("lose")) {
        loseCount++;
      }
    }

    textView.setText("Wins: " + winCount + "\nLosses: " + loseCount);
  }

  String getMessage(int total) {
    switch (total) {
      case 7:
      case 11:
        return "win";
      case 2:
      case 3:
```

```
      case 12:
        return "lose";
      case 4:
      case 5:
      case 6:
      case 8:
      case 9:
      case 10:
        return "continue";
      default:
        return "not a valid dice roll";
    }
  }
}
```

Listing 8-5 declares an `int` variable named `i`. This declaration is inside the first line of the `for` statement. The starting value of `i` is `1`. As long as the condition `i <= 100` is true, Java repeatedly executes the statements inside the loop. After each iteration of the statements inside the loop, Java executes `i++` (adding `1` to the value of `i`).

After 100 iterations, the value of `i` gets to be `101`, in which case the condition `i <= 100` is no longer true. At that point, Java stops repeating the statements inside the loop and moves on to execute any statements that come after the `for` statement.

In Listing 8-5, the statements inside the `for` loop simulate a roll of the dice, and keep tallies of the number of winning and losing rolls. The only statement that comes after the `for` loop is a statement that displays the tallies in the `textView` component. A run of the code is shown in Figure 8-8.

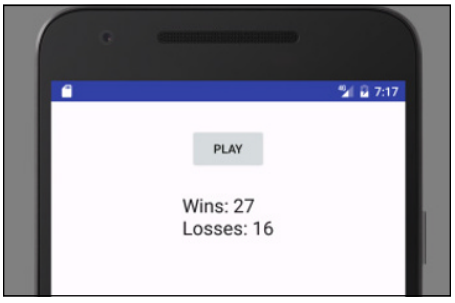


FIGURE 8-8: One run of the code in Listing 8-5.

Notice the combination of `if` statements in Listing 8-5. Some programming languages have their own special `elseif` keywords, but Java doesn't have such a thing. Instead, you can put an `if` statement inside the `else` clause of another `if` statement. In Listing 8-5, Java checks to find out if the `message` is `"win"`. When the `message` is `"win"`, it's the end of the `if` statement story. But when the `message` isn't `"win"`, Java goes on to check whether the message is `"lose"`. When the `message` is neither `"win"` nor `"lose"`, the execution of these `if` statements doesn't change either of the tallies' values.

Some formalities concerning Java for statements

A `for` statement has the following form:

```
for (initialization ; condition ; update) {
    statements inside the loop
}
```

- An *initialization* (such as `int i = 1` in Listing 8-5) defines the action to be taken before the first loop iteration.
- A *condition* (such as `i <= 100` in Listing 8-5) defines the value to be checked before an iteration. If the condition is `true`, Java executes the iteration. If the condition is `false`, Java doesn't execute the iteration, and it moves on to execute whatever code comes after the `for` statement.
- An *update* (such as `i++` in Listing 8-5) defines an action to be taken at the end of each loop iteration.

You can omit the curly braces when only one statement is inside the loop.

What's Next?

This chapter describes several ways to jump from one place in your code to another.

Java provides other ways to move from place to place in a program, including enhanced `for` statements and `try` statements. But descriptions of these elements don't belong in this chapter. To understand the power of enhanced `for` statements and `try` statements, you need a firm grasp of classes and objects, so Chapter 9 dives fearlessly into the classes-and-objects waters.

I'm your swimming instructor. Everyone into the pool!

3 Working with the Big Picture: Object-Oriented Programming

IN THIS PART . . .

Understanding object-oriented programming (at last!)

Writing code that other developers can use

Reusing other developers' code

IN THIS CHAPTER

- The truth about object-oriented programming
- Why a class is actually a Java type
- An end to the mystery surrounding words like `static`

Chapter 9

Why Object-Oriented Programming Is Like Selling Cheese

Andy's Cheese and Java Emporium carries fine cheeses and freshly brewed java from around the world (especially from Java in Indonesia). The Emporium is in Cheesetown, Pennsylvania, a neighborhood along the Edenville–Cheesetown Road in Franklin County.

The emporium sells cheese by the bag, each containing a certain variety, such as Cheddar, Swiss, Munster, or Limburger. Bags are labeled by weight and by the number of days the cheese was aged (admittedly, an approximation). Bags also carry the label *Domestic* or *Imported,* depending on the cheese's country of origin.

Before starting up the emporium, Andy had lots of possessions — material and otherwise. He had a family, a cat, a house, an abandoned restaurant property, a bunch of restaurant equipment, a checkered past, and a mountain of debt. But for the purpose of this narrative, Andy had only one thing: a form. Yes, Andy had developed a form for keeping track of his emporium's inventory. The form is shown in Figure 9-1.

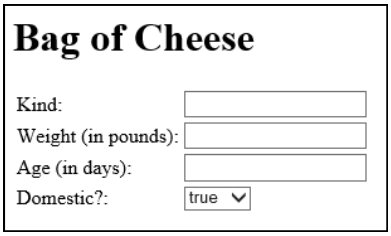


FIGURE 9-1: An online form.

Exactly one week before the emporium's grand opening, Andy's supplier delivered one bag of cheese. Andy entered the bag's information into the inventory form. The result is shown in Figure 9-2.

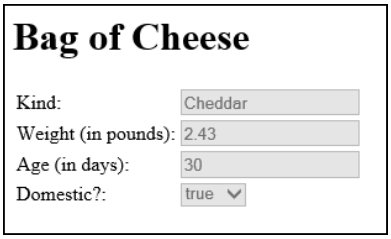


FIGURE 9-2: A virtual bag of cheese.

Andy had only a form and a bag of cheese (which isn't much to show for all his hard work), but the next day the supplier delivered five more bags of cheese. Andy's second entry looked like the one shown in Figure 9-3, and the next several entries looked similar.

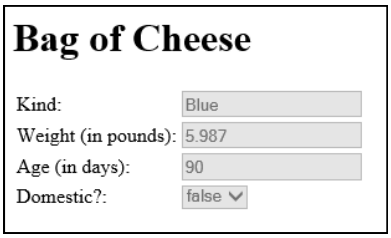


FIGURE 9-3: Another virtual bag of cheese.

At the end of the week, Andy was giddy: He had exactly one inventory form and six bags of cheese.

The story doesn't end here. As the grand opening approached, Andy's supplier brought many more bags so that, eventually, Andy had his inventory form and several hundred bags of cheese. The business even became an icon on Interstate Highway 81 in Cheesetown, Pennsylvania. But as far as you're concerned, the

business had, has, and always will have only one form and any number of cheese bags.

That's the essence of object-oriented programming!

Classes and Objects

Java is an object-oriented programming language. A program that you create in Java consists of at least one class.

A class is like Andy's blank form, described in this chapter's introduction. That is, a class is a general description of some kind of thing. In the introduction to this chapter, the class (the form) describes the characteristics that any bag of cheese possesses. But imagine other classes. For example, Figure 9-4 illustrates a bank account class:

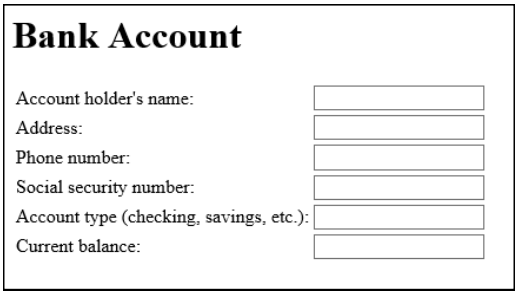


FIGURE 9-4: A bank account class.

Figure 9-5 illustrates a sprite class, which is a class for a character in a computer game:

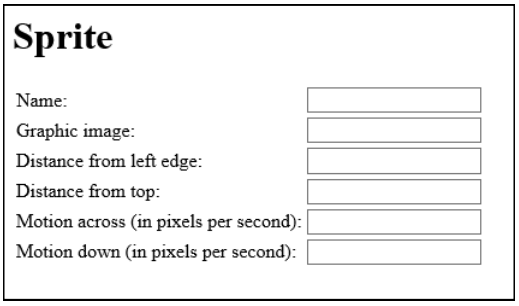


FIGURE 9-5: A sprite class.

What is a class, really?

In practice, a class doesn't look like any of the forms in Figures 9-1 through 9-5. In fact, a class doesn't look like anything. Instead, a Java class is a bunch of text describing the kinds of things that I refer to as "blanks to be filled in." Listing 9-1 contains a real Java class — the kind of class you write when you program in Java.

LISTING 9-1: **A Class in the Java Programming Language**

```
package com.allmycode.a09_01;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;
}
```

REMEMBER

As a developer, your primary job is to create classes. You don't develop attractive online forms like the form shown earlier, in Figure 9-1. Instead, you write Java language code — code containing descriptions, like the one in Listing 9-1.

WARNING

You won't find a folder named *09_01* in the stuff that you downloaded from this book's website. That's because the code in Listing 9-1 doesn't constitute a complete, runnable app. Instead, you can find the code from Listing 9-1 in this chapter's other projects — projects named *09_02*, *09_03*, and so on.

Compare Figure 9-1 with Listing 9-1. In what ways are they the same, and in what ways are they different? What does one have that the other doesn't have?

- **The form in Figure 9-1 appears on a user's screen. The code in Listing 9-1 does not.**

  A Java class isn't necessarily tied to a particular display. Yes, you can display a bank account on a user's screen. But the bank account isn't a bunch of items on a computer screen — it's a bunch of information in the bank's computers.

  In fact, some Java classes are difficult to visualize. Android's `SQLiteOpenHelper` class assists developers in the creation of databases. An `SQLiteOpenHelper` doesn't look like anything in particular, and certainly not like an online form or a bag of cheese.

- **Online forms appear in some contexts but not in others. In contrast, classes affect every part of every Java program's code.**

Forms show up on web pages, in dialog boxes, and in other situations. But when you use a word processing program to type a document, you deal primarily with free-form input. I didn't write this paragraph by filling in some blanks. (Heaven knows! I wish I could!)

The paragraphs I've written started out as part of a document in a word processing application. In the document, every paragraph has its own alignment, borders, indents, line spacing, styles, and many other characteristics. As a Java class, a list of paragraph characteristics might look something like this:

```
class Paragraph {
  int alignment;
  int borders;
  double leftIndent;
  double lineSpacing;
  int style;
}
```

When I create a paragraph, I don't fill in a form. Instead, I type words, and the underlying word processing app deals silently with its `Paragraph` class.

» **The form shown in Figure 9-1 contains several fields, and so does the code in Listing 9-1.**

In an online form, a field is a blank space — a place that's eventually filled with specific information. In Java, a *field* is any characteristic that you (the developer) attribute to a class. The `BagOfCheese` class in Listing 9-1 has four fields, and each of the four fields has a name: `kind`, `weight`, `daysAged`, or `isDomestic`.

Like an online form, a Java class describes items by listing the characteristics that each of the items has. Both the form in Figure 9-1 and the code in Listing 9-1 say essentially the same thing: Each bag of cheese has a certain kind of cheese, a certain weight, a number of days that the cheese was aged, and a domestic-or-imported characteristic.

» **The code in Listing 9-1 describes exactly the kind of information that belongs in each blank space. The form in Figure 9-1 is much more permissive.**

Nothing in Figure 9-1 indicates what kinds of input are permitted in the Weight field. The weight in pounds can be a whole number (0, 1, 2, and so on) or a decimal number (such as 3.14159, the weight of a big piece of "pie"). What happens if the user types the words *three pounds* into the form in Figure 9-1? Does the form accept this input, or does the computer freeze up? A developer can add extra code to test for valid input in a form, but, on its own, a form cares little about the kind of input that the user enters.

In contrast, the code in Listing 9-1 contains this line:

```
double weight;
```

This line tells Java that every bag of cheese has a characteristic named `weight` and that a bag's weight must be of type `double`. Similarly, each bag's `daysAged` value is an `int`, each bag's `isDomestic` value is `boolean`, and each bag's `kind` value has the type `String`.


REMEMBER

The unfortunate pun in the previous paragraph makes life more difficult for me, the author! A Java `String` has nothing to do with the kind of cheese that peels into strips. A Java `String` is a sequence of characters, like the sequence `"Cheddar"` or the sequence `"qwoiehasljsal"` or the sequence `"Go2theMoon!"`. So the `String kind` line in Listing 9-1 indicates that a bag of cheese might contain `"Cheddar"`, but it might also contain `"qwoiehasljsal"` cheese or `"Go2theMoon!"` cheese. Well, that's what happens when Andy starts a business from scratch.

If you look at Listing 9-1, you may notice my liberal use of the word `public`. In declaring the `BagOfCheese` class, I've decided that everything should be public. The class itself is public, `kind` field is public, the `weight` field is public, and so on.

When you declare a class, you don't have to make things public. But in this chapter's examples, the keyword `public` helps a lot. To find out why, see the later section "Java's Modifiers."


REMEMBER

In an online form, fields are places where the user types text. And in a Java class such as the class in Listing 9-1, variables such as `kind`, `weight`, `daysAged`, and `isDomestic` are fields. In this section, I emphasize the similarity between a form's fields and a Java class's fields. But don't mistake form fields for Java class fields. Form fields and Java class fields are two different kinds of things. A form's field may or may not be associated with a Java class's variable. And a Java class's field may or may not make an appearance on any device's screen.

What is an object?

At the start of this chapter's detailed Cheese Emporium exposé, Andy had nothing to his name except an online form — the form in Figure 9-1. Life was simple for Andy and his dog Fido. But eventually the suppliers delivered bags of cheese. Suddenly, Andy had more than just an online form — he had things whose characteristics matched the fields in the form. One bag had the characteristics shown in Figure 9-2; another bag had the characteristics shown in Figure 9-3.

In the terminology of object-oriented programming, each bag of cheese is an *object*, and each bag of cheese is an *instance* of the class in Listing 9-1.

You can also think of classes and objects as part of a hierarchy. The `BagOfCheese` class is at the top of the hierarchy, and each instance of the class is attached to the class itself. See Figures 9-6 and 9-7.

TECHNICAL STUFF

The diagrams in Figures 9-6 and 9-7 are part of the standardized Unified Modeling Language (UML). For more info about UML, visit `www.omg.org/spec/UML`.

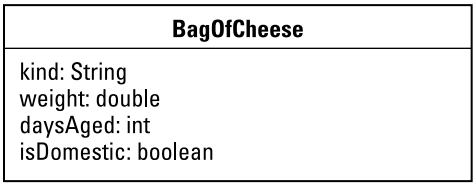


FIGURE 9-6: First, Andy has a class.

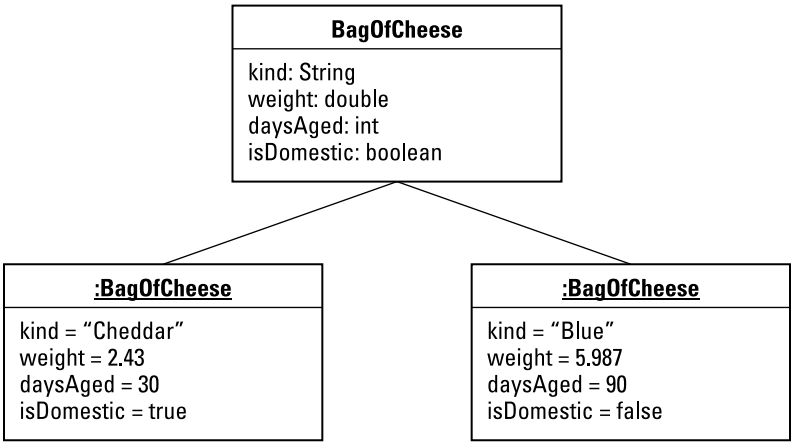


FIGURE 9-7: Later, Andy has a class and two objects.

REMEMBER

An object is a particular thing. (For Andy, an object is a particular bag of cheese.) A class is a description with blanks to be filled in. (For Andy, a class is a form with four blank fields: a field for the kind of cheese, another field for the cheese's weight, a third field for the number of days aged, and a fourth field for the Domestic-or-Imported designation.)

And don't forget: Your primary job is to create classes. You don't develop attractive online forms like the form in Figure 9-1. Instead, you write Java language code — code containing descriptions, like the one in Listing 9-1.

Creating objects

Listing 9-2 contains real-life Java code to create two objects: two instances of the class in Listing 9-1.

LISTING 9-2: **Creating Two Objects**

```
package com.allmycode.a09_02;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_01.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    BagOfCheese bag1 = new BagOfCheese();
    bag1.kind = "Cheddar";
    bag1.weight = 2.43;
    bag1.daysAged = 30;
    bag1.isDomestic = true;

    BagOfCheese bag2 = new BagOfCheese();
    bag2.kind = "Blue";
    bag2.weight = 5.987;
    bag2.daysAged = 90;
    bag2.isDomestic = false;

    textView.setText("");

    textView.append(bag1.kind + ", " +  bag1.weight + ", " +
        bag1.daysAged + ", " + bag1.isDomestic + "\n");

    textView.append(bag2.kind + ", " + bag2.weight + ", " +
        bag2.daysAged + ", " + bag2.isDomestic + "\n");
  }
}
```

A run of the code in Listing 9-2 is shown in Figure 9-8.

FIGURE 9-8: Running the code from Listing 9-2.

TECHNICAL STUFF

To vary the terminology, I might say that the code in Listing 9-2 creates "two `BagOfCheese` objects" or "two `BagOfCheese` instances," or I might say that the `new BagOfCheese()` statements in Listing 9-2 *instantiate* the `BagOfCheese` class. One way or another, Listing 9-1 declares the existence of one class, and Listing 9-2 declares another class — a class that declares the existence of two objects.

CROSS-REFERENCE

In Listing 9-2, each use of the words `new BagOfCheese()` is a *constructor call*. For details, see the "Calling a constructor" section, later in this chapter.

In Listing 9-2, I use ten statements to create two bags of cheese. The first statement (`BagOfCheese bag1 = new BagOfCheese()`) does three things:

- With the words

  ```
  BagOfCheese bag1
  ```

  the first statement declares that the variable `bag1` refers to a bag of cheese.

- With the words

  ```
  new BagOfCheese()
  ```

  the first statement creates a bag with no particular cheese in it. (If it helps, you can think of it as an empty bag reserved for eventually storing cheese.)

- Finally, with the equal sign, the first statement makes the `bag1` variable refer to the newly created bag.

The next four statements in Listing 9-2 assign values to the fields of `bag1`:

```
bag1.kind = "Cheddar";
bag1.weight = 2.43;
bag1.daysAged = 30;
bag1.isDomestic = true;
```


REMEMBER

To refer to one of an object's fields, follow a reference to the object with a dot and then the field's name. (For example, follow `bag1` with a dot and then the field name `kind`.)

The next five statements in Listing 9-2 do the same for a second variable, `bag2`, and a second bag of cheese.

ONE APP; TWO JAVA FILES

To run the code in Listing 9-2, I put two Java files (`BagOfCheese.java` from Listing 9-1 and `MainActivity.java` from Listing 9-2) in the same Android Studio project. To up the ante a bit more, I put the two Java files into two different packages. As you can see at the top of each listing, my `BagOfCheese` class is in the `com.allmycode.a09_01` package, and my `MainActivity` class is in the `com.allmycode.a09_02` package. I didn't have to create different classes for these two packages. But I was following my convention of naming the packages after listing numbers. Then I realized that, with two different package names, I can show you how to deal with new packages in Android Studio. So here goes:

When you create a new project, Android Studio creates a package containing the project's main activity. To add an additional package to the project, follow these steps:

1. Select the `app/java` branch in the Project tool window.
2. In the main menu bar, choose File ➪ New ➪ Package.

   A Choose Destination Directory dialog box appears. If this dialog box is the same as the one that I see in mid-2016, the dialog box lists three directories — `androidTest/java`, `main/java`, and `test/java`.
3. Select the `main/java` directory.

4. Click OK.

   The New Package dialog box appears.

5. In the New Package dialog box, type the name of your new package.

   When I started this section's project, I already had a package named `com.allmycode.a09_02`. So, in the New Package dialog box, I typed **com.allmycode.a09_01,** the name of the package for Listing 9-1.

6. Click OK.

Voilà! Your project has a new package.

To add an additional class (such as `BagOfCheese` in Listing 9-1) to your project, follow these steps:

1. In the Project tool window, select the branch of the package that will contain your new class.

   For example, if you're adding the `BagOfCheese` class in Listing 9-1, select the `app/java/com.allmycode/a09_01` branch.

2. In the main menu bar, choose File ➪ New ➪ Java Class.

   A Create New Class dialog box appears.

3. In the Name field of the Create New Class dialog box, type the name of your new class.

   To create the class in Listing 9-1, I typed **BagOfCheese**.

4. Make sure that the new class's package name appears in the dialog box's Package field.

5. Click OK.

And there you have it — a brand-new Java class in your Android app's project.

Reusing names

In Listing 9-2, I declare two variables — `bag1` and `bag2` — to refer to two different `BagOfCheese` objects. That's fine. But sometimes, having only one variable and reusing it for the second object works just as well, as shown in Listing 9-3.

LISTING 9-3: **Reusing the bag Variable**

```
package com.allmycode.a09_03;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_01.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    BagOfCheese bag = new BagOfCheese();
    bag.kind = "Cheddar";
    bag.weight = 2.43;
    bag.daysAged = 30;
    bag.isDomestic = true;

    textView.setText("");

    textView.append(bag.kind + ", " +  bag.weight + ", " +
        bag.daysAged + ", " + bag.isDomestic + "\n");

    bag = new BagOfCheese();
    bag.kind = "Blue";
    bag.weight = 5.987;
    bag.daysAged = 90;
    bag.isDomestic = false;

    textView.append(bag.kind + ", " +  bag.weight + ", " +
        bag.daysAged + ", " + bag.isDomestic + "\n");
  }
}
```

In Listing 9-3, when Java executes the second `bag = new BagOfCheese()` statement, the old object (the bag containing cheddar) has disappeared. Without `bag` (or any other variable) referring to that cheddar object, there's no way your code can do anything with the cheddar object. Fortunately, by the time you reach the second `bag = new BagOfCheese()` statement, you're finished doing everything you want to do with the original cheddar bag. In this case, reusing the `bag` variable is acceptable.


WARNING

When you reuse a variable (like the one and only `bag` variable in Listing 9-3), you do so by using an assignment statement, not an initialization. In other words, you don't write `BagOfCheese bag` a second time in your code. If you do, you see error messages in the Android Studio editor.


TECHNICAL STUFF

To be painfully precise, you can, in fact, write `BagOfCheese bag` more than once in the same piece of code. For an example, see the use of shadowing later in this chapter, in the "Constructors with parameters" section.

In Listing 9-1, none of the `BagOfCheese` class's fields is `final`. In other words, the class's code lets you reassign values to the fields inside a `BagOfCheese` object. With this information in mind, you can shorten the code in Listing 9-3 by one more line, as shown in Listing 9-4.

LISTING 9-4: Reusing a bag Object's Fields

```
package com.allmycode.a09_04;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_01.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    BagOfCheese bag = new BagOfCheese();
    bag.kind = "Cheddar";
```

(continued)

LISTING 9-4: *(continued)*

```
        bag.weight = 2.43;
        bag.daysAged = 30;
        bag.isDomestic = true;

        textView.setText("");

        textView.append(bag.kind + ", " +  bag.weight + ", " +
            bag.daysAged + ", " + bag.isDomestic + "\n");

        // bag = new BagOfCheese();
        bag.kind = "Blue";
        bag.weight = 5.987;
        bag.daysAged = 90;
        bag.isDomestic = false;

        textView.append(bag.kind + ", " +  bag.weight + ", " +
            bag.daysAged + ", " + bag.isDomestic + "\n");
    }
}
```

With the second constructor call in Listing 9-4 commented out, you don't make the `bag` variable refer to a new object. Instead, you economize by assigning new values to the existing object's fields.

In some situations, reusing an object's fields can be more efficient (quicker to execute) than creating a new object. But whenever I have a choice, I prefer to write code that mirrors real data. If an actual bag's content doesn't change from cheddar cheese to blue cheese, I prefer not to change a `BagOfCheese` object's `kind` field from `"Cheddar"` to `"Blue"`.

Calling a constructor

In Listing 9-2, the words `new BagOfCheese()` look like method calls, but they aren't — they're constructor calls. A *constructor call* creates a new object from an existing class. You can spot a constructor call by noticing that

- **A constructor call starts with Java's `new` keyword:**

  ```
  new BagOfCheese()
  ```

  and

» **A constructor call's name is the name of a Java class:**

```
new BagOfCheese()
```

When Java encounters a method call, Java executes the statements inside a method's declaration. Similarly, when Java encounters a constructor call, Java executes the statements inside the constructor's declaration. When you create a new class (as I did in Listing 9-1), Java can create a constructor declaration automatically. If you want, you can type the declaration's code manually. Listing 9-5 shows you what the declaration's code would look like:

LISTING 9-5: **The Parameterless Constructor**

```
package com.allmycode.a09_05;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;

  public BagOfCheese() {
  }
}
```

In Listing 9-5, the boldface code

```
public BagOfCheese() {
}
```

is a very simple constructor declaration. This declaration (unlike most constructor declarations) has no statements inside its body. This declaration is simply a *header* (`BagOfCheese()`) and an empty body (`{}`).

CROSS-REFERENCE

You can type Listing 9-5 exactly as it is. Alternatively, you can omit the code in boldface type, and Java creates that constructor for you automatically. (You don't see the constructor declaration in the Android Studio editor, but Java behaves as if the constructor declaration exists.) To find out when Java creates a constructor declaration automatically and when it doesn't, see the "Constructors with parameters" section, later in this chapter.

A constructor's declaration looks much like a method declaration. But a constructor's declaration differs from a method declaration in two ways:

- **A constructor's name is the same as the name of the class whose objects the constructor constructs.**

  In Listing 9-5, the class name is `BagOfCheese`, and the constructor's header starts with the name `BagOfCheese`.

- **Before the constructor's name, the constructor's header has no type.**

  Unlike a method header, the constructor's header doesn't say `int BagOfCheese()` or even `void BagOfCheese()`. The header simply says `BagOfCheese()`.

The constructor declaration in Listing 9-5 contains no statements. That isn't typical of a constructor, but it's what you get in the constructor that Java creates automatically. With or without statements, calling the constructor in Listing 9-5 creates a brand-new `BagOfCheese` object.

More About Classes and Objects (Adding Methods to the Mix)

In Chapters 4 and 7, I introduce parameter passing. In those chapters, I unobtrusively avoid details about passing objects to methods. (At least, I hope it's unobtrusive.) In this chapter, I shed my coy demeanor and face the topic (passing objects to methods) head-on.

I start with an improvement on an earlier example. The code in Listing 9-2 contains two nasty-looking `textView.append` calls. This code has two nearly identical occurrences of a complicated expression:

```
textView.append(bag1.kind + ", " +  bag1.weight + ", " +
    bag1.daysAged + ", " + bag1.isDomestic + "\n");

textView.append(bag2.kind + ", " + bag2.weight + ", " +
    bag2.daysAged + ", " + bag2.isDomestic + "\n");
```

You can streamline the code by moving this complicated expression to a method. Here's how:

1. **View the code from Listing 9-2 in the Android Studio editor.**

   This `MainActivity.java` file is in the 09_02 project, which is in the `Java4Android_Projects.zip` file that you download in Chapter 2.

2. **Use the mouse to select the entire expression inside the parameter list of the first call to `textView.append`.**

   Be sure to highlight everything in the expression, starting with `bag1.kind` and ending with `"\n"`.

3. **On the Android Studio main menu, choose Refactor ➪ Extract ➪ Method.**

   The Extract Method dialog box in Android Studio appears, as shown in Figure 9-9.

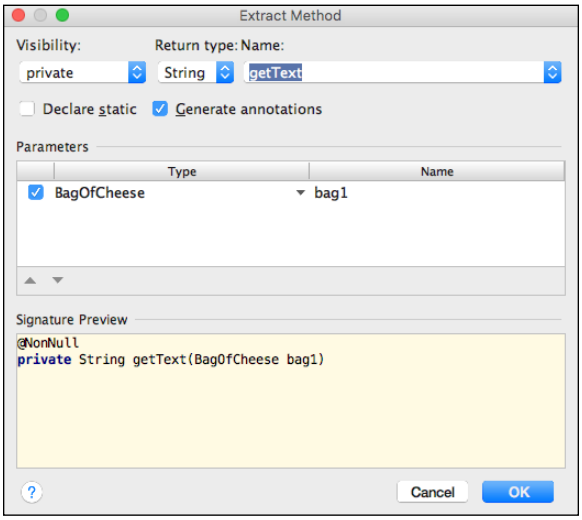


FIGURE 9-9: The Extract Method dialog box.

In the next two steps, you make the names in your code the same as the names in this book's examples.

4. **(Optional) In the Name field in the Extract Method dialog box, type** toString**.**

5. **(Optional) In the Name column of the Parameters list, change** bag1 **to** bag**.**

6. **Click OK.**

   Android Studio dismisses the Extract Method dialog box.

Android Studio creates a method named `toString` and replaces the string in the first `textView.append` call with a call to the new `toString` method.

Android Studio also displays a dialog box like the one in Figure 9-10.

7. **In the dialog box, click Yes.**

   Clicking Yes tells Android Studio to replace the string in the second `textView.append` call with a call to the new `toString` method.

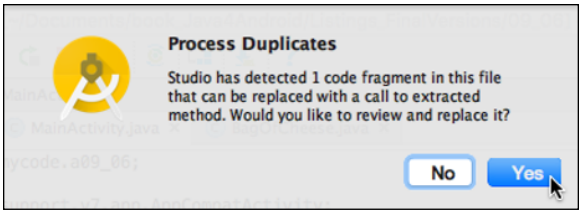


FIGURE 9-10: Would you like to replace more code?

As a result of all this typing and clicking, you have the code in Listing 9-6.

LISTING 9-6: **A Method Displays a Bag of Cheese**

```
package com.allmycode.a09_06;

import android.support.annotation.NonNull;
import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_05.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);
```

```
    BagOfCheese bag1 = new BagOfCheese();
    bag1.kind = "Cheddar";
    bag1.weight = 2.43;
    bag1.daysAged = 30;
    bag1.isDomestic = true;

    BagOfCheese bag2 = new BagOfCheese();
    bag2.kind = "Blue";
    bag2.weight = 5.987;
    bag2.daysAged = 90;
    bag2.isDomestic = false;

    textView.setText("");

    textView.append(toString(bag1));

    textView.append(toString(bag2));
  }

  @NonNull
  private String toString(BagOfCheese bag) {
    return bag.kind + ", " +  bag.weight + ", " +
        bag.daysAged + ", " + bag.isDomestic + "\n";
  }
}
```

According to the `toString` declaration (refer to Listing 9-6), the `toString` method takes one parameter. That parameter must be a `BagOfCheese` instance. Inside the body of the method declaration, you refer to that instance with the parameter name `bag`. (You refer to `bag.kind`, `bag.weight`, `bag.daysAged`, and `bag.isDomestic`.)

In the `onCreate` method, you create two `BagOfCheese` instances: `bag1` and `bag2`. You call `toString` once with the first instance (`toString(bag1)`), and call it a second time with the second instance (`toString(bag2)`).

CROSS-REFERENCE

The `@NonNull` business in Listing 9-6 is an *annotation*. For the story on Java annotations, see Chapter 10.

Constructors with parameters

Listing 9-7 contains a variation on the theme from Listing 9-2.

LISTING 9-7: **Another Way to Create Two Objects**

```
package com.allmycode.a09_07;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_08.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    BagOfCheese bag1 = new BagOfCheese("Cheddar", 2.43, 30, true);
    BagOfCheese bag2 = new BagOfCheese("Blue", 5.987, 90, false);

    textView.setText("");

    textView.append(toString(bag1));
    textView.append(toString(bag2));
  }

  private String toString(BagOfCheese bag) {
    return bag.kind + ", " +  bag.weight + ", " +
        bag.daysAged + ", " + bag.isDomestic + "\n";
  }
}
```

Listing 9-7 calls a `BagOfCheese` constructor with four parameters, so the code has to have a four-parameter constructor. In Listing 9-8, I show you how to declare that constructor.

LISTING 9-8: **A Constructor with Parameters**

```
package com.allmycode.a09_08;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;

  public BagOfCheese() {
  }

  public BagOfCheese(String dKind, double dWeight,
                     int dDaysAged, boolean dIsDomestic) {
    kind = dKind;
    weight = dWeight;
    daysAged = dDaysAged;
    isDomestic = dIsDomestic;
  }
}
```

Listing 9-8 borrows some tricks from Chapters 4 and 7. In those chapters, I introduce the concept of *overloading* — reusing a name by providing different parameter lists. Listing 9-8 has two different `BagOfCheese` constructors — one with no parameters and another with four parameters. When you call a `BagOfCheese` constructor (as in Listing 9-7), Java knows which declaration to execute by matching the parameters in the constructor call. The call in Listing 9-7 has parameters of type `String`, `double`, `int`, and `boolean`, and the second constructor in Listing 9-8 has the same types of parameters in the same order, so Java calls the second constructor in Listing 9-8.

You might also notice another trick from Chapter 7. In Listing 9-8, in the second constructor declaration, I use different names for the parameters and the class's fields. For example, I use the parameter name `dKind` and the field name `kind`. What happens if you use the same names for the parameters and the fields, as in this example:

```
// DON'T DO THIS
public class BagOfCheese {
  public String kind;
  public double weight;
```

```
    public int daysAged;
    public boolean isDomestic;

    public BagOfCheese() {
    }

    public BagOfCheese(String kind, double weight,
                       int daysAged, boolean isDomestic) {
      kind = kind;
      weight = weight;
      daysAged = daysAged;
      isDomestic = isDomestic;
    }
  }
```

Figure 9-11 shows you exactly what happens. (Spoiler alert! Nothing good happens!)

FIGURE 9-11: Some unpleasant results.

The code with duplicate parameter and field names gives you the useless results from Figure 9-11. The code has two `kind` variables — one inside the constructor and another outside of the constructor, as shown in Figure 9-12.

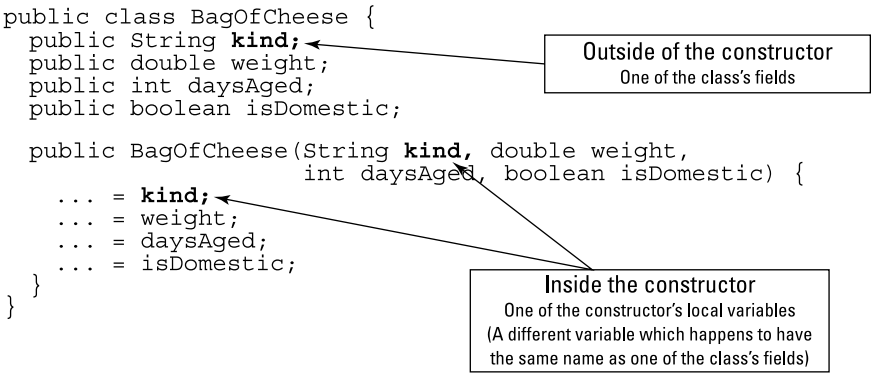


FIGURE 9-12: Two `kind` variables.

Inside a constructor or method, a parameter *shadows* any identically named field. So, outside the constructor declaration, the word `kind` refers to the field name. Inside the constructor declaration, however, the word `kind` refers only to the parameter name. In the horrible code with duplicate names, the statement

```
kind = kind;
```

does nothing to the `kind` field. Instead, this statement tells Java to make the `kind` parameter refer to the same string that the `kind` parameter already refers to.

If this explanation sounds like nonsense to you, it is.

The `kind` variable in the constructor declaration's parameter list is *local* to the constructor. Any use of the word `kind` outside the constructor cannot refer to the constructor's local `kind` variable.

Fields are different. You can refer to a field anywhere in the class's code. For example, in Listing 9-8, the second constructor declaration has no local `kind` variable of its own. Inside that constructor's body, the word `kind` refers to the class's field.

One way or another, the second constructor in Listing 9-8 is cumbersome. Do you always have to make up peculiar names like `dKind` for a constructor's parameters? No, you don't. To find out why, see the "This is it!" section, later in this chapter.

The default constructor

I don't see any constructors in Listing 9-1. So why can I make a constructor call (the call `new BagOfCheese()`) in Listing 9-2? I can call `new BagOfCheese()` because, without explicitly adding text to the code in Listing 9-1, Java silently creates a parameterless constructor for me.

But Listing 9-8 is different. In Listing 9-8, if I didn't explicitly type the parameterless constructor in my code, Java wouldn't have created a parameterless constructor for me. A call to `new BagOfCheese()` with no parameters would have been illegal. If I added a `new BagOfCheese()` call, Android Studio's editor would tell me that *The BagOfCheese() in BagOfCheese cannot be applied*. Sounds bad. Doesn't it?

Here's how it works: When you declare a class, Java creates a parameterless constructor (known formally as a *default constructor*) if, and only if, you haven't explicitly declared any constructors in your class's code. When Java encounters Listing 9-1, Java automatically adds a parameterless constructor to your `BagOfCheese` class. But when Java encounters Listing 9-8, with its 4-parameter

constructor already declared, you don't get a parameterless constructor unless you explicitly type the lines

```
public BagOfCheese() {
}
```

into your code. Without a parameterless constructor, calls to `new BagOfCheese()` (with no parameters) will be illegal.

This is it!

The naming problem that crops up earlier in this chapter, in the "Constructors with parameters" section, has an elegant solution. Listing 9-9 illustrates the idea.

LISTING 9-9: Using Java's `this` Keyword

```
package com.allmycode.a09_09;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;

  public BagOfCheese() {
  }

  public BagOfCheese(String kind, double weight,
                     int daysAged, boolean isDomestic) {
    this.kind = kind;
    this.weight = weight;
    this.daysAged = daysAged;
    this.isDomestic = isDomestic;
  }
}
```

To use the class in Listing 9-9, you can run the `MainActivity` code in Listing 9-7. When you do, you see the run shown earlier, in Figure 9-8.

You can persuade Android Studio to create the big constructor that you see in Listing 9-9. Here's how:

1. **Start with the code from Listing 9-1 (or Listing 9-5) in the Android Studio editor.**

2. **Click the mouse cursor anywhere inside the editor.**

3. **On the Android Studio main menu, select Code ➪ Generate ➪ Constructor.**

   The Choose Fields to Initialize by Constructor dialog box appears, as shown in Figure 9-13.

4. **In the Choose Fields to Initialize by Constructor dialog box, make sure that all four of the `BagOfCheese` fields are selected.**

   To do so, start by selecting the topmost field (the `kind` field). Then, with your computer's Shift key pressed, select the bottommost field (the `isDomestic` field).

   This ensures that the new constructor will have a parameter for each of the class's fields.

5. **Click OK.**

   That does it! Android Studio dismisses the dialog box and adds a freshly brewed constructor to the editor's code.

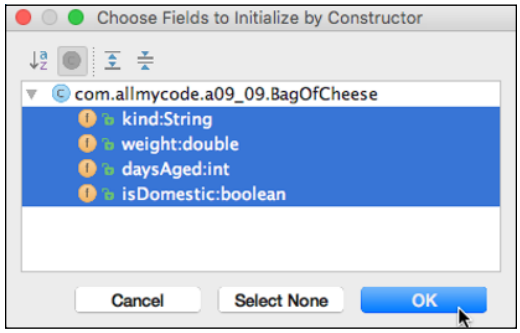


FIGURE 9-13: Choose Fields to Initialize by Constructor.

Java's `this` keyword refers to "the object that contains the current line of code." So in Listing 9-9, the word `this` refers to an instance of `BagOfCheese` (that is, to the object that's being constructed). That object has a `kind` field, so `this.kind` refers to the first of the object's four fields (and not to the constructor's `kind` parameter). That object also has `weight`, `daysAged`, and `isDomestic` fields, so `this.weight`, `this.daysAged`, and `this.isDomestic` refer to that object's fields, as shown in Figure 9-14. And the assignment statements inside the constructor give values to the new object's fields.

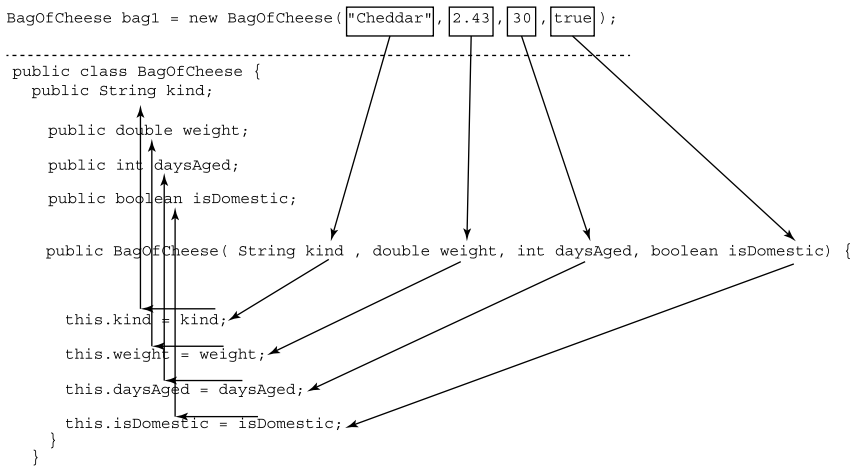


FIGURE 9-14: Assigning values to an object's fields.

Giving an object more responsibility

You have a printer and you try to install it on your computer. It's a capable printer, but it didn't come with your computer, so your computer needs a program to *drive* the printer: a printer *driver*. Without a driver, your new printer is nothing but a giant paperweight.

But, sometimes, finding a device driver can be a pain in the neck. Maybe you can't find the disk that came with the printer. (That's always my problem.)

I have one off-brand printer whose driver is built into its permanent memory. When I plug the printer into a USB port, the computer displays a new storage location. (The location looks, to ordinary users, like another of the computer's disks.) The drivers for the printer are stored directly on the printer's internal memory. It's as though the printer knows how to drive itself!

Now consider the code in Listings 9-7 and 9-8. You're the `MainActivity` class (refer to Listing 9-7), and you have a new gadget to play with — the `BagOfCheese` class in Listing 9-8. You want to display the properties of a particular bag, and you don't like dealing with a bag's nitty-gritty details. In particular, you don't like worrying about commas, blank spaces, and field names when you display a bag:

```
bag.kind + ", " +  bag.weight + ", " +
        bag.daysAged + ", " + bag.isDomestic + "\n"
```

You'd rather have the `BagOfCheese` class figure out how to display one of its own objects.

Here's the plan: Move the big string with the bag's fields, the commas and the spaces from the `MainActivity` class to the `BagOfCheese` class. That is, make each `BagOfCheese` object be responsible for describing itself in `String` form. With the Andy's Cheese Emporium metaphor that starts this chapter, each bag's form has its own Display button, as shown in Figure 9-15.

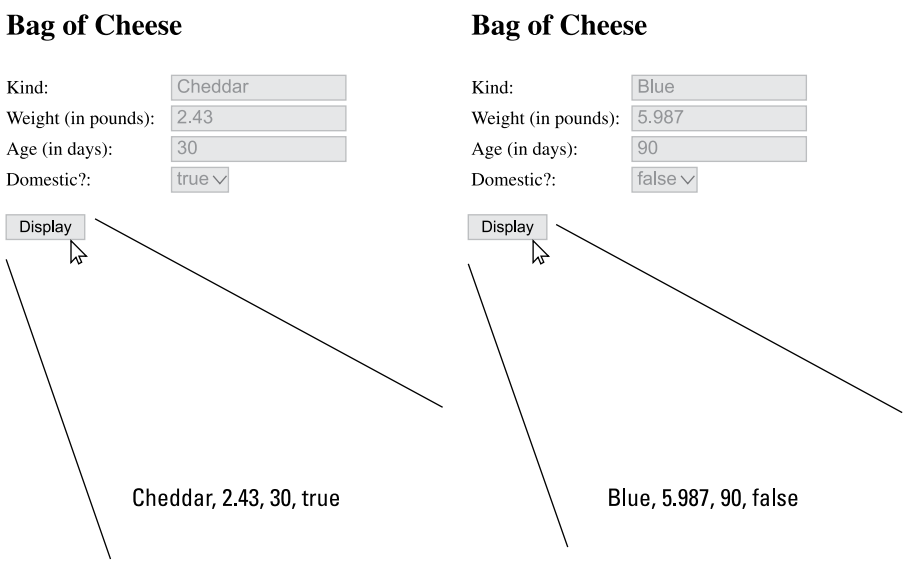


FIGURE 9-15: Two bag objects and two displays.

The interesting characteristic of a Display button is that when you press it, the text you see depends on the bag of cheese you're examining. More precisely, the text you see depends on the values in that particular form's fields.

The same thing happens in Listing 9-11 when you call `bag1.toString()`. Java runs the `toString` method shown in Listing 9-10. The values used in that method call — `kind`, `weight`, `daysAged`, and `isDomestic` — are the values in the `bag1` object's fields. Similarly, the values used when you call `bag2.toString()` are the values in the `bag2` object's fields.

LISTING 9-10: **A Self-Displaying Class**

```
package com.allmycode.a09_10;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;
```

(continued)

LISTING 9-10: *(continued)*

```
  public BagOfCheese() {
  }

  public BagOfCheese(String kind, double weight,
                     int daysAged, boolean isDomestic) {
    this.kind = kind;
    this.weight = weight;
    this.daysAged = daysAged;
    this.isDomestic = isDomestic;
  }

  public String toString() {
    return kind + ", " +  weight + ", " + daysAged + ", " + isDomestic + "\n";
  }
}
```

LISTING 9-11: **Having a Bag Display Itself**

```
package com.allmycode.a09_11;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_10.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    BagOfCheese bag1 = new BagOfCheese("Cheddar", 2.43, 30, true);
    BagOfCheese bag2 = new BagOfCheese("Blue", 5.987, 90, false);

    textView.setText("");
```

```
        textView.append(bag1.toString());
        textView.append(bag2.toString());
    }
}
```

In Listing 9-10, the `BagOfCheese` object has its own, parameterless `toString` method. And in Listing 9-11, the following two lines make two calls to the `toString` method — one call for `bag1` and another call for `bag2`:

```
textView.append(bag1.toString());
textView.append(bag2.toString());
```

A call to `toString` behaves differently depending on the particular bag that's being displayed. When you call `bag1.toString()`, you see the field values for `bag1`, and when you call `bag2.toString()`, you see the field values for `bag2`.

REMEMBER

To call one of an object's methods, follow a reference to the object with a dot and then the method's name.

Members of a class

Notice the similarity between fields and methods:

- As I say earlier in this chapter, in the "Creating objects" section:

  To refer to one of an object's fields, follow a reference to the object with a dot and then the field's name.

- As I say earlier in this chapter, in the "Giving an object more responsibility" section:

  To call one of an object's methods, follow a reference to the object with a dot and then the method's name.

The similarity between fields and methods stretches far and wide in object-oriented programming. The similarity is so strong that special terminology is necessary to describe it. In addition to each `BagOfCheese` object having its own values for the four fields, you can think of each object as having its own copy of the `toString` method. So the `BagOfCheese` class in Listing 9-10 has five *members*. Four of the members are the fields `kind`, `weight`, `daysAged`, and `isDomestic`, and the remaining member is the `toString` method.

Reference types

Here's a near-quotation from the earlier section "Creating objects:"

> *In Listing 9-2, the initialization of bag1 makes the bag1 variable refer to the newly created bag.*

In the quotation, I choose my words carefully. "The initialization makes the `bag1` variable *refer to* the newly created bag." Notice how I italicize the words *refer to.* A variable of type `int` *stores* an `int` value, but the `bag1` variable in Listing 9-2 *refers to* an object.

What's the difference? The difference is similar to holding an object in your hand versus pointing to it in the room. Figure 9-16 shows you what I mean.

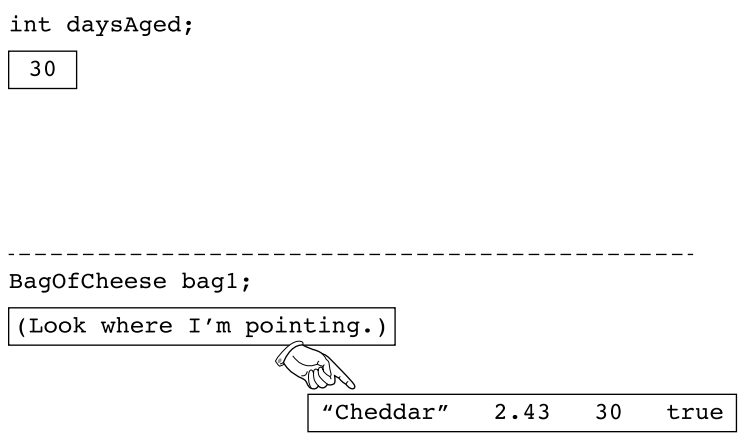


FIGURE 9-16: Primitive types versus reference types.

Java has two kinds of types: primitive types and reference types.

- I cover primitive types in Chapter 5. Java's eight primitive types are `int`, `double`, `boolean`, `char`, `byte`, `short`, `long`, and `float`.
- A *reference type* is the name of a class or (as you see in Chapter 10) an interface.

In Figure 9-16, the variable `daysAged` contains the value `30` (indicating that the cheese in a particular bag has been aged for 30 days). I imagine the value `30` being right inside the `daysAged` box because the `daysAged` variable has type `int` — a primitive type.

But the variable `bag1` has type `BagOfCheese`, and `BagOfCheese` isn't a primitive type. (I know of no computer programming language in which a bag of cheese is a built-in, primitive type!) So the `bag1` variable doesn't contain `"Cheddar" 2.43 30 true`. Instead, the variable `bag1` contains the information required to locate the `"Cheddar" 2.43 30 true` object. The variable `bag1` stores information that *refers to* the `"Cheddar" 2.43 30 true` object.


REMEMBER

The types `int`, `double`, `boolean`, `char`, `byte`, `short`, `long`, and `float` are primitive types. A primitive type variable (`int daysAged`, `double weight`, and `boolean isDomestic`, for example) stores a value. In contrast, a class is a reference type, such as `String`, which is defined in Java's API, and `BagOfCheese`, which you or I declare ourselves. A reference type variable (`BagOfCheese bag` and `String kind`, for example) *refers* to an object.


TECHNICAL STUFF

The `String` type is a reference type, so Figure 9-16 would be slightly more accurate if the bottommost box had another hand pointing to the letters `'C'`, `'h'`, `'e'`, `'d'`, `'d'`, `'a'`, and `'r'`. (See Figure 9-17.) To keep my diagrams uncluttered, I don't put that other hand in Figure 9-16 and I don't put the other hand in similar diagrams in this chapter.

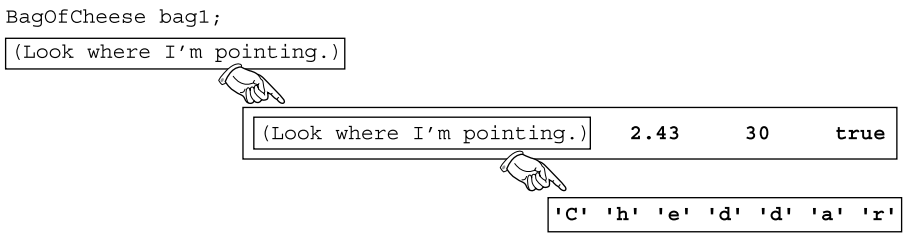


FIGURE 9-17: The String type is also a reference type.


TECHNICAL STUFF

In this section, I say that the `bag1` variable *refers to* the `"Cheddar" 2.43 30 true` object. It's also common to say that the `bag1` variable *points to* the `"Cheddar" 2.43 30 true` object. Alternatively, you can say that the `bag1` variable stores the number of the memory address where the `"Cheddar" 2.43 30 true` object's values begin. Neither the pointing language nor the memory language expresses the truth of the matter, but if the rough terminology helps you understand what's going on, there's no harm in using it.

Pass by reference

In the previous section, I emphasize that classes are reference types. A variable whose type is a class contains something that refers to blah, blah, blah. You might ask, "Why should I care?"

Look at Listing 7-2, over in Chapter 7, and notice the result of passing a primitive type to a method:

> When the method's body changes the parameter's value, the change has no effect on the value of the variable in the method call.

This principle holds true for reference types as well. But in the case of a reference type, the value that's passed is the information about where to find an object, not the object itself. When you pass a reference type in a method's parameter list, you can change values in the object's fields.

See, for example, the code in Listing 9-12.

LISTING 9-12: **Another Day Goes By**

```
package com.allmycode.a09_12;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_10.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    BagOfCheese bag1 = new BagOfCheese("Cheddar", 2.43, 30, true);

    addOneDay(bag1);

    textView.setText("");
    textView.append(bag1.toString());
  }
```

```
  void addOneDay(BagOfCheese bag) {
    bag.daysAged++;
  }

}
```

A run of the code in Listing 9-12 is shown in Figure 9-18. In that run, the constructor creates a bag that is aged 30 days, but the `addOneDay` method successfully adds a day. In the end, the display in Figure 9-18 shows 31 days aged.

Unlike the story with `int` values, you can change a bag of cheese's `daysAged` value by passing the bag as a method parameter. Why does it work this way?

FIGURE 9-18: Thirty-one days old.

When you call a method, you make a copy of each parameter's value in the call. You initialize the declaration's parameters with the copied values. Immediately after making the `addOneDay` call in Listing 9-12, you have two variables: the original `bag1` variable in the `onCreate` method and the new `bag` variable in the `addOneDay` method. The new `bag` variable has a copy of the value from the `onCreate` method, as shown in Figure 9-19. That "value" from the `onCreate` method is a reference to a `BagOfCheese` object. In other words, the `bag1` and `bag` variables refer to the same object.

The statement in the body of the `addOneDay` method adds `1` to the value stored in the object's `daysAged` field. After one day is added, the program's variables look like the information in Figure 9-20.

Notice how both the `bag1` and `bag` variables refer to an object whose `daysAged` value is 31. After returning from the call to `addOneDay`, the `bag` variable goes away. All that remains is the original `onCreate` method and its `bag1` variable, as shown in Figure 9-21. But `bag1` still refers to an object whose `daysAged` value has been changed to 31.

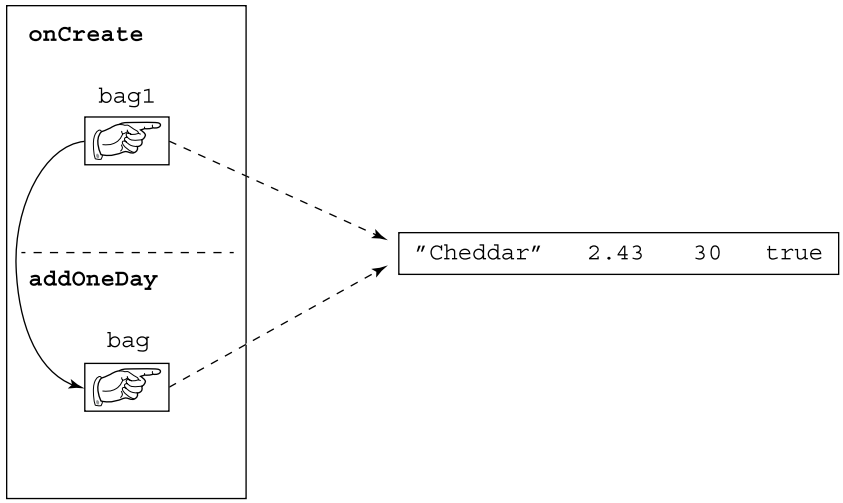


FIGURE 9-19: Java copies a pointer.

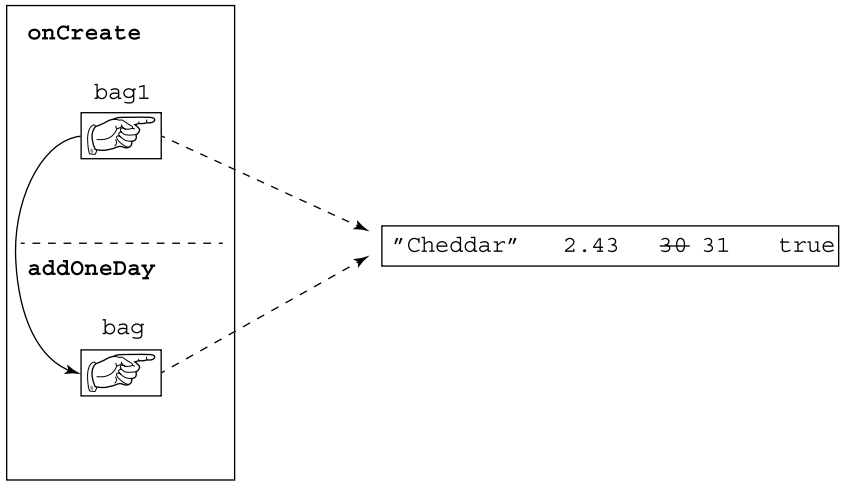


FIGURE 9-20: Java adds 1 to daysAged.

In Chapter 7, I show you how to pass primitive values to method parameters. Passing a primitive value to a method parameter is called *pass-by value*. In this section, I show you how to pass both primitive values and objects to method parameters. Passing an object (such as `bag1`) to a method parameter is called *pass-by reference*.

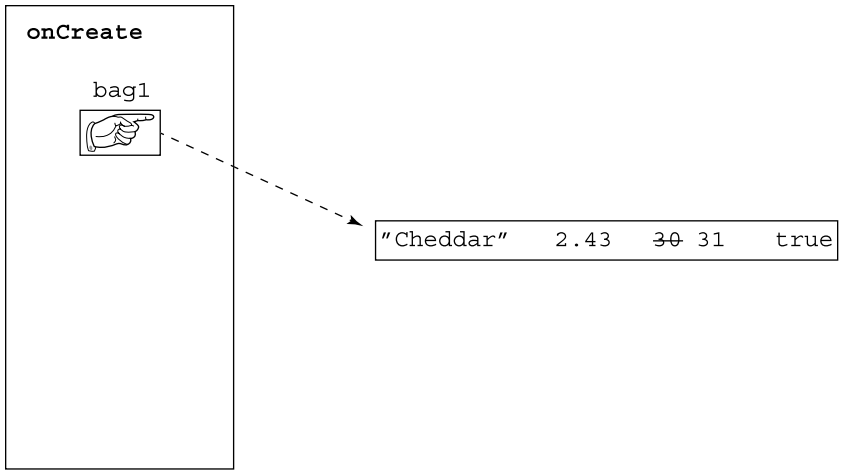


FIGURE 9-21: The original bag is aged 31 days.

Java's Modifiers

Throughout this book, you see words like `public` and `protected` peppered throughout the code listings. You might wonder what these words mean. (Actually, if you're reading from front to back, you might have grown accustomed to seeing them and started thinking of them as background noise.) In the next few sections, I tackle some of these *modifier* keywords.

Public classes and default-access classes

Most of the classes in this chapter's listings begin with the word `public`. When a class is public, any program in any package can use the code (or at least some of the code) inside that class. If a class isn't public, then for a program to use the code inside that class, the program must be inside the same package as the class. Listings 9-13, 9-14, and 9-15 illustrate these ideas.

LISTING 9-13: **What Is a Paragraph?**

```
package com.allyourcode.wordprocessor;

class Paragraph {
  int alignment;
  int borders;
  double leftIndent;
  double lineSpacing;
  int style;
}
```

LISTING 9-14: **Making a Paragraph with Code in the Same Package**

```
package com.allyourcode.wordprocessor;

class MakeAParagraph {
  Paragraph paragraph = new Paragraph();

  {
    paragraph.leftIndent = 1.5;
  }
}
```

LISTING 9-15: **Making a Paragraph with Code in Another Package**

```
// THIS IS BAD CODE:

package com.allyourcode.editor;

import com.allyourcode.wordprocessor.Paragraph;

public class MakeAnotherParagraph {
  Paragraph paragraph = new Paragraph();

  {
    paragraph.leftIndent = 1.5;
  }
}
```

The `Paragraph` class in Listing 9-13 has *default access* — that is, the `Paragraph` class isn't public. The code in Listing 9-14 is in the same package as the `Paragraph` class (the `com.allyourcode.wordprocessor` package). So in Listing 9-14, you can declare an object to be of type `Paragraph`, and you can refer to that object's `leftIndent` field.

The code in Listing 9-15 isn't in the same `com.allyourcode.wordprocessor` package. For that reason, the use of names like `Paragraph` and `leftIndent` (from Listing 9-13) aren't legal in Listing 9-15, even if Listings 9-13 and 9-15 are in the same Android Studio project. When you type Listings 9-13, 9-14, and 9-15 into the Android Studio editor, you see a red, blotchy mess for Listing 9-15, as shown in Figure 9-22.

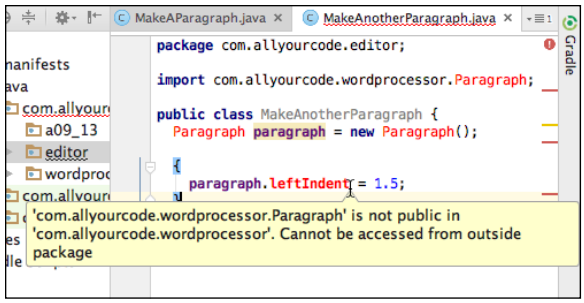


FIGURE 9-22: Errors in Listing 9-15.

TECHNICAL STUFF

Have you ever seen an assignment statement that's not inside of a method? Think about it. When you work with the `textView` variable in Listing 9-12, you declare `TextView textView` outside of any method, and then you assign `textView = (TextView) findViewById...` inside the `onCreate` method. Outside of a method, you can't assign values to things unless you create an initializer block. Like any other kind of block, an *initializer block* has open and close curly braces. Between the braces, the initializer block has statements that assign values to things. In Listing 9-14, an initializer block assigns the value 1.5 to a paragraph's `leftIndent` field. In Listing 9-15, an initializer block tries to assign a value, but the assignment doesn't work because the `Paragraph` class isn't public.

The `.java` file containing a public class must have the same name as the public class. For example, the file containing the code in Listing 9-1 must be named `BagOfCheese.java`.

Even the capitalization of the filename must be the same as the public class's name. You see an error message if you put the code in Listing 9-1 inside a file named `bagofcheese.java`. In the file's name, you have to capitalize the letters `B`, `O`, and `C`.

Because of the file-naming rule, you can't declare more than one public class in a `.java` file. If you put the public classes from Listings 9-1 and 9-2 into the same file, would you name the file `BagOfCheese.java` or `CreateBags.java`? Neither name would satisfy the file-naming rule. For that matter, *no* name would satisfy it.

Access for fields and methods

A class can have either public access or nonpublic (default) access. But a member of a class has four possibilities: public, private, default, and protected.

REMEMBER

A class's fields and methods are the class's *members*. For example, the class in Listing 9-10 has five members: the fields `kind`, `weight`, `daysAged`, and `isDomestic` and the method `toString`.

Here's how member access works:

- A default member of a class (a member whose declaration doesn't contain the words `public`, `private`, or `protected`) can be used by any code inside the same package as that class.
- A private member of a class cannot be used in any code outside the class.
- A public member of a class can be used wherever the class itself can be used; that is:
  - Any program in any package can refer to a public member of a public class.
  - For a program to reference a public member of a default access class, the program must be inside the same package as the class.

To see these rules in action, check out the public class in Listing 9-16.

LISTING 9-16: A Class with Public Access

```
package com.allyourcode.bank;

public class Account {
  public String customerName;
  private int internalIdNumber;
  String address;
  String phone;
  public int socialSecurityNumber;
  int accountType;
  double balance;

  public static int findById(int internalIdNumber) {
    Account foundAccount = new Account();
    // Code to find the account goes here.
    return foundAccount.internalIdNumber;
  }
}
```

The code in Figures 9-23 and 9-24 uses the `Account` class and its fields.

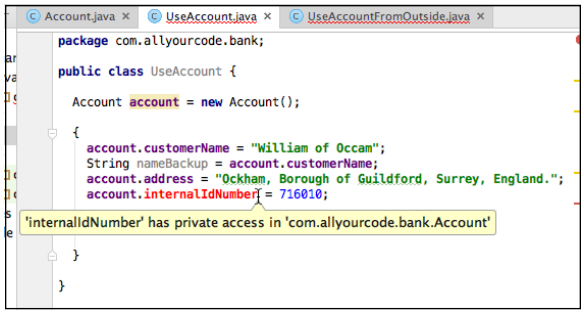


FIGURE 9-23: Referring to a public class in the same package.

The error messages in Figures 9-23 and 9-24 point to some troubles with the code. Here's a list of facts about these two pieces of code:

- The `UseAccount` class is in the same package as the `Account` class.
- The `UseAccount` class can create a variable of type `Account`.
- The `UseAccount` class's code can refer to the public `customerName` field of the `Account` class and to the default `address` field of the `Account` class.
- The `UseAccount` class cannot refer to the private `internalIdNumber` field of the `Account` class, even though `UseAccount` and `Account` are in the same package. (Refer to Figure 9-23.)
- The `UseAccountFromOutside` class is not in the same package as the `Account` class. (In Figure 9-24, notice `allyourcode` versus `allmycode`.)

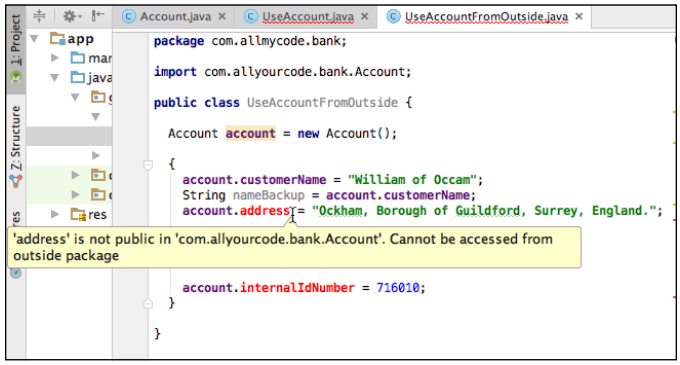


FIGURE 9-24: Referring to a public class in a different package.

- The `UseAccountFromOutside` class can create a variable of type `Account`. (An `import` declaration keeps me from having to repeat the fully qualified `com.allyourcode.bank.Account` name everywhere in the code.)

- The `UseAccountFromOutside` class's code can refer to the public `customerName` field of the `Account` class.
- The `UseAccountFromOutside` class's code cannot refer to the default `address` field of the `Account` class or to the private `internalIdNumber` field of the `Account` class. (Figure 9-24 shows the `address` field's error message.)

Now examine the nonpublic class in Listing 9-17.

LISTING 9-17: A Class with Default Access

```
package com.allyourcode.game;

class Sprite {
  public String name;
  String image;
  double distanceFromLeftEdge, distanceFromTop;
  double motionAcross, motionDown;
  private int renderingValue;

  void render() {
    if (renderingValue == 2) {
      // Do stuff here
    }
  }
}
```

The code in Figures 9-25 and 9-26 uses the `Sprite` class and its fields.

FIGURE 9-25: Referring to a default access class in the same package.

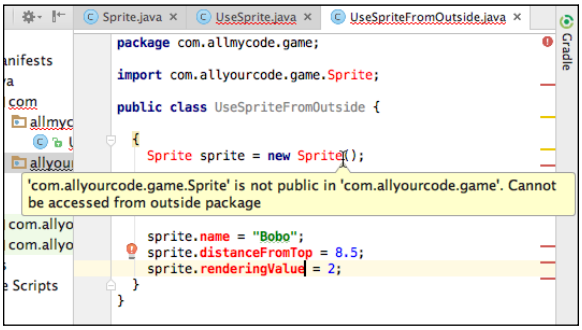


FIGURE 9-26: Referring to a default access class in a different package.

The error messages in Figures 9-25 and 9-26 point to some troubles with the code. Here's a list of facts about these two pieces of code:

- The `UseSprite` class is in the same package as the `Sprite` class.
- The `UseSprite` class can create a variable of type `Sprite`.
- The `UseSprite` class's code can refer to the public `name` field of the `Sprite` class and to the default `distanceFromTop` field of the `Sprite` class.
- The `UseSprite` class cannot refer to the private `renderingValue` field of the `Sprite` class, even though `UseSprite` and `Sprite` are in the same package. (Refer to Figure 9-25.)
- The `UseSpriteFromOutside` class isn't in the same package as the `Sprite` class. (In Figure 9-26, notice `allyourcode` versus `allmycode`.)
- The `UseSpriteFromOutside` class cannot create a variable of type `Sprite`. (Not even an `import` declaration can save you from an error message here.)
- Inside the `UseAccountFromOutside` class, references to `sprite.name`, `sprite.distanceFromTop`, and `sprite.renderingValue` are all meaningless because the `sprite` variable doesn't have a type.

Using getters and setters

In Figures 9-23 and 9-24, the `UseAccount` and `UseAccountFromOutside` classes can set an account's `customerName` and get the account's existing `customerName`:

```
account.customerName = "Occam";
String nameBackup = account.customerName;
```

But neither the `UseAccount` class nor the `UseAccountFromOutside` class can tinker with an account's `internalIdNumber` field.

What if you want a class like `UseAccount` to be able to get an existing account's `internalIdNumber` but not to change an account's `internalIdNumber`? (In many situations, getting information is necessary, but changing existing information is dangerous.) You can do all this with a *getter* method, as shown in Listing 9-18.

LISTING 9-18: Creating a Read-Only Field

```
package com.allyourcode.bank;

public class Account {
  public String customerName;
  private int internalIdNumber;
  String address;
  String phone;
  public int socialSecurityNumber;
  int accountType;
  double balance;

  public static int findById(int internalIdNumber) {
    Account foundAccount = new Account();
    // Code to find the account goes here.
    return foundAccount.internalIdNumber;
  }

  public int getInternalIdNumber() {
    return internalIdNumber;
  }
}
```

With the `Account` class in Listing 9-18, another class's code can call

```
int backupIdNumber = account.getInternalIdNumber();
```

The `Account` class's `internalIdNumber` field is still private, so another class's code has no way to assign a value to an account's `internalIdNumber` field. If you want to enable other classes to change an account's private `internalIdNumber` value, you can add a setter method to the code in Listing 9-18, like this:

```
public void setInternalIdNumber(int internalIdNumber) {
  this.internalIdNumber = internalIdNumber;
}
```

Getter and setter methods aren't built-in features in Java — they're simply ordinary Java methods. But this pattern (having a method whose purpose is to access an otherwise inaccessible field's value) is used so often that programmers use the terms *getter* and *setter* to describe it.

REMEMBER

Getter and setter methods are *accessor* methods. Java programmers almost always follow the convention of starting an accessor method name with `get` or `set` and then capitalizing the name of the field being accessed. For example, the field `internalIdNumber` has accessors named `getInternalIdNumber` and `setInternalIdNumber`. The field `renderingValue` has accessors named `getRenderingValue` and `setRenderingValue`.

You can have Android Studio create getters and setters for you. Here's how:

1. **Start with the code from Listing 9-16 in the Android Studio editor.**
2. **Click the mouse cursor anywhere inside the editor.**
3. **On the Android Studio main menu, select Code ➪ Generate ➪ Getter and Setter.**

   The Select Fields to Generate Getters and Setters dialog box appears, as shown in Figure 9-27.

   Alternatively, you can generate only getters by selecting Code ➪ Generate ➪ Getter. And you can generate only setters by selecting Code ➪ Generate ➪ Setter.

   A dialog box lists the fields in the class that appears in Android Studio's editor.
4. **Select one or more fields in the dialog box's list of fields.**

   To create the code in Listing 9-18, I selected only the `internalIdNumber` field.

   Alternatively, you can generate only getters by selecting Code

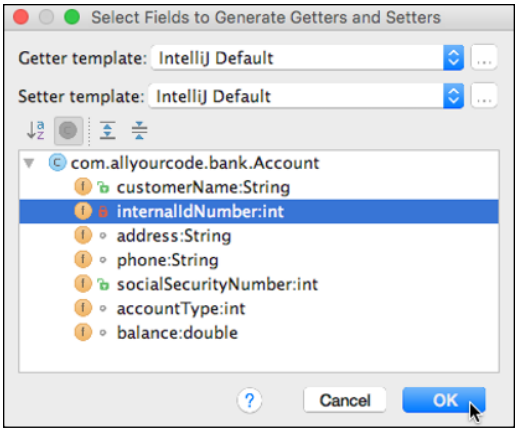


FIGURE 9-27: Select Fields to Generate Getters and Setters.

5. **Click OK.**

   Android Studio dismisses the dialog box and adds freshly brewed getter and setter methods to the editor's code.

CROSS-REFERENCE

I cover protected access in Chapter 10.

What does static mean?

This chapter begins with a discussion of cheese and its effects on Andy's business practices. Andy has a blank form that represents a class. He also has a bunch of filled-in forms, each of which represents an individual bag-of-cheese object.

One day, Andy decides to take inventory of his cheese by counting all the bags of cheese. (See Figure 9-28.)

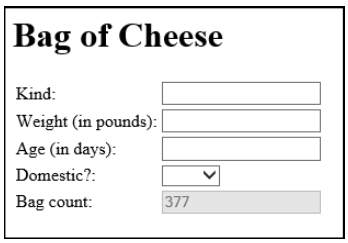


FIGURE 9-28: Counting bags of cheese.

Compare the various fields shown in Figure 9-28. From the object-oriented point of view, how is the `daysAged` field so different from the `count` field?

The answer is that a single bag can keep track of how many days it has been aged, but it shouldn't count *all* the bags. As far back as Listing 9-1, a `BagOfCheese` object has its own `daysAged` field. That makes sense. (Well, it makes sense to an object-oriented programmer.)

But giving a particular object the responsibility of counting all objects in its class doesn't seem fair. To have each `BagOfCheese` object speak on behalf of all the others violates a prime directive of computer programming: The structure of the program should imitate the structure of the real-life data. For example, I can post a picture of myself on Facebook, but I can't promise to count everyone else's pictures on Facebook. ("All you other Facebook users, count your own @#!% pictures!")

A field to count all bags of cheese belongs in one central place. That's why, in Figure 9-29, I have one, and only one, `count` field. Each object has its own `daysAged` value, but only the class itself has a `count` value.

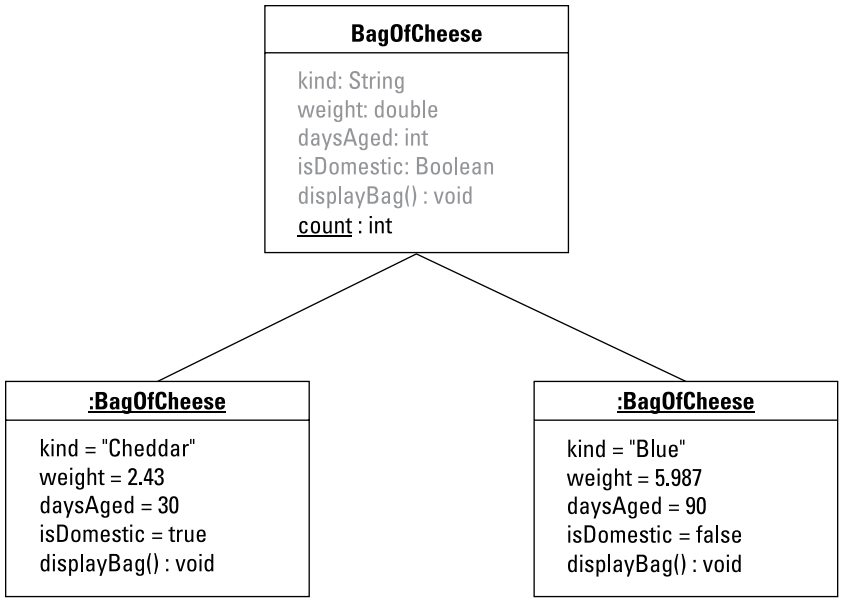


FIGURE 9-29: The UML diagram has only one `count` variable.

A field or method that belongs to an entire class rather than to each individual object is a *static* member of the class. To declare a static member of a class, you use Java's `static` keyword (what a surprise!), as shown in Listing 9-19.

LISTING 9-19: **Creating a Static Field**

```
package com.allmycode.a09_19;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;

  public static int count = 0;

  public BagOfCheese() {
    count++;
  }
}
```

For each call to the `BagOfCheese` constructor, the constructor adds 1 to the value of `count`.

To refer to a class's static member, you preface the member's name with the name of the class, as shown in Listing 9-20.

LISTING 9-20: Referring to a Static Field

```
package com.allmycode.a09_20;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_19.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    BagOfCheese bag1 = new BagOfCheese();
    BagOfCheese bag2 = new BagOfCheese();

    textView.setText(BagOfCheese.count + " bags");
  }
}
```

Fields aren't the only things that can be static. Methods can be static too. Consider the code in Listing 9-21.

LISTING 9-21: A Static Field and a Static Method

```
package com.allmycode.a09_21;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;
```

```
  private static int count = 0;

  public static int getCount() {
    return count;
  }

  public BagOfCheese() {
    count++;
  }
}
```

Listing 9-21 contains a static field and a static method. The static `count` field is private, so another class's code can't refer to `BagOfCheese.count`. But the method `getCount` is public. So, in place of `BagOfCheese.count`, another class can obtain the same information by calling `BagOfCheese.getCount()`.

TIP

Android's official code style guidelines, posted at `http://source.android.com/source/code-style.html`, tell you to start every nonpublic, nonstatic field name with a lowercase letter `m`. In an introductory Java book, I depart from these guidelines. But that's why, in a professionally written Android program, you'll see so many names start with the letter `m`.

To dot, or not

Consider the three ways to refer to a member (a field or a method):

- **You can preface the member name with a name that refers to an object.**

  For example, in Listing 9-11, I preface calls to `toString` with the names `bag1` and `bag2`, each of which refers to an object:

  ```
  textView.append(bag1.toString());
  textView.append(bag2.toString());
  ```

  When you do this, you're referring to something that belongs to each individual object. (You're referring to the object's nonstatic field, or calling the object's nonstatic method.)

- **You can preface the member name with a name that refers to a class.**

  For example, in Listing 9-20, I prefaced the field name `count` with the class name `BagOfCheese`.

  When you do this, you're referring to something that belongs to the entire class. (You're referring to the class's static field, or calling the class's static method.)

» **You can preface the member name with nothing.**

For example, in Listing 9-10, inside the `toString` method, I use the names `kind`, `weight`, `daysAged`, and `isDomestic` with no dots in front of them:

```
public String toString() {
  return kind + ", " +  weight + ", " + daysAged + ", " + isDomestic +
                                                                "\n";
}
```

A method can do this when it refers to its own object's fields, not when it refers to some other object's fields.


TECHNICAL STUFF

Java provides a loophole in which you break one of the three rules I just described. In Listing 9-20, you can replace `BagsOfCheese.count` with `bag1.count` or with `bag2.count`. That is, you can refer to a static member by prefacing it with the name of an object. This isn't a good a thing to do. It's just something that you're allowed to do.

A bad example

Don't do what I do in Listing 9-22.

LISTING 9-22: Trouble in River City

```
// BAD CODE!!! GO TO YOUR ROOM, CODE.
package com.allmycode.a09_22;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;

  private int count = 0;

  public static int getCount() {
    return count;
  }

  public BagOfCheese() {
    count++;
  }
}
```

If you type the code in Listing 9-22 into Android Studio's editor and then hover the mouse over the `return count` statement, you see this ferocious-looking error message: `Non-static field 'count' cannot be referenced from a static context`. What gives? In my own code, I saw this error message dozens and dozens of times before I started feeling comfortable with the meaning of the word `static`.

If the `count` field isn't static, each instance of the `BagOfCheese` class has its own `count` field, and each `count` field belongs to an instance of the `BagOfCheese` class. But that's not true of the `getCount` method. In Listing 9-22, the `getCount` method is static. So the `getCount` method doesn't belong to any particular `BagOfCheese` instance. The `getCount` method belongs to the entire `BagOfCheese` class. See Figure 9-30.

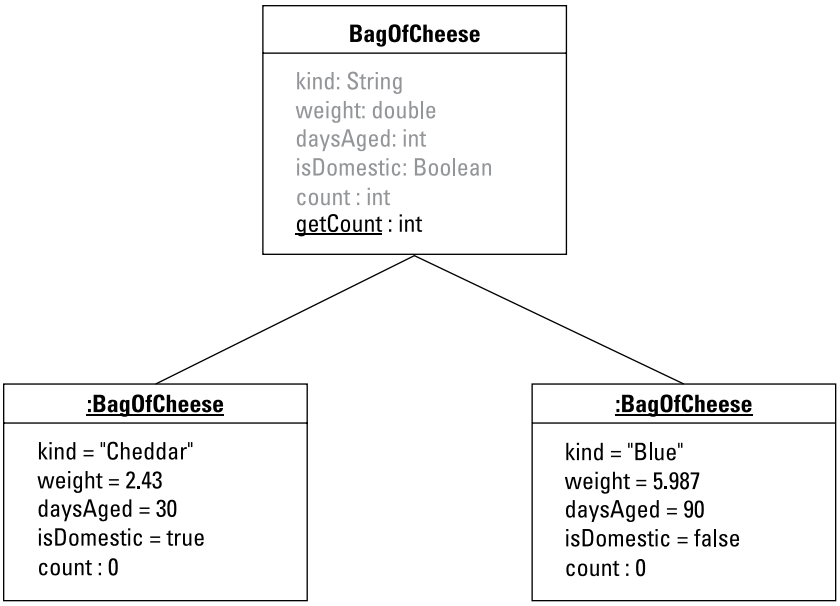


FIGURE 9-30: Not good! Several count variables but only one getCount method.

Inside of the `getCount` method, when Java sees the `return count` statement, Java doesn't know which instance's `count` to return. So Java refuses to compile your code. Android Studio displays an error message, and you're out of luck!

What's Next?

This chapter talks about individual classes. Most classes don't exist in isolation from other classes. Most classes belong to hierarchies of classes, subclasses, and sub-subclasses, so the next chapter covers the relationships among classes.

IN THIS CHAPTER

- Tweaking your code
- Adding new life to old code
- Making changes without spending a fortune

Chapter 10
Saving Time and Money: Reusing Existing Code

Wouldn't it be nice if every piece of software did just what you wanted it to do? In an ideal world, you could simply buy a program, make it work right away, plug it seamlessly into new situations, and update it easily whenever your needs changed. Unfortunately, software of this kind doesn't exist. (*Nothing* of this kind exists.) The truth is that no matter what you want to do, you can find software that does some of it, but not all of it.

This is one reason that object-oriented programming has been successful. For years, companies were buying prewritten code only to discover that the code didn't do what they wanted it to do. So the companies began messing with the code. Their programmers dug deep into the program files, changed variable names, moved subprograms around, reworked formulas, and generally made the code worse. The reality was that if a program didn't already do what you wanted (even if it did something ever so close to it), you could never improve the situation by mucking around inside the code. The best option was to chuck the whole program (expensive as that was) and start over. What a sad state of affairs!

Object-oriented programming has brought about a big change. An object-oriented program is, at its heart, designed to be modified. Using correctly written software, you can take advantage of features that are already built in, add new features of your own, and override features that don't suit your needs. The best aspect of this situation is that the changes you make are clean — no clawing and digging into other

people's brittle program code. Instead, you make nice, orderly additions and modifications without touching the existing code's internal logic. It's the ideal solution.

The Last Word on Employees — Or Is It?

When you write an object-oriented program, you start by considering the data. You're writing about accounts. So what's an account? You're writing code to handle button clicks. So what's a button? You're writing a program to send payroll checks to employees. What's an employee?

In this chapter's first example, an employee is someone with a name and a job title — sure, employees have other characteristics, but for now I stick to the basics:

```
class Employee {
  String name;
  String jobTitle;
}
```

Of course, any company has different kinds of employees. For example, your company may have full-time and part-time employees. Each full-time employee has a yearly salary:

```
class FullTimeEmployee extends Employee {
  double salary;
}
```

In this example, the words `extends Employee` tell Java that the new class (the `FullTimeEmployee` class) has all the properties that any `Employee` has and, possibly, more. In other words, every `FullTimeEmployee` object is an `Employee` object (an employee of a certain kind, perhaps). Like any `Employee`, a `FullTimeEmployee` has a `name` and a `jobTitle`. But a `FullTimeEmployee` also has a salary. That's what the words `extends Employee` do for you.

A part-time employee has no fixed yearly salary. Instead, every part-time employee has an hourly pay rate and a certain number of hours worked in a week:

```
class PartTimeEmployee extends Employee {
  double hourlyPay;
  int hoursWorked;
}
```

So far, a `PartTimeEmployee` has four characteristics: `name`, `jobTitle`, `hourlyPay`, and number of `hoursWorked`.

Then you have to consider the big shots — the executives. Every executive is a full-time employee. But in addition to earning a salary, every executive receives a bonus (even if the company goes belly up and needs to be bailed out):

```
class Executive extends FullTimeEmployee {
  double bonus;
}
```

Java's `extends` keyword is cool because, by extending a class, you inherit all the complicated code that's already in the other class. The class you extend can be a class that you have (or another developer has) already written. One way or another, you're able to reuse existing code and to add ingredients to the existing code.

Here's another example: The creators of Android wrote the `AppCompatActivity` class, with its 460 lines of code. You get to use all those lines of code for free by simply typing `extends AppCompatActivity`:

```
public class MainActivity extends AppCompatActivity {
```

With the two words `extends AppCompatActivity`, your new `MainActivity` class can do all the things that a typical Android activity can do — start running, find items in the app's `res` directory, show a dialog box, respond to a low-memory condition, start another activity, return an answer to an activity, finish running, and much more.

Extending a class

So useful is Java's `extends` keyword that developers have several different names to describe this language feature:

- **Superclass/subclass:** The `Employee` class (see the earlier section "The Last Word on Employees — Or Is It?") is the *superclass* of the `FullTimeEmployee` class. The `FullTimeEmployee` class is a *subclass* of the `Employee` class.
- **Parent/child:** The `Employee` class is the *parent* of the `FullTimeEmployee` class. The `FullTimeEmployee` class is a *child* of the `Employee` class.

  In fact, the `Executive` class extends the `FullTimeEmployee` class, which in turn extends the `Employee` class. So `Executive` is a *descendant* of `Employee`, and `Employee` is an *ancestor* of `Executive`. The Unified Modeling Language (UML) diagram in Figure 10-1 illustrates this point.
- **The "is a" relationship:** Every `FullTimeEmployee` object *is an* `Employee` object.

» **Inheritance:** The `FullTimeEmployee` class *inherits* the `Employee` class's members. (If any of the `Employee` class's members were declared to be `private`, the `FullTimeEmployee` class wouldn't inherit those members.)

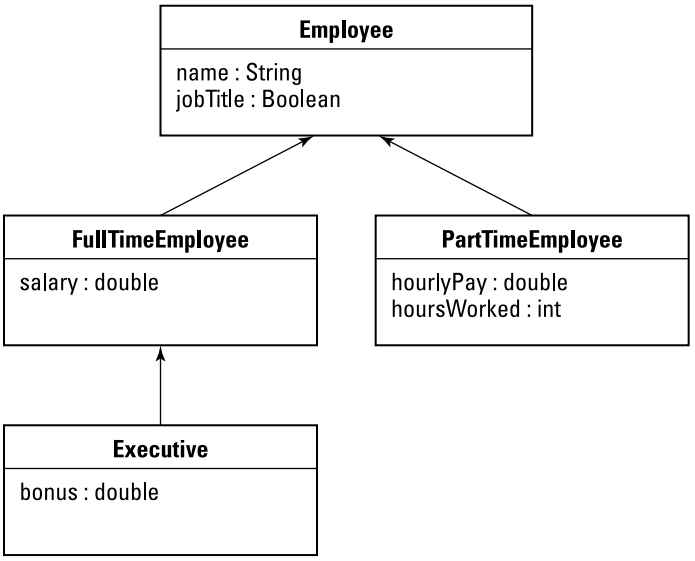


FIGURE 10-1: A class, two child classes, and a grandchild class.

The `Employee` class has a `name` field, so the `FullTimeEmployee` class has a `name` field, and the `Executive` class has a `name` field. In other words, with the declarations of `Employee`, `FullTimeEmployee`, and `Executive` at the start of this section, the code in Listing 10-1 is legal.

All descendants of the `Employee` class have `name` fields, even though a `name` field is explicitly declared only in the `Employee` class itself.

LISTING 10-1: **Using the `Employee` Class and Its Subclasses**

```
Employee employee = new Employee();
employee.name = "Sam";

FullTimeEmployee ftEmployee = new FullTimeEmployee();
ftEmployee.name = "Jennie";

Executive executive = new Executive();
executive.name = "Harriet";
```

Almost every Java class extends another Java class. I write *almost* because one (and only one) class doesn't extend any other class. Java's built-in `Object` class doesn't extend anything. The `Object` class is at the top of Java's class hierarchy. Any class whose header has no `extends` clause automatically extends Java's `Object` class. So every other Java class is, directly or indirectly, a descendant of the `Object` class, as shown in Figure 10-2.

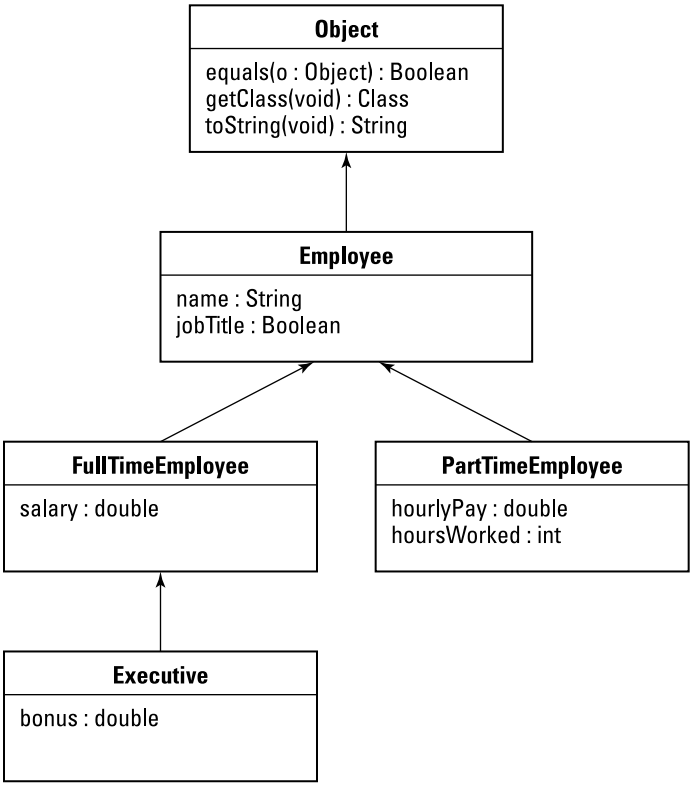


FIGURE 10-2: Everything comes from Java's `Object` class.

The notion of extending a class is one pillar of object-oriented programming. In the 1970s, computer scientists were noticing that programmers tended to reinvent the wheel. If you needed code to balance an account, for example, you started writing code from scratch to balance an account. Never mind that other people had written their own account-balancing code. Integrating other peoples' code with yours, and adapting other peoples' code to your own needs, was a big headache. All things considered, it was easier to start from scratch.

Then, in the 1980s, object-oriented programming became popular. The notion of classes and subclasses provided a clean way to connect existing code (such as Android's `Activity` class code) with new code (such as your new `MainActivity` class code). By extending an existing class, you hook into the class's functionality, and you reuse features that have already been programmed.


REMEMBER

By reusing code, you avoid the work of reinventing the wheel. But you also make life easier for the end user. When you extend Android's `Activity` class, your new activity behaves like other peoples' activities because both your activity and the other peoples' activities inherit the same behavior from Android's `Activity` class. With so many apps behaving the same way, the user learns familiar patterns. It's a win-win situation.

Overriding methods

In this section, I expand on all the employee code snippets from the start of this chapter. From these snippets, I can present a fully baked program example. The example, as laid out in Listings 10-2 through 10-6, illustrates some important ideas about classes and subclasses.

LISTING 10-2: **What Is an Employee?**

```
package com.allyourcode.company;

public class Employee {
  public String name;
  public String jobTitle;

  public Employee() {
  }

  public Employee(String name, String jobTitle) {
    this.name = name;
    this.jobTitle = jobTitle;
  }

  public String getPayString() {
    return name + ", Pay not known\n";
  }
}
```

LISTING 10-3: **Full-Time Employees Have Salaries**

```
package com.allyourcode.company;

import java.text.NumberFormat;
import java.util.Locale;
public class FullTimeEmployee extends Employee {
  public double salary;

  static NumberFormat currency = NumberFormat.getCurrencyInstance(Locale.US);

  public FullTimeEmployee() {
  }

  public FullTimeEmployee(String name, String jobTitle, double salary) {
    this.name = name;
    this.jobTitle = jobTitle;
    this.salary = salary;
  }

  public double pay() {
    return salary;
  }

  @Override
  public String getPayString() {
    return name + ", " + currency.format(pay()) + "\n";
  }
}
```

LISTING 10-4: **Executives Get Bonuses**

```
package com.allyourcode.company;

public class Executive extends FullTimeEmployee {
  public double bonus;

  public Executive() {
  }

  public Executive(String name, String jobTitle, double salary, double bonus) {
    this.name = name;
    this.jobTitle = jobTitle;
```

(continued)

LISTING 10-4: *(continued)*

```
    this.salary = salary;
    this.bonus = bonus;
  }

  @Override
  public double pay() {
    return salary + bonus;
  }
}
```

LISTING 10-5: **Part-Time Employees Are Paid by the Hour**

```
package com.allyourcode.company;

import java.text.NumberFormat;
import java.util.Locale;

public class PartTimeEmployee extends Employee {
  public double hourlyPay;
  public int hoursWorked;

  static NumberFormat currency = NumberFormat.getCurrencyInstance(Locale.US);

  public PartTimeEmployee() {
  }

  public PartTimeEmployee(String name, String jobTitle,
                          double hourlyPay, int hoursWorked) {
    this.name = name;
    this.jobTitle = jobTitle;
    this.hourlyPay = hourlyPay;
    this.hoursWorked = hoursWorked;
  }

  public double pay() {
    return hourlyPay * hoursWorked;
  }

  @Override
  public String getPayString() {
    return name + ", " + currency.format(pay()) + "\n";
  }
}
```

LISTING 10-6: **Putting Your Employee Classes to the Test**

```
package com.allyourcode.a10_06;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allyourcode.company.Employee;
import com.allyourcode.company.FullTimeEmployee;
import com.allyourcode.company.Executive;
import com.allyourcode.company.PartTimeEmployee;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    Employee employee = new Employee("Barry", "Author");

    FullTimeEmployee ftEmployee =
        new FullTimeEmployee("Ed", "Manager", 10000.00);

    PartTimeEmployee ptEmployee =
        new PartTimeEmployee("Joe", "Intern", 8.00, 20);

    Executive executive =
        new Executive("Jane", "CEO", 20000.00, 5000.00);

    textView.setText("");

    textView.append(employee.getPayString());
    textView.append(ftEmployee.getPayString());
    textView.append(ptEmployee.getPayString());
    textView.append(executive.getPayString());
  }
}
```

Figure 10-3 shows a run of the code in Listings 10-2 through 10-6.

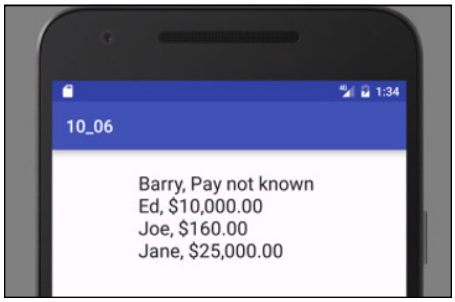


FIGURE 10-3: Running the code in Listings 10-2 through 10-6.

Figure 10-4 contains a UML diagram for the `Employee` class and its descendants.

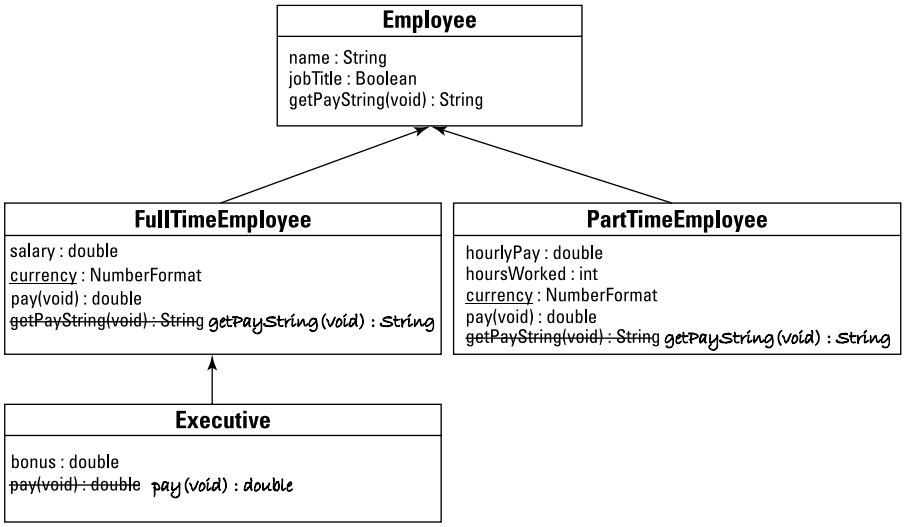


FIGURE 10-4: Classes and subclasses with fields and methods.

TECHNICAL STUFF

In Figure 10-4, I use strikethrough text and simulated handwriting to represent overridden methods. These typographical tricks are my own inventions. Neither the strikethrough nor the simulated handwriting is part of the UML standard. In fact, the UML standard has all kinds of rules that I ignore in this book. My main purpose in showing you the rough UML diagrams is to help you visualize the hierarchies of classes and their subclasses.

Consider the role of the `getPayString` method in Figure 10-4 and in Listings 10-2 through 10-6. In the figure, `getPayString` appears in all except the `Executive` class; in the listings, I define `getPayString` in all except the `Executive` class.

The `getPayString` method appears for the first time in the `Employee` class (refer to Listing 10-2), where it serves as a placeholder for not knowing the employee's pay. The `FullTimeEmployee` class (refer to Listing 10-3) would inherit this vacuous `getPayString` class except that the `FullTimeEmployee` class declares its own version of `getPayString`. In the terminology from Chapter 4, the `getPayString` method in `FullTimeEmployee` *overrides* the `getPayString` method in `Employee`.

Listing 10-6 contains a call to a full-time employee's `getPayString` method:

```
FullTimeEmployee ftEmployee = ... Etc.
...
textView.append(ftEmployee.getPayString());
```

And in Figure 10-3, the call to `ftEmployee. getPayString()` gives you the `FullTimeEmployee` class's version of `getPayString`, not the `Employee` class's clueless version of `getPayString`. (If `ftEmployee.getPayString()` called the `Employee` class's version of `getPayString`, you'd see `Ed, Pay not known` in Figure 10-3.) Overriding a method declaration means taking precedence over that existing version of the method.

Of course, overriding a method isn't the same as obliterating a method. In Listing 10-6, the statements

```
Employee employee = ... Etc.
...
textView.append(employee.getPayString());
```

conjure up the `Employee` class's noncommittal version of `showPay`. It happens because an object declared with the `Employee` constructor has no `salary` field, no `hourlyPay` field, and no `getPayString` method other than the method declared in the `Employee` class. The `Employee` class, and any objects declared using the `Employee` constructor, could do their work even if the other classes (`FullTimeEmployee`, `PartTimeEmployee`, and so on) didn't exist.


REMEMBER

The only way to override a method is to declare a method with the same name and the same parameters inside a subclass. By *same parameters*, I mean the same number of parameters, each with the same type. For example, `calculate(int count, double amount)` overrides `calculate(int x, double y)` because both declarations have two parameters: The first parameter in each declaration is of type `int`, and the second parameter in each declaration is of type `double`. But `calculate(int count, String amount)` doesn't override `calculate(int count, double amount)`. In one declaration, the second parameter has type `double`, and in the other declaration, the second parameter has type `String`. If you call `calculate(42, 2.71828)`, you get the `calculate(int x, double y)` method, and if you call `calculate(42, "Euler")` you get the `calculate(int count, String amount)` method.

Listings 10-2 through 10-5 have other examples of overriding methods. For example, the `Executive` class in Listing 10-4 overrides its parent class's `pay` method, but not the parent class's `getPayString` method. Calculating an executive's pay is different from calculating an ordinary full-time employee's pay. But after you know the two peoples' pay amounts, showing an executive's pay is no different from showing an ordinary full-time employee's pay.

When I created this section's examples, I considered giving the `Employee` class a `pay` method (returning `0` on each call). This strategy would make it unnecessary for me to create identical `getPayString` methods for the `FullTimeEmployee` and `PartTimeEmployee` classes. For various reasons (none of them interesting), I decided against doing it that way.

Overriding works well in situations in which you want to tweak an existing class's features. Imagine having a news ticker that does everything you want except scroll sideways. (I'm staring at one on my computer right now! As one news item disappears toward the top, the next news item scrolls in from below. The program's options don't allow me to change this setting.) After studying the code's documentation, you can subclass the program's `Ticker` class and override the `Ticker` class's `scroll` method. In your new `scroll` method, the user has the option to move text upward, downward, sideways, or inside out (whatever that means).

Java's super keyword

You can inherit a lot from your parents. But one thing you can't inherit is their experiences of having been born. Yes, you can see pictures that your grandparents took. But that's not the same as having been there.

At this point, you may feel like quibbling. What would it mean to "inherit" your parents' birth experiences? Well, you can stop right there. I'm not trying to form a perfect metaphor. I'm only trying to introduce an important fact about Java programming — the fact that classes don't inherit constructors from their parent classes.

Look at the constructors in Listings 10-2 and 10-3.

- The `FullTimeEmployee` class extends the `Employee` class.
- Both classes have parameterless constructors.
- Both classes have constructors that initialize all of their fields.

In fact, a `FullTimeEmployee` constructor initializes three fields. Only one of these fields — the `salary` field — is declared in the `FullTimeEmployee` class's code. The

FullTimeEmployee class inherits the other two fields — name and jobTitle — from the Employee class. This isn't a matter of FullTimeEmployee overriding its parent class's constructors. There are no constructors to override. Like any other subclass, the FullTimeEmployee class doesn't inherit its parent class's constructors.

Is there any way to avoid the loathsome redundancy of all the constructor declarations in Listings 10-2 to 10-5? There is. Java's super keyword can refer to a parent class's constructor:

```
public FullTimeEmployee(String name, String jobTitle, double salary) {
  super(name, jobTitle);
  this.salary = salary;
}
```

In this code, the FullTimeEmployee constructor calls its parent class's constructor. The call to super has two parameters and, as luck would have it, the parent Employee class has a two-parameter constructor:

```
public Employee(String name, String jobTitle) {
  this.name = name;
  this.jobTitle = jobTitle;
}
```

The super call sends two parameters to the parent class's constructor, and the parent class's constructor uses those two parameters to give name and jobTitle their initial values. Finally, the FullTimeEmployee class assigns a value to its own salary field. Everything works very nicely.

Java annotations

In Java, elements that start with an at-sign (@) are *annotations.* In Listings 10-3, 10-4, and 10-5, each @Override annotation reminds Java that the method immediately below the annotation has the same name and the same parameter types as a method in the parent class. The use of the @Override annotation is optional. If you remove all @Override lines from Listings 10-3, 10-4, and 10-5, the code works the same way.

Why use the @Override annotation? Imagine leaving off the annotation and mistakenly putting the following getPayString method (and no other getPayString method declaration) in Listing 10-3:

```
public String getPayString(double salary) {
  return name + ", " + currency.format(salary) + "\n";
}
```

You might think that you've overridden the parent class's `getPayString` method, but you haven't! The `Employee` class's `getPayString` method has no parameters, and your new `FullTimeEmployee` class's `getPayString` method has a parameter. Android Studio looks at this stuff in the editor and says, "Okay, I guess the developer is inheriting the `Employee` class's parameterless `getPayString` method and declaring an additional version of `getPayString`. Both `getPayString` methods are available in the `FullTimeEmployee` class." (By the way, when Android Studio speaks, you can't see my lips moving.)

Everything goes smoothly until you run the code. The Java virtual machine sees the statement

```
textView.append(ftEmployee.getPayString());
```

in the main activity and calls the *parameterless* version of `getPayString`, which the `FullTimeEmployee` class inherits from its parent. That parent's method returns the useless `Pay not known` message. On the emulator screen, you see `Ed, Pay not known` for the full-time employee. That's not what you want.

The problem in this hypothetical example isn't so much that you commit a coding error — everybody makes mistakes like this one. (Yes, even I do. I make lots of them.) The problem is that, without an `@Override` annotation, you don't catch the error until you're running the program. That is, you don't see the error message as soon as you compose the code in the Android Studio editor. Waiting until runtime can be as painless as saying, "Aha! I know why this program didn't run correctly." But waiting until runtime can also be quite painful — as painful as saying, "My app was rated 1 on a scale of 5 because of this error that I didn't see until a user called my bad `getPayString` method."

Ideally, Android Studio is aware of your intention to override an existing method, and it can complain to you while you're staring at the editor. If you use the `@Override` annotation in conjunction with the bad `getPayString` method, the editor underlines `@Override` in red. When you hover the mouse over the word `@Override`, you see the message shown in Figure 10-5. That's good because you can fix the problem long before the problem shows up in a run of your code.

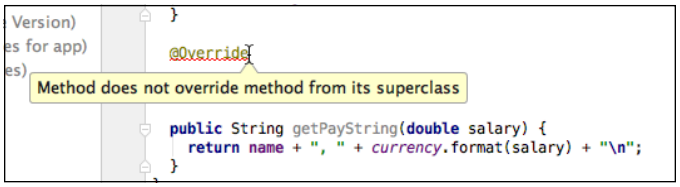


FIGURE 10-5: The `getPayString` method doesn't override the parent class's `getPayString` method.

In Chapter 9, Android Studio creates a `toString` method and puts another annotation — the `@NonNull` annotation — at the top of the method declaration. In Java, any reference type variable that doesn't point to anything has the value `null`. Consider the following cases:

- If you write `String greeting = "Hello"`, the `greeting` variable points to the characters `H`, `e`, `l`, `l`, `o`.
- If you write `String greeting = ""`, the `greeting` variable points to a string containing no characters. No, the string has no characters in it, but yes, it's still a string. If you execute

  ```
  greeting.length()
  ```

  you get the number 0.
- If you write `String greeting = null`, the `greeting` variable doesn't point to anything. In this case, if you execute

  ```
  greeting.length()
  ```

  your app crashes and you see a `NullPointerException` in Android Studio's Logcat pane.

In Chapter 9, the `@NonNull` annotation reminds Android Studio that the value returned by the new `toString` method must not be `null`. If Android Studio detects that the method returns `null`, you see a little yellow mark along the editor's rightmost edge. If you hover over that mark, you see a `'null' is returned by the method` warning.

More about Java's Modifiers

I start the conversation about Java's modifiers in Chapters 5 and 9. Chapter 5 describes the keyword `final` as it applies to variables, and Chapter 9 deals with the keywords `public` and `private`. In this section, I add a few more fun facts about Java modifiers.

The word `final` has many uses in Java programs. In addition to having final variables, you can have these elements:

- **Final class:** If you declare a class to be `final`, no one (not even you) can extend it.

» **Final method:** If you declare a method to be `final`, no one (not even you) can override it.

Figures 10-6 and 10-7 put these rules into perspective. In Figure 10-6, I can't extend the `Stuff` class, because the `Stuff` class is `final`. And in Figure 10-7, I can't override the `Stuff` class's `increment` method because the `Stuff` class's `increment` method is `final`.

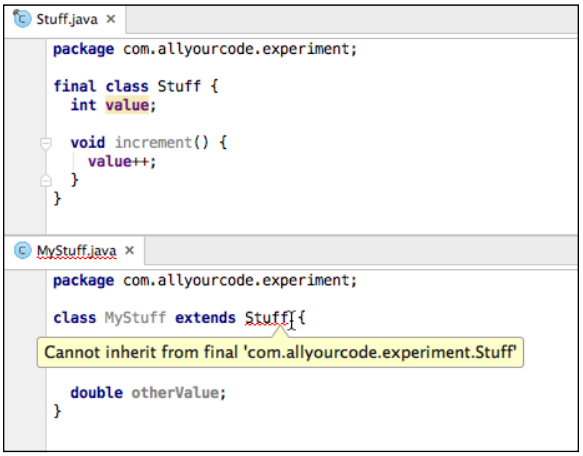


FIGURE 10-6: Trying to extend a final class.

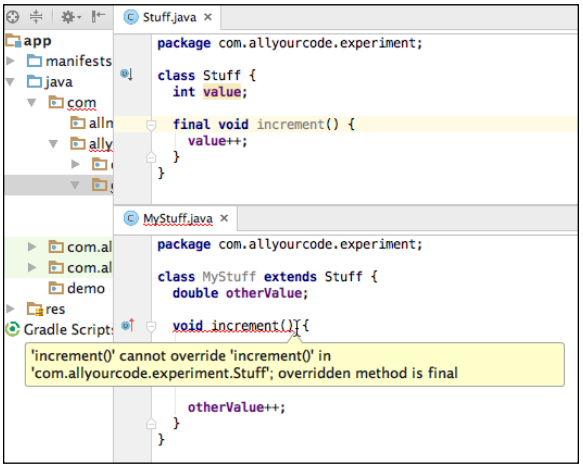


FIGURE 10-7: Trying to override a final method.

You can apply Java's `protected` keyword to a class's members. This `protected` keyword has always seemed a bit strange to me. In common English usage, when my possessions are "protected," my possessions aren't as available as they'd normally be. But in Java, when you preface a field or a method with the `protected` keyword, you make that field or method a bit more available than it would be by default, as shown in Figure 10-8.

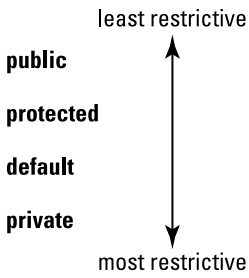


FIGURE 10-8: Access modes for fields and methods.

Here's what I say in Chapter 9 about members with default access:

> A default member of a class (a member whose declaration doesn't contain the words `public`, `private`, or `protected`) can be used by any code inside the same package as that class.

The same thing is true about a `protected` class member. But in addition, a `protected` member is inherited outside the class's package by any subclass of the protected member's class.

Huh? What does that last sentence mean? To make things concrete, Figure 10-9 shows you the carefree existence in which two classes are in the same package. With both `Stuff` and `MyStuff` in the same package, the `MyStuff` class inherits the `Stuff` class's default access `value` variable. The `MyStuff` class also inherits (and then overrides) the `Stuff` class's default access `increment` method.

If you move the `Stuff` class to a different package, `MyStuff` no longer inherits the `Stuff` class's default access `value` variable, as shown in Figure 10-10. In addition, the `MyStuff` class doesn't inherit the `Stuff` class's default access `increment` method.

But if, in the `Stuff` class, you turn `value` into a `protected` variable and you turn `increment` into a `protected` method, the `MyStuff` class again inherits its parent class's `value` variable and `increment` method, as shown in Figure 10-11.

Stuff.java

```
package com.allyourcode.experiment;

public class Stuff {
  int value;

  void increment() {
    value++;
  }
```

MyStuff.java

```
package com.allyourcode.experiment;

class MyStuff extends Stuff {
  double otherValue;

  @Override
  void increment() {
    value += 2;
  }
}
```

FIGURE 10-9: Two classes in the same package.

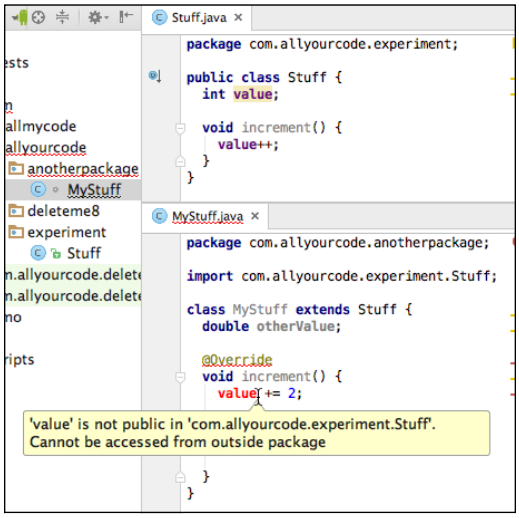


FIGURE 10-10: Classes in different packages.

Notice one more detail in Figure 10-11. I change the `MyStuff` class's `increment` method from default to `public`. I do this to avoid seeing an interesting little error message. You can't override a method with another method whose access is more restrictive than the original method. In other words, you can't override a public method with a private method. You can't even override a public method with a default method.

Java's default access is more restrictive than protected access. (Refer to Figure 10-8.) So you can't override a protected method with a default method. In Figure 10-11, I avoid the whole issue by making the `MyStuff` class's `increment` method be public. That way, I override the `increment` method with the least restrictive kind of access.

Stuff.java

```
package com.allyourcode.experiment;

public class Stuff {
  protected int value;

  protected void increment() {
    value++;
  }
}
```

MyStuff.java

```
package com.allyourcode.anotherpackage;

import com.allyourcode.experiment.Stuff;

class MyStuff extends Stuff {
  double otherValue;

  @Override
  public void increment() {
    value += 2;


  }
}
```

FIGURE 10-11: Using the protected modifier.

Keeping Things Simple

Most programs operate entirely in the virtual realm. They have no bricks, nails, or girders. You can type a fairly complicated program in minutes. Even with no muscle and no heavy equipment, you can create a structure whose complexity rivals that of many complicated physical structures. You, the developer, have the power to build intricate, virtual bridges.

One goal of programming is to manage complexity. A good app isn't simply useful or visually appealing — a good app's code is nicely organized, easy to understand, and easy to modify.

Certain programming languages, like C++, support *multiple inheritance*, in which a class can have more than one parent class. For example, in C++ you can create a `Book` class, a `TeachingMaterial` class, and a `Textbook` class. You can make `Textbook` extend both `Book` and `TeachingMaterial`. This feature makes class hierarchies quite flexible, but it also makes those same hierarchies extremely complicated. You need tricky rules to decide how to inherit the `move` methods of both the computer's `Mouse` class and the rodent's `Mouse` class.

To avoid all this complexity, Java doesn't support multiple inheritance. In Java, each class has one (and only one) superclass. A class can have any number of subclasses. You can (and will) create many subclasses of Android's `AppCompatActivity` class. And other developers create their own subclasses of Android's `AppCompatActivity` class. But classes don't have multiple personalities. A Java class can have only one

parent. The `Executive` class (refer to Listing 10-4) cannot extend both the `FullTimeEmployee` class and the `PartTimeEmployee` class.

Using an interface

The relationship between a class and its subclass is one of inheritance. In many real-life families, a child inherits assets from a parent. That's the way it works.

But consider the relationship between an editor and an author. The editor says, "By signing this contract, you agree to submit a completed manuscript by the fifteenth of August." Despite any excuses that the author gives before the deadline date, the relationship between the editor and the author is one of obligation. The author agrees to take on certain responsibilities; and, in order to continue being an author, the author must fulfill those responsibilities. (By the way, there's no subtext in this paragraph — none at all.)

Now consider Barry Burd. Who? Barry Burd — that guy who writes *Java Programming for Android Developers For Dummies,* 2nd Edition, and certain other *For Dummies* books (all from Wiley Publishing). He's a college professor, and he's also an author. You want to mirror this situation in a Java program, but Java doesn't support multiple inheritance. You can't make Barry extend both a `Professor` class and an `Author` class at the same time.

Fortunately for Barry, Java has interfaces. A class can extend only one parent class, but a class can implement many interfaces. A parent class is a bunch of stuff that a class inherits. On the other hand, as with the relationship between an editor and an author, an *interface* is a bunch of stuff that a class is obliged to provide.

Here's another example. Listings 10-2 through 10-5 describe what it means to be an employee of various kinds. Though a company might hire consultants, consultants who work for the company aren't employees. Consultants are normally self-employed. They show up temporarily to help companies solve problems and then leave the companies to work elsewhere. In the United States, differentiating between an employee and a consultant is important: So serious are the U.S. tax withholding laws that labeling a consultant an "employee" of any kind would subject the company to considerable legal risk.

To include consultants with employees in your code, you need a `Consultant` class that's separate from your existing `Employee` class hierarchy. On the other hand, consultants have a lot in common with a company's regular employees. For example, every consultant has a `getPayString` method. You want to represent this commonality in your code, so you create an interface. The interface obligates a class to give meaning to the method name `getPayString`, as shown in Listing 10-7.

LISTING 10-7: **Behold! An Interface!**

```
package com.allyourcode.company;

public interface Payable {

  public String getPayString();
}
```

The element in Listing 10-7 isn't a class — it's a Java interface. Here's what the listing's code says:

> As an interface, my `getPayString` method has a header, but no body. In this interface, the `getPayString` method takes no arguments and returns a value of type `String`. A class that claims to implement me (the `Payable` interface) must provide (either directly or indirectly) a body for the `getPayString` method. That is, a class that claims to implement `Payable` must, in one way or another, implement the `getPayString` method.

CROSS-REFERENCE

> To find out about the difference between a method declaration's header and its body, see Chapter 4.

Listings 10-8 and 10-9 implement the `Payable` interface and provide bodies for the `getPayString` method.

LISTING 10-8: **Implementing an Interface**

```
package com.allyourcode.company;

import java.text.NumberFormat;
import java.util.Locale;

public class Consultant implements Payable {

  String name;
  double hourlyFee;
  int hoursWorked;

  static NumberFormat currency = NumberFormat.getCurrencyInstance(Locale.US);

  public Consultant() {
  }
```

(continued)

LISTING 10-8: *(continued)*

```
  public Consultant(String name, double hourlyFee, int hoursWorked) {
    this.name = name;
    this.hourlyFee = hourlyFee;
    this.hoursWorked = hoursWorked;
  }

  public double pay() {
    return hourlyFee * hoursWorked;
  }

  @Override
  public String getPayString() {
    return name + ", " + currency.format(pay()) + "\n";
  }
}
```

LISTING 10-9: **Another Class Implements the Interface**

```
package com.allyourcode.company;

public class Employee implements Payable {
  String name;
  String jobTitle;
  int vacationDays;
  double taxWithheld;

  public Employee() {
  }

  public Employee(String name, String jobTitle) {
    this.name = name;
    this.jobTitle = jobTitle;
  }

  @Override
  public String getPayString() {
    return name + ", Pay not known\n";
  }
}
```

In Listings 10-8 and 10-9, both the `Consultant` and `Employee` classes implement the `Payable` interface — the interface that summarizes what it means to be paid by the company. With this in mind, consider the code in Listing 10-10.

LISTING 10-10: **Using an Interface**

```
package com.allyourcode.a10_10;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allyourcode.company.Consultant;
import com.allyourcode.company.Employee;
import com.allyourcode.company.Payable;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    Employee employee = new Employee("Barry", "Author");
    Consultant consultant = new Consultant("Willy", 100.00, 30);

    textView.setText("");

    displayPay(employee);
    displayPay(consultant);
  }

  void displayPay(Payable payable) {
    textView.append(payable.getPayString());
  }
}
```

A run of the code in Listing 10-10 is shown in Figure 10-12.

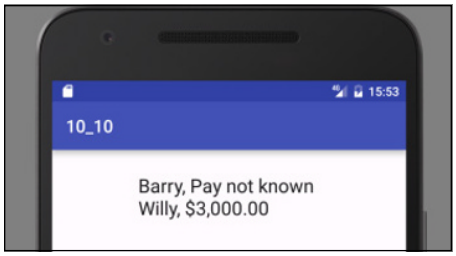


FIGURE 10-12: Paying an employee and a consultant.

In Listing 10-10, the `displayPay` method doesn't know anything about `Employee` classes or `Consultant` classes. All the `displayPay` method knows is that it wants its parameter to implement the `Payable` interface. As long as the object you pass to `displayPay` implements the `Payable` interface, the `displayPay` method's body can safely call the `getPayString` method.

Both the `Employee` and `Consultant` classes implement the `Payable` interface. So, in Listing 10-10, you can pass an `Employee` object to the `displayPay` method, and pass a `Consultant` object to the `displayPay` method. That flexibility — the ability to pass more than one kind of object to a method — illustrates the power of Java's interfaces.

In this section's example, two otherwise unrelated classes (`Employee` and `Consultant`) both implement the `Payable` interface. When I picture a Java interface, it's an element that cuts across levels of Java's class/subclass hierarchy, as shown in Figure 10-13.

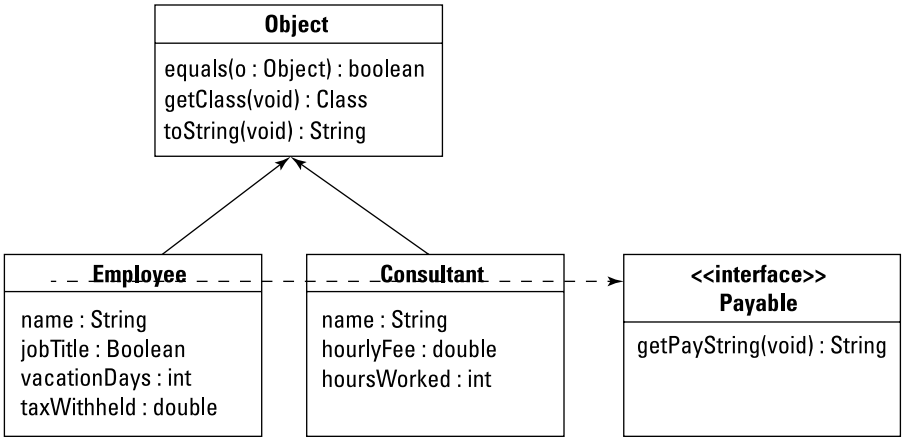


FIGURE 10-13: An interface cuts across the class hierarchy.

TECHNICAL STUFF

The dotted line in Figure 10-13 isn't part of standard UML. The folks who manage the standard have much better ways to represent interfaces than I use in this chapter's figures.

Some Observations about Android's Classes

When you start a new project, Android Studio offers to create an activity for your project. Android Studio offers you several different kinds of activities, such as a Basic Activity, an Empty Activity, a Login Activity, and so on. If you ask for an Empty Activity, you get the code shown in Listing 10-11.

LISTING 10-11: Android Studio Creates a Main Activity

```
package com.allyourcode.a10_11;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;

public class MainActivity extends AppCompatActivity {

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
  }
}
```

The code declares a class named `MainActivity`. This name `MainActivity` isn't part of the Android API library. It's a name that you make up when you create a new Android project. (Actually, Android Studio makes up the name. You accept the name or change it to some other name when you follow the steps to create a new project.)

The `MainActivity` class in Listing 10-11 extends a class that belongs to Android's SDK library, namely, the `AppCompatActivity` class. In other words, the `MainActivity` object *is an* `AppCompatActivity` object. The `MainActivity` object has all the rights and responsibilities that any `AppCompatActivity` instance has. For example, the `MainActivity` has an `onCreate` method, which it overrides in Listing 10-11.

In fact, the `MainActivity` class inherits about 460 lines of code from Android's `AppCompatActivity` class, which inherits about 1,000 lines from Android's `FragmentActivity` class, which inherits about 6,700 lines from Android's `Activity` class. The inherited methods include ones such as `getCallingActivity`, `getCallingPackage`, `getParent`, `getTitle`, `getTitleColor`, `getWindow`,

onBackPressed, onKeyDown, onKeyLongPress, onLowMemory, onMenuItemSelected, setTitle, setTitleColor, startActivity, finish, and many, many others. You inherit all this functionality with two simple words: extends AppCompatActivity.

REMEMBER

In the terminology of familial relationships, your MainActivity class is a descendant of Android's Activity class. Your MainActivity class is a kind of Activity.

Figure 10-14, taken directly from Android's online documentation, summarizes this information about the AppCompatActivity class.

TIP

For easy access to Android's API library documentation, bookmark https://developer.android.com/reference/packages.html.

In addition to being a subclass, the AppCompatActivity class implements a bunch of interfaces, including the AppCompatCallback interface, the TaskStackBuilder interface, and others. You don't have to remember any of this. If you ever need to know it, you can look it up on Android's documentation page. I write about the MainActivity class's genealogy to drive home the importance of classes and objects in Java programming.

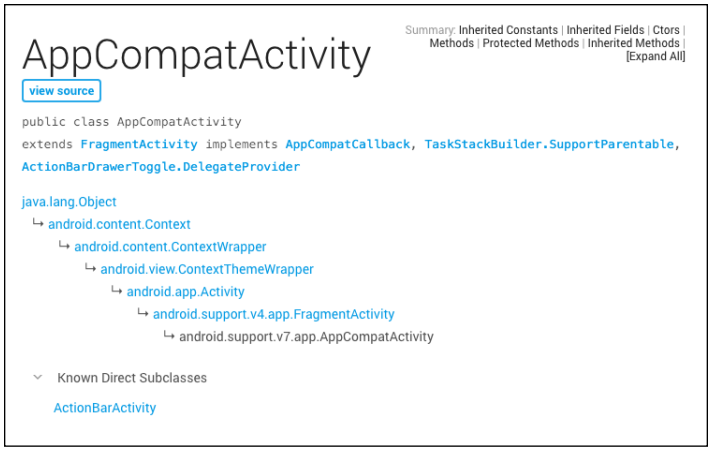


FIGURE 10-14: An AppCompatActivity family tree.

Java's super keyword, revisited

In an earlier section, the word super stands for the superclass's constructor. Listing 10-11, and many other listings, use the super keyword in a slightly different way. Yes, super always has something to do with a class's parent class. But, no, super doesn't always refer to the parent class's constructor.

In an `onCreate` method, the call `super.onCreate(savedInstanceState)` sends `savedInstanceState` to the parent class's `onCreate` method. In Listing 10-11, the parent class is the `AppCompatActivity` class. So Java calls the `AppCompatActivity` class's `onCreate` method.

The `AppCompatActivity` class's `onCreate` method contains its own call to `super.onCreate(savedInstanceState)`. The `AppCompatActivity` class's parent is the `FragmentActivity` class. So Java passes `savedInstanceState` to the `FragmentActivity` class's `onCreate` method. And so on.

It's not until you get to the `Activity` class — your `MainActivity` class's great-grandparent — that the code makes direct use of the `savedInstanceState` variable. From this `savedInstanceState` information, the code puts the activity back the way it was before the system destroyed it.

CROSS-REFERENCE

To find out why the poor activity may have been destroyed, see Chapter 4.

Casting, again

When you call `findViewById`, Java doesn't know what kind of view it will find. The `findViewById` method always returns a `View` instance, but lots of Android's classes extend the `View` class. For example, the classes `Button`, `TextView`, `ImageView`, `CheckBox`, `Chronometer`, and `RatingBar` all extend Android's `View` class. If you type the following code:

```
// DON'T DO THIS!!

TextView textView;

textView = findViewById(R.id.textView);
```

Java lets out a resounding, resentful roar: "How dare you assume that the object returned by a call to `findViewById` refers to an instance of the `TextView` class!" (Actually, Java quietly and mechanically displays an *Incompatible types* error message in Android Studio's editor. But I like to personify Java as though it's a stern taskmaster.)

In Chapter 6, *narrowing* means trying to assign a `long` value to an `int` value. A `long` value has 64 bits, and an `int` value has only 32 bits. So the attempt at narrowing fails. In this section, the bad `findViewById` call is another attempt to do narrowing — assigning the `View` value returned by a method call to a `TextView` variable. The `TextView` class is a subclass of the `View` class, so the assignment fails miserably.

But in so many of this book's examples, you prevent this failure. You appease the Java gods by adding a casting operator to the code. You tell Java to convert whatever pops out of the `findViewById` method call into a `TextView` object.

```
textView = (TextView) findViewById(R.id.textView1);
```

While you're typing the code, Java humors you and says, "Your casting operator shows me that you're aware of the difference between a `TextView` and any old `View`. I'll do my best to interpret the `View` object that I find at runtime as a `TextView` object." (Actually, while you're typing the code, Java says nothing. The fact that Java doesn't display any error messages when you use this casting trick is a good sign. Java's casting feature saves the day!)

REMEMBER

Casting prevents you from seeing an error message while you develop your code. In that way, casting is quite a useful feature of Java. But casting can't save you if your code contains runtime errors. When you type

```
textView = (TextView) findViewById(R.id.textView1);
```

you verify that the name `textView` represents a `TextView` widget. When the app runs, Java grabs the `R.id.textView` widget from the `activity_main.xml` file, and everything works just fine. But you may sometimes forget to check your `R.java` names against the components in the XML file. A call to `findViewById` surprisingly spits out a `Button` component when your casting tells Java to expect a `TextView` widget. When this happens, Java chokes on the casting operator and your app crashes during its run. Back to the drawing board!

CROSS-REFERENCE

For a more complete discussion of casting, see Chapter 6.

4 Powering Android with Java Code

IN THIS PART . . .

Becoming a collector (in the Java sense)

Creating an app that uses social media

Creating an Android game

IN THIS CHAPTER

- Putting a class inside another class
- Putting strings where they belong
- Using Java's special tricks to avoid programming hassles

Chapter 11
The Inside Story

In common English usage, an *insider* is someone with information that's not available to most people. An insider gets special information because of her position within an organization.

American culture has many references to insiders. Author John Gunther became famous for writing *Inside Europe* and *Inside Africa* and other books in his *Inside* series. On TV crime shows, an inside job is a theft or a murder committed by someone who works in the victim's own company. So significant is the power of inside information that, in most countries, insider stock trading is illegal.

In the same way, a Java class can live inside another Java class. When this happens, the inner class has useful insider information. This chapter explains why.

A Button-Click Example

The last listing in Chapter 3 illustrates the industrial-strength way to make a button respond to a click. In Chapter 3, I treat the listing like a black box. I show you the listing, but I don't write much about it.

Now you're reading Chapter 11, and you know a lot about Java. You know about classes, about classes that extend other classes, and about interfaces. (Chapters 9 and 10 deal with these topics.) So in this chapter, I can introduce Java's inner classes, and I can build up to the code in that Chapter 3 listing.

I start with the code in Listings 11-1 and 11-2.

LISTING 11-1: **Your Main Activity**

```
package com.allmycode.a11_01;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.Button;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  Button button;
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    button = (Button) findViewById(R.id.button);
    button.setOnClickListener(new MyOnClickListener(this));

    textView = (TextView) findViewById(R.id.textView);
  }

}
```

LISTING 11-2: **A Class Listens for Button Clicks**

```
package com.allmycode.a11_01;

import android.view.View;
import android.view.View.OnClickListener;

public class MyOnClickListener implements OnClickListener {
  MainActivity caller;

  public MyOnClickListener(MainActivity activity) {
    caller = activity;
  }
```

```
  public void onClick(View view) {
    caller.textView.setText(R.string.you_clicked);
  }
}
```

A run of the code in Listings 11-1 and 11-2 is shown in Figures 11-1 and 11-2.

FIGURE 11-1: Beginning a run of the code in Listings 11-1 and 11-2.

FIGURE 11-2: What you see after clicking the button in Listings 11-1 and 11-2.

CROSS-REFERENCE

In Listing 11-2, the expression `R.string.you_clicked` stands for the string `"You clicked the button!"`. For details, see this chapter's later section "Android String resources (A slight detour)."

In Android, every button has a `setOnClickListener` method. When you call a button's `setOnClickListener` method, you tell Java that an object should respond when the user clicks the button. And what does *respond* mean? In the case of a button click, the responding object always runs its `onClick` method. So in Listing 11-1, the statement

```
button.setOnClickListener(new MyOnClickListener(this));
```

tells Java to run a particular object's `onClick` method when the user clicks the button.

In Listing 11-1, the responding object is a brand-new instance of the `MyOnClickListener` class. That's good, because I declare the `MyOnClickListener` class in Listing 11-2.

So far, so good. But, in Listing 11-1, what's that word `this` doing in the call to the `MyOnClickListener` constructor? To answer the question, take another peek at some code from Listing 11-2:

```
MainActivity caller;

public MyOnClickListener(MainActivity activity) {
  caller = activity;
}
```

The `MyOnClickListener` constructor remembers whatever parameter you pass to it. The constructor stores the parameter in a field named `caller`. So if you execute `new MyOnClickListener(this)`, the field name `caller` ends up referring to whatever `this` stands for. See Figure 11-3.

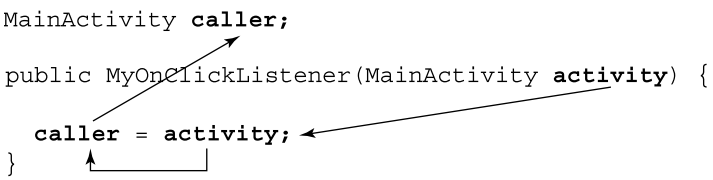


FIGURE 11-3: The caller field remembers the constructor's parameter.

The word `this` always stands for the object in which the word `this` appears. In Listing 11-1, the word `this` stands for the object that's described in Listing 11-1 — the `MainActivity` object. So in Listing 11-2, the field name `caller` ends up referring to the `MainActivity` described in Listing 11-1. That's interesting! Figure 11-4 illustrates the situation.

If `caller` refers to the stuff that's declared in Listing 11-1, `caller.textView` refers to the `textView` field in Listing 11-1. So, in Listing 11-2, the statement

```
caller.textView.setText(R.string.you_clicked);
```

tells Java to put the `R.string.you_clicked` string (the words `You clicked the button!`) into the activity's `textView` component. And that's how the words `You clicked the button!` get to appear on the screen shown in Figure 11-2. Figure 11-5 shows you what happens when Java runs the code.

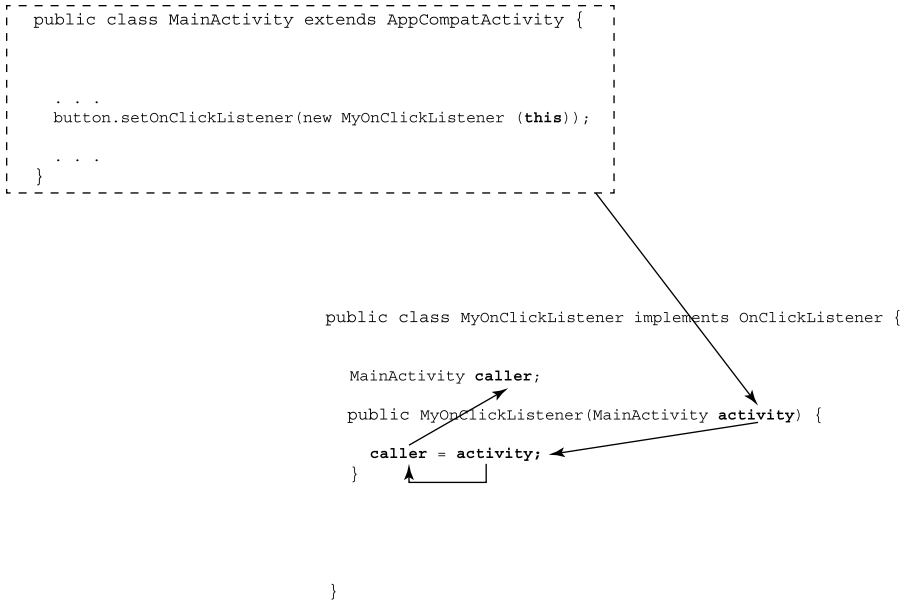


FIGURE 11-4: The caller field refers to the calling activity.

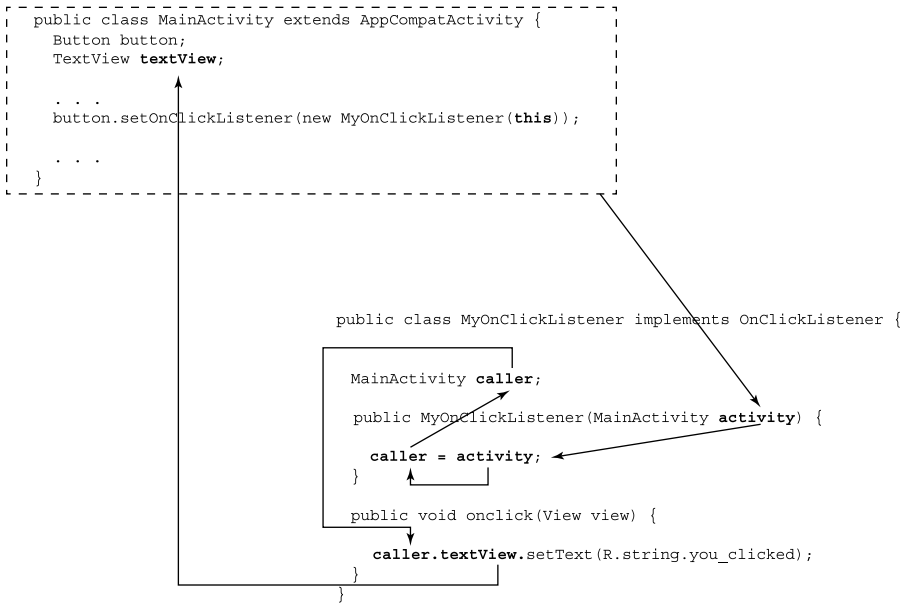


FIGURE 11-5: The journey of your application's main activity.

This is a callback

The pattern that I use in Listings 11-1 and 11-2 is known as a *callback*. When the user clicks the button, the `MyOnClickListener` object in Listing 11-2 calls back to the activity that created it. This callback is possible for two reasons:

- **Android's built-in `setOnClickListener` method expects its parameter to implement Android's `OnClickListener` interface.**

  I looked online for the first line of the `setOnClickListener` method's code. Here's what I found:

  ```
  public void setOnClickListener(OnClickListener l)
  ```

  Remember that `OnClickListener` is an interface, not a class.

  When you call `setOnClickListener`, you pass an object to the method. The `setOnClickListener` method doesn't know much about that object's class. The method doesn't know whether you'll pass it one of your `MyOnClickListener` objects or a `BagOfCheese` object or a `WhateverElse` object. The `setOnClickListener` method wants the flexibility to accept any of those objects as its parameter.

  All the `setOnClickListener` method knows is that it wants the object that you pass to it to implement Android's `OnClickListener` interface. That's why, in Listing 11-2, the `MyOnClickListener` class implements the `OnClickListener` interface.

- **The `MyOnClickListener` object knows how to call back the activity that constructed it.**

  Again, in Listing 11-1, the `MyOnClickListener` constructor call passes `this` to its new `MyOnClickListener` object. ("Call *me* back," says your activity's code in Listing 11-1.) Refer to Figure 11-5.

  Then, in Listing 11-2, the `MyOnClickListener` constructor makes a mental note of who gets called back, by storing a reference to your activity in its own `caller` field. So, when push comes to shove, the code in Listing 11-2 calls back `caller.textView.setText`, which changes the words displayed in the original activity's `textView`.

Android string resources (A slight detour)

Here's an experiment for you to try:

1. **Start with this statement (or a statement much like this statement) in Android Studio's editor:**

   ```
   textView.setText("You clicked the button!");
   ```

2. **Click the mouse on the `"You clicked the button!"` string. When you do, you see a message about Android resources. (See Figure 11-6.)**

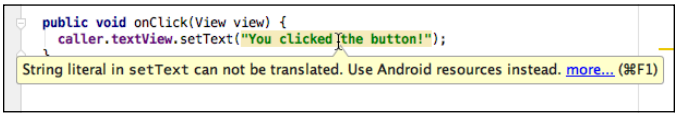


FIGURE 11-6: Please use Android resources.

3. **In response to the message, press Alt+Enter. When you do, you see a list of suggested actions. (See Figure 11-7.)**

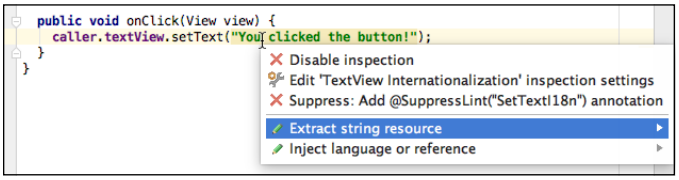


FIGURE 11-7: Android Studio suggests some actions.

4. **In the list of suggested actions, select the Extract String Resource action.**

   When you do, Android Studio displays an Extract Resource dialog box. (See Figure 11-8.)

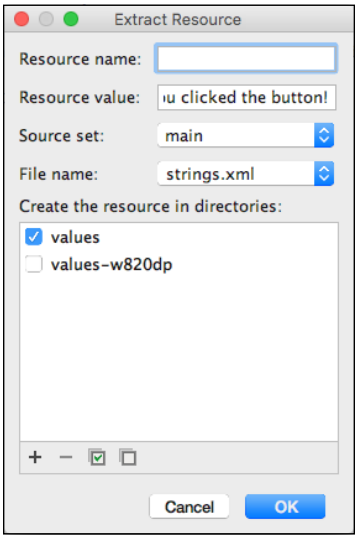


FIGURE 11-8: The Extract Resource dialog box.

5. **In the dialog box's name field, type you_clicked, or something like that.**

   Type something with only letters, digits, and underscores — something that reminds you about the `"You clicked the button!"` string's text.

6. **In the Extract Resource dialog box, click OK.**

When you do all this, Android Studio replaces the `"You clicked the button!"` string with the expression `R.string.you_clicked`. (Refer to Listing 11-2.) This expression stands for the `"You clicked the button!"` string because Android Studio has also added a line to your project's `app/res/values/strings.xml` file:

```
<resources>
    <string name="app_name">11_01</string>
    <string name="you_clicked">You clicked the button!</string>
    <string name="click_me">CLICK ME</string>
</resources>
```

When you run the project, Android looks up the meaning of `R.string.you_clicked` the same way Android finds a `TextView` component when you write `R.id.textView`. Some details are in Chapter 3.

WARNING

Android Studio's editor doesn't always show you the text that's actually in your Java code. After you've followed the previous steps, you may still see

```
textView.setText("You clicked the button!");
```

in the editor. If you hover the mouse over the `"You clicked the button!"` string, you see a popup showing the text that's actually in your code — the `R.string.you_clicked` expression.

While you're looking at my little `strings.xml` file, notice the file's `CLICK ME` line. When I created the app belonging to Listings 11-1 and 11-2, I started by putting `CLICK ME` on the face of the button using the Designer tool's Properties pane. Then I changed the Designer tool to its Text mode, where I saw the following lines in the `activity_main.xml` file:

```
    <Button
        android:text="CLICK ME"
```

I clicked my mouse on the code's `"CLICK ME"` value and followed steps similar to those for my `"You clicked the button!"` string. As a result, Android Studio changed the `activity_main.xml` file's lines to

```
    <Button
        android:text="@string/click_me"
```

and added the `CLICK ME` line in the `strings.xml` file.

What's the purpose of all this `R.string` and `@string` stuff? Don't you have enough problems following your code's logic without having to look up the values of things like `R.string.you_clicked`? To discover an important advantage of string resources, try this experiment:

1. **Follow this section's steps to create an `R.string.you_clicked` resource.**
2. **Open your project's `app/res/values/strings.xml` file in Android Studio's editor.**

   At the top of the editor, you see a notification about something called the Translations editor.
3. **Click the translation notification's Open Editor link.**

   As a result, Android Studio's Translations Editor appears. (See Figure 11-9.)

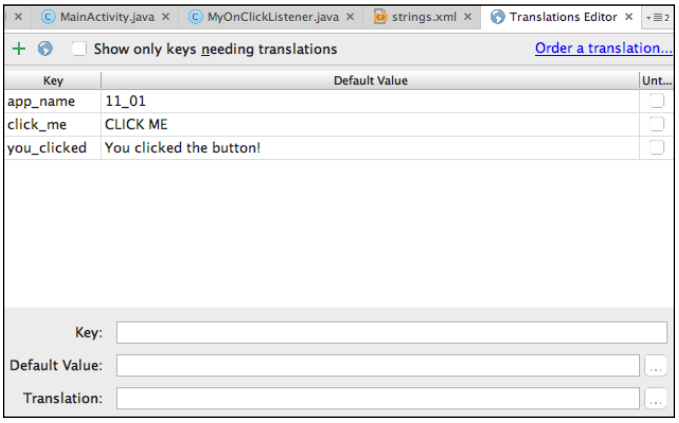


FIGURE 11-9: The Translations editor.

4. **Near the top of the Translations Editor, click the Globe icon.**

   A list of language locales appears. (See Figure 11-10.)

   For the full scoop on language locales, visit `www.iso.org/iso/country_codes`.

ON THE WEB

5. **Select a language locale from the list.**

   For this exercise, I select French (fr). As a result, the `strings.xml` branch in the Project tool window now has two subbranches. Both subbranches sport the label `strings.xml`, but the new subbranch's icon is a tiny picture of the flag of France. (See Figure 11-11.)

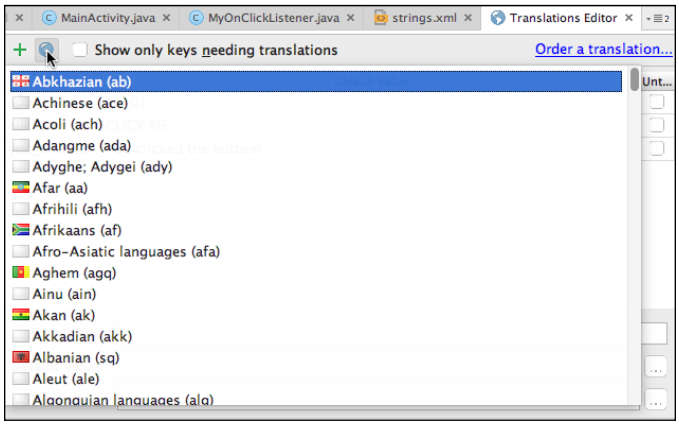


FIGURE 11-10
Select a language.

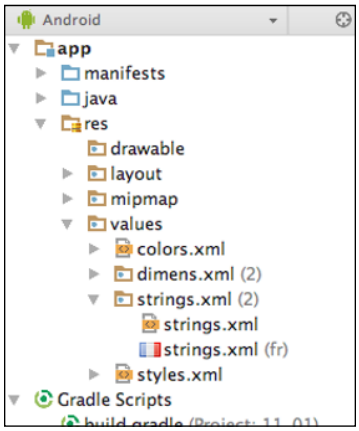


FIGURE 11-11:
Look! You have two `strings.xml` files.

In the Translations Editor, the term *you_clicked* is in red because you haven't yet translated *You clicked the button!* into French. The same is true for other terms that you haven't yet translated.

6. **Double-click the French (fr) column in the *you_clicked* row. In that column, type *Vous avez cliqué sur le bouton!* and then press Enter.**

Now, in the French version of the `strings.xml` file, you can find the following line:

```
<string name="you_clicked">Vous avez cliqué sur le bouton!</string>
```

(Sorry. The Translations Editor doesn't do any translating for you. The Translations Editor only adds code to your project when you type in the translations of words and phrases.)

7. **If you're ambitious, you can repeat these steps for the text on the face of the button.**

   With *R.string.click_me* referring to the English words *CLICK ME*, create the French translation *CLIQUEZ SUR-MOI*.

8. **Test your app.**

   As with most devices, the emulator has a setting for Language & Input. Change this setting to French (France), and suddenly your app looks like the display in Figure 11-12.

FIGURE 11-12: C'est formidable!

REMEMBER

In most of this book's examples, I keep your life simple by putting Java `String` literals in calls to `setText`. I also put English language phrases in layout files by typing the phrases in Android Studio's Properties pane. It's all good for beginners, but professional Android developers favor this section's use of string resources. With string resources, you separate the words the user sees from the code, making it easy to provide translations. This is great because, when you upload an app to Google Play, the app is available to people in more than 137 countries.

Introducing Inner Classes

Does the diagram in Figure 11-5 seem unnecessarily complicated? Look at all those arrows! You might expect to see a few somersaults as the `caller` object bounces from place to place! The `MyOnClickListener` class (refer to Listing 11-2) devotes much of its code to obsessively keeping track of this `caller` object.

Another problem with Listings 11-1 and 11-2 is the way one class tinkers with the other class's value. In Listing 11-2, with the line

```
caller.textView.setText(R.string.you_clicked);
```

the `MyOnClickListener` class changes the text in the `MainActivity` class's `textView` variable. That's not good programming practice. It's like sneaking into someone's house and moving some furniture around. It may be okay, but it's always disconcerting.

Is there a better way to handle a simple button click?

There is. You can define a class inside another class. When you do, you're creating an *inner class*. It's a lot like any other class. But within an inner class's code, you can refer to the enclosing class's fields with none of the froufrou in Listing 11-2. That's why, at the beginning of this chapter, I sing the praises of insider knowledge.

One big class with its own inner class can replace both Listings 11-1 and 11-2. And the new inner class requires none of the exotic gyrations that you see in the old `MyOnClickListener` class. Listing 11-3 contains this wonderfully improved code.

LISTING 11-3: **A Class within a Class**

```
package com.allmycode.a11_03;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.view.View.OnClickListener;
import android.widget.Button;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  Button button;
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    button = (Button) findViewById(R.id.button);
    button.setOnClickListener(new MyOnClickListener());

    textView = (TextView) findViewById(R.id.textView);
  }

  class MyOnClickListener implements OnClickListener {
```

```
    public void onClick(View view) {
      textView.setText(R.string.you_clicked);
    }
  }

}
```

When you run the code in Listing 11-3, you see the results shown earlier, in Figures 11-1 and 11-2.

Notice the relative simplicity of the new `MyOnClickListener` class in Listing 11-3. Going from the old `MyOnClickListener` class (refer to Listing 11-2) to the new `MyOnClickListener` inner class (refer to Listing 11-3), you reduce the number of files from two to one. But aside from the shrinkage, all the complexity of Figure 11-6 is absent from Listing 11-3. The use of `this`, `caller`, and `textView` in Listings 11-1 and 11-2 feels like a tangled rope. But in Listing 11-3, when you pull both ends of the rope, you find that the rope *isn't* knotted.

An inner class needs no fancy bookkeeping in order to keep track of its enclosing class's fields. Near the end of Listing 11-3, the line

```
textView.setText(R.string.you_clicked);
```

refers to the `MainActivity` class's `textView` field, which is exactly what you want. It's that straightforward.

REMEMBER

In this section, I show how a class can live inside of another class. An interface can live inside of a class, too. Look at two of the import declarations in Listing 11-3:

```
import android.view.View;
import android.view.View.OnClickListener;
```

Android's `View` class is in the `android.view` package. And Android's `OnClickListener` interface is an interface that's declared inside the `View` class.

No Publicity, Please!

Notice that the code in Listing 11-3 uses the `MyOnClickListener` class only once. (The only use is in a call to `button.setOnClickListener`.) So I ask: Do you really need a name for something that's used only once? No, you don't. (If there's only one cat in the house, you can name it "Cat.")

When you give a name to your disposable class, you have to type the name twice: once when you call the class's constructor:

```
button.setOnClickListener(new MyOnClickListener());
```

and a second time when you declare the class:

```
class MyOnClickListener implements OnClickListener {
```

To eliminate this redundancy, you can substitute the entire definition of the class in the place where you'd ordinarily call the constructor. When you do this, you have an *anonymous inner class*. Listing 11-4 shows you how it works.

LISTING 11-4: A Class with No Name (Inside a Class with a Name)

```
package com.allmycode.a11_04;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.view.View.OnClickListener;
import android.widget.Button;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  Button button;
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    button = (Button) findViewById(R.id.button);
    button.setOnClickListener(new OnClickListener() {
      public void onClick(View view) {
        textView.setText(R.string.you_clicked);
      }
    });

    textView = (TextView) findViewById(R.id.textView);
  }
}
```

A run of the code from Listing 11-4 is shown in Figures 11-1 and 11-2. In other words, the listing does exactly the same thing as its wordier counterparts in this chapter. The big difference is that, unlike this chapter's previous examples, the listing uses an anonymous inner class.

An anonymous inner class is a lot like an ordinary inner class. The big difference is that an anonymous inner class has no name. Nowhere in Listing 11-4 do you see a name like `MyOnClickListener`. Instead, you see what looks like an entire class declaration inside a call to `button.setOnClickListener`. It's as though the `setOnClickListener` call says, "The following listener class, which no one else refers to, responds to the button clicks."

Android Studio can turn the inner class code in Listing 11-3 into the anonymous class code in Listing 11-4. Here's how:

1. **View the code from Listing 11-3 in the Android Studio editor.**
2. **In the editor, click your mouse on either occurrence of the word `MyOnClickListener`.**
3. **On the Android Studio main menu, choose Refactor ➪ Inline.**

   The Inline to Anonymous Class dialog box appears, as shown in Figure 11-13.

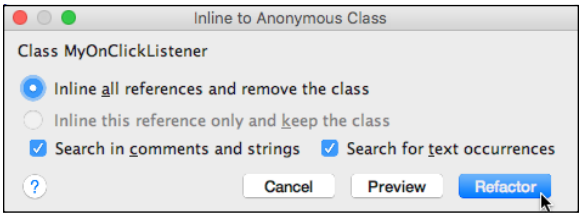


FIGURE 11-13: The Inline to Anonymous Class dialog box.

4. **In the dialog box, select the Inline All References and Remove the Class radio button.**
5. **Click OK.**

   As a result, Android Studio dismisses the dialog box and creates the code in Listing 11-4.

As far as I'm concerned, the most difficult aspect of using an anonymous inner class is keeping track of the code's parentheses, curly braces, and other non-alphabetic characters. Notice, for example, the string of closing punctuation characters — `!");}});` — that straddles a few lines in Listing 11-4. The indentation in that listing helps a little bit when you try to read a big *mush* of anonymous

inner class code, but it doesn't help a lot. Fortunately, there's a nice correspondence between the code in Listing 11-3 and the anonymized code in Listing 11-4. Figure 11-14 illustrates this correspondence.

I feel obliged to include a written explanation of the material in Figure 11-14. Here goes:

> To go from a named inner class to an anonymous inner class, you replace the named class's constructor call with the entire class declaration. In place of the class name, you put the name of the interface that the inner class implements (or, possibly, the name of the class that the inner class extends).

If you find my explanation helpful, I'm pleased. But if you don't find it helpful, I'm neither offended nor surprised. When I create a brand-new inner class, I find my gut feeling and Figure 11-14 to be more useful than Java's formal grammar rules.

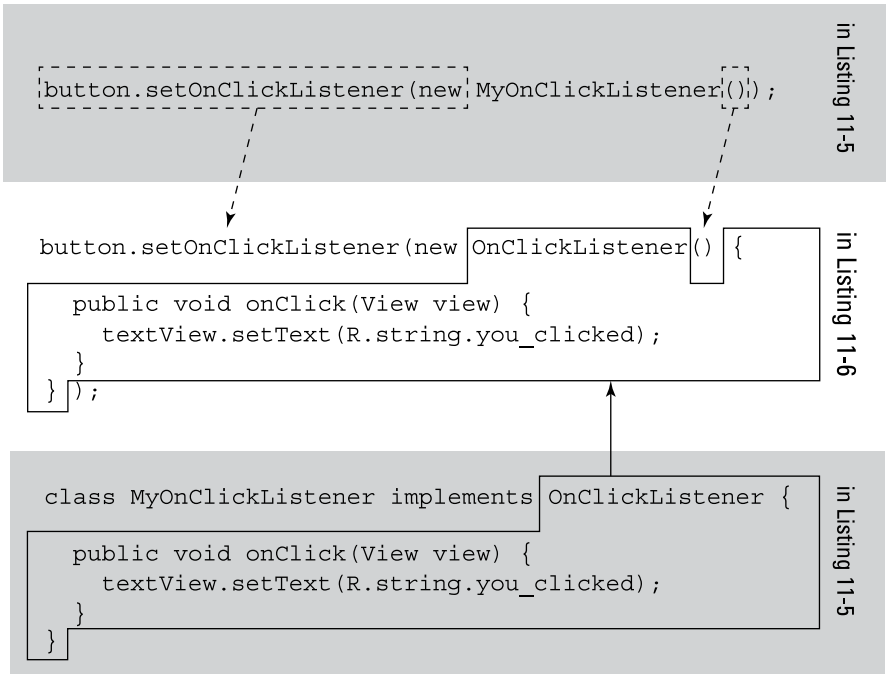


FIGURE 11-14: Turning ordinary inner class code into anonymous inner class code.

My humble advice: Start by writing code with no inner classes, such as the code in Listing 11-3. Later, when you become bored with ordinary Java classes, experiment by changing some of your ordinary classes into anonymous inner classes.

Lambda Expressions

If you open Listing 11-4 in Android Studio's editor and hover the mouse over the words `new OnClickListener`, you get an interesting surprise. (See Figure 11-15.) Android Studio tells you that you can replace the anonymous inner class with a lambda expression.

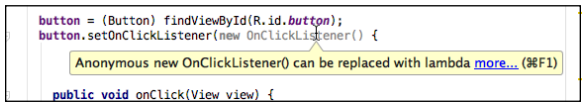


FIGURE 11-15: You can create a lambda expression.

Okay. What's a lambda expression? For starters, *lambda* is a letter in the Greek alphabet, and the term *lambda expression* comes from papers written in the 1930s by mathematician Alonzo Church.

In 2013, Oracle released Java 8, adding lambda expressions to the Java language. And in 2016, Google made Java 8 features available to Android developers.

I still haven't told you what a lambda expression is. A *lambda expression* is a concise way of declaring an interface that contains only one method. In Listing 11-4, the anonymous `OnClickListener` has only one method, namely, the `onClick` method. So you can replace this anonymous `OnClickListener` with a lambda expression.

If you respond to the message in Figure 11-15 by pressing Alt+Enter, Android Studio offers you a Replace with Lambda option. If you accept this option, Android Studio turns your code into the stuff shown in Listing 11-5.

LISTING 11-5: **Using a Lambda Expression**

```
package com.allmycode.a11_05;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.widget.Button;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  Button button;
  TextView textView;
```

(continued)

LISTING 11-5: *(continued)*

```
  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    button = (Button) findViewById(R.id.button);
    button.setOnClickListener(view -> textView.setText(R.string.you_clicked));

    textView = (TextView) findViewById(R.id.textView);
  }

}
```

The code in Listing 11-5 does exactly the same thing as the code in Listings 11-1 to 11-6. The only difference is that Listing 11-5 uses a lambda expression. Figure 11-16 illustrates the transition from a class that implements a one-method interface to a lambda expression.

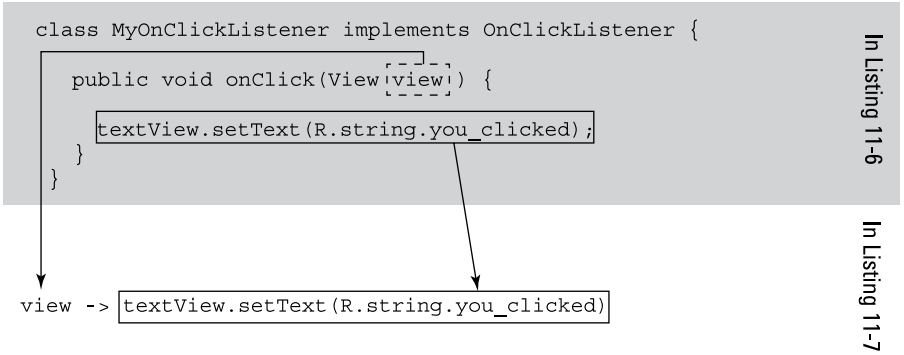


FIGURE 11-16: Turning an interface into a lambda expression.

In Figure 11-16, notice the lightweight role of the word `view`. When you declare an `onClick` method, you give the method a parameter of type `View` even if the statements inside the method don't use that parameter. In the same way, when you create a lambda expression for an `onClick` method, you preface the `->` symbol with a parameter name, even if you don't use that parameter name to the left of the `->` symbol.

TECHNICAL STUFF

In order to use lambda expressions, you must satisfy certain requirements. For example, you must compile your code with Java 8 or higher. Your Android Studio version must be 2.1 or higher. And your project's `build.gradle` file must include the following code:

```
android {
  ...
  defaultConfig {
    ...
    jackOptions {
      enabled true
    }
  }
  ...
}
```


TIP

A lambda expression may have more than one parameter to the left of the –> symbol. If it does, you must enclose all the parameters in parentheses and separate the parameters from one another with commas. For example, the expression

```
(price1, price2) -> price1 + price2
```

is a valid lambda expression.

If you're comfortable with lambda expressions, Listing 11-5 is much more readable than the earlier listings in this chapter. What started out as about ten lines of code in Listing 11-2 has become only part of a line in Listing 11-5.

IN THIS CHAPTER

- Dealing with many objects at a time
- Creating versatile classes and methods
- Creating a drop-down list

Chapter 12

Dealing with a Bunch of Things at a Time

All the world's a class,

And all the data, merely objects.

— JIMMY SHAKESPEARE, 11-YEAR-OLD COMPUTER GEEK

A *class* is a blueprint for things, and an *object* is a thing made from the blueprint. By *thing,* I mean a particular employee, a customer, an Android activity, or a more ethereal element, such as an `SQLiteOpenHelper`.

Android's `SQLiteOpenHelper` class assists developers in the creation of databases. An `SQLiteOpenHelper` doesn't look like anything in particular, certainly not like an employee or a bag of cheese. Nevertheless, `SQLiteOpenHelper` is a class.

This chapter covers another thing that you might not normally consider a class or an object — namely, a bunch of things. I use the word *bunch,* by the way, to avoid the formal terminology. (There's nothing wrong with the formal terminology, but I want to save it for this chapter's official grand opening, in the first section.)

Creating a Collection Class

A *collection class* is a class whose job is to store a bunch of objects at a time — a bunch of `String` objects, a bunch of `BagOfCheese` objects, a bunch of tweets, or whatever. You can create a collection class with the code in Listing 12-1.

LISTING 12-1: **Making an ArrayList**

```
package com.allmycode.a12_01;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import java.util.ArrayList;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    ArrayList arrayList = new ArrayList();
    arrayList.add("Hello");
    arrayList.add(", ");
    arrayList.add("readers");
    arrayList.add("!");

    textView.setText("");

    for (int i = 0; i < 4; i++) {
      textView.append((String) arrayList.get(i));
    }
  }
}
```

When you run the code in Listing 12-1, you see the output shown in Figure 12-1.

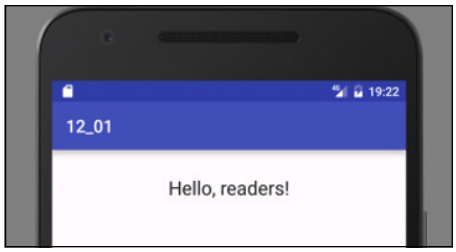


FIGURE 12-1: Running the code in Listing 12-1.

The code in Listing 12-1 constructs a new `ArrayList` instance and makes the `arrayList` variable refer to that new instance. The `ArrayList` class is one of many kinds of collection classes.

REMEMBER

The statement `ArrayList arrayList = new ArrayList()` creates an empty list of things and makes the `arrayList` variable refer to that empty list. What does a list look like when it's empty? I don't know. I guess it looks like a blank sheet of paper. Anyway, the difference between having an empty list and having *no* list is important. Before executing `ArrayList arrayList = new ArrayList()`, you have no list. After executing `ArrayList arrayList = new ArrayList()`, you have a list that happens to be empty.

After calling `arrayList.add`, the list is no longer empty. The code in Listing 12-1 calls `arrayList.add` four times in order to put these four objects (all strings) into the list:

- `"Hello"`
- `", "`
- `"readers"`
- `"!"`

Each object in the list has an *index* — a number from 0 to 3. You can think of an object's index as the object's position in the list. The string `"Hello"` has index 0, the string `", "` has index 1, the string `"readers"` has index 2, and the string `"!"` has index 3.

REMEMBER

In a Java collection, the initial index is always 0, not 1.

An `ArrayList` instance's `get` method fetches the object for a particular index. So, in Listing 12-1, `arrayList.get(0)` is `"Hello"`, `arrayList.get(1)` is `", "`, and so on. To display all the strings in the list, the `for` statement in Listing 12-1 marches from index 0 to index 1, and then 2, and finally 3.

More casting

Notice the use of casting in Listing 12-1.

```
textView.append((String) arrayList.get(i));
```

When you create an `ArrayList` the way I did in Listing 12-1, Java assumes that the list contains things of type `Object`. In Java's class hierarchy, the `Object` class is the ancestor of all other classes. In fact, the parent class of Java's `String` class is the `Object` class.

When you call

```
arrayList.add("Hello");
```

Java says "That's nice. The developer has added a kind of `Object` to the `arrayList`." And Java is happy.

Notice what Java *doesn't* say. Java doesn't say "I'll remember that the developer added something of type `String` to the `arrayList`." In fact, Java forgets about this. By the time you get to the statement

```
textView.append((String) arrayList.get(i));
```

Java has forgotten all about the string `"Hello"`. All Java knows is that you're trying to `get` an `Object` of some kind from the `arrayList`. So Java would get upset if you wrote

```
// With arrayList declared as in Listing 12-1, don't do this:
textView.append(arrayList.get(i));
```

The `textView.append` method wants its parameter to be a character sequence of some kind, and an `Object` that you obtain when you call the `arrayList` object's `get` method isn't necessarily a character sequence. That's why, in Listing 12-1, I have to cast the result of `arrayList.get(i)`. This casting tells Java that, this time around, I expect the thing that it gets from the `arrayList` to be a `String`.


REMEMBER

Casting isn't a magic cure-all. The casting in Listing 12-1 is okay because all the objects in the `arrayList` have type `String`. But if, for some reason, the thing that Java obtains from `(String) arrayList.get(i)` isn't a `String`, the call to `textView.append` crashes and the person using your app gives you a bad rating on Google Play. You don't want that to happen.

Java generics

Starting with Java 5, the collection classes use generic types. You can recognize a generic type because of the angle brackets around its type name. For example, the following declaration uses `String` for a generic type:

```
ArrayList<String> arrayList = new ArrayList<>();
```

This improved declaration tells Java that the `arrayList` variable refers to a bunch of objects, each of which is an instance of `String`. When you substitute this new declaration in place of the nongeneric declaration from Listing 12-1, you don't need casting. Listing 12-2 has the code.

LISTING 12-2: **Using Java Generics**

```
package com.allmycode.a12_02;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import java.util.ArrayList;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    ArrayList<String> arrayList = new ArrayList<>();
    arrayList.add("Hello");
    arrayList.add(", ");
    arrayList.add("readers");
    arrayList.add("!");

    textView.setText("");
```

(continued)

LISTING 12-2: *(continued)*

```
    for (int i = 0; i < 4; i++) {
      textView.append(arrayList.get(i));
    }
  }
}
```

You can get away with using the nongeneric declaration in Listing 12-1. But creating a nongeneric collection has some disadvantages. When you don't use generics (as in Listing 12-1), you create a collection that might contain objects of any kind. In that case, Java can't take advantage of any special properties of the items in the collection. In Listing 12-1, you can't call `textView.append` without doing some casting. In some other code, nongeneric declarations may have other limitations.

REMEMBER

With its use of generics, the `ArrayList` declaration in Listing 12-2 has two pairs of angle brackets. The first pair contains the word `String` — the name of the class whose instances are being stuffed into the collection. The second pair of angle brackets is empty.

Here's another example using Java generics. Chapter 9 starts with a description of the `BagOfCheese` class. The declaration looks like this:

```
package com.allmycode.a09_01;

public class BagOfCheese {
  public String kind;
  public double weight;
  public int daysAged;
  public boolean isDomestic;
}
```

You can put a few `BagOfCheese` objects into a nongeneric collection:

```
ArrayList bags = new ArrayList();
```

But when your code gets items from the collection or makes use of the collection's items in any way, Java remembers only that the items in the collection are objects. Java doesn't remember that they're `BagOfCheese` objects. To display a bag's `kind` field, you can't write

```
// If arrayList isn't generic, don't do this:
textView.append(arrayList.get(i).kind);
```

In fact, you can't write `arrayList.get(i).kind` in any context, even if you're trying not to display what you got. Java doesn't remember that `arrayList.get(i)` is always a `BagOfCheese` instance. So Java refuses to reference the object's `kind` field.

Using casting, you can remind Java that the item you're getting from `arrayList` is a `BagOfCheese` instance:

```
textView.append(((BagOfCheese)arrayList.get(i)).kind);
```

But look at all the parentheses you need in order to make the casting work correctly. It's a mess.

If you tweak the code to make `arrayList` generic, Java knows that what you get from `arrayList` is always a `BagOfCheese` instance, and every `BagOfCheese` instance has a `kind` field:

```
ArrayList<BagOfCheese> bags = new ArrayList<>();
```

Then the statement `textView.append(arrayList.get(i).kind)` is okay.

You can use generics to create your own collection class. When you do, the generic type serves as a placeholder for an otherwise unknown type. Listing 12-3 contains a home-grown declaration of an `OrderedPair` class.

LISTING 12-3: A Custom-Made Collection Class

```
package com.allmycode.a12_04;

public class OrderedPair<T> {
  private T x;
  private T y;

  public T getX() {
    return x;
  }

  public void setX(T x) {
    this.x = x;
  }
  public T getY() {
    return y;
  }
```

(continued)

LISTING 12-3: ***(continued)***

```
  public void setY(T y) {
    this.y = y;
  }
}
```

An `OrderedPair` object has two components: an `x` component and a `y` component. If you remember your high school math, you can probably plot ordered pairs of numbers on a two-dimensional grid. But who says that every ordered pair must contain numbers? The newly declared `OrderedPair` class stores objects of type `T`, and `T` can stand for any Java class or interface. In Listing 12-4, I show you how to create an ordered pair of `BagOfCheese` objects.

LISTING 12-4: **Using the Custom-Made Collection Class**

```
package com.allmycode.a12_04;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

import com.allmycode.a09_01.BagOfCheese;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    OrderedPair<BagOfCheese> pair = new OrderedPair<>();

    BagOfCheese bag = new BagOfCheese();
    bag.kind = "Muenster";
    pair.setX(bag);

    bag = new BagOfCheese();
    bag.kind = "Brie";
    pair.setY(bag);
```

```
    textView.setText("");
    textView.append(pair.getX().kind);
    textView.append("\n");
    textView.append(pair.getY().kind);
  }
}
```

Java's wrapper classes

Chapters 5 and 9 describe primitive types and reference types:

- **Each primitive type is baked into the language.**

  Java has eight primitive types.

- **Each reference type is a class or an interface.**

  You can define your own reference type. So the number of reference types in Java is potentially endless.

The difference between primitive types and reference types is one of Java's most controversial features. Here's one of the primitive-versus-reference-type "gotchas:" You can't store a primitive value in an `ArrayList`. You can write

```
// THIS IS OKAY:
ArrayList<String> arrayList = new ArrayList<>();
```

because `String` is a reference type. But you can't write

```
// DON'T DO THIS:
ArrayList<int> arrayList = new ArrayList<>();
```

because `int` is a primitive type. Fortunately, each of Java's primitive types has a *wrapper* type, which is a reference type whose purpose is to contain another type's value. For example, an object of Java's `Integer` type contains a single `int` value. An object of Java's `Double` type contains a single `double` value. An object of Java's `Character` type contains a single `char` value. You can't create an `ArrayList` of `int` values, but you can create an `ArrayList` of `Integer` values:

```
// THIS IS OKAY:
ArrayList<Integer> arrayList = new ArrayList<>();
```

TIP

Every primitive type's name begins with a lowercase letter. Each of the corresponding wrapper types' names begins with an uppercase letter.

In addition to containing primitive values, wrapper classes provide useful methods for working with primitive values. For example, the `Integer` wrapper class contains `parseInt` and other useful methods for working with `int` values:

```
String string = "17";
int number = Integer.parseInt(string);
```

On the downside, working with wrapper types can be clumsy. For example, you can't use arithmetic operators with Java's numeric wrapper types. Here's the way I usually create two `Integer` values and add them together:

```
Integer myInteger = new Integer(3);
Integer myOtherInteger = new Integer(15);

Integer sum = myInteger.intValue() + myOtherInteger.intValue();
```

A call to `intValue` gets an ordinary primitive `int` from an `Integer`. I can use the plus sign to add these `int` values. Java lets me assign the resulting `int` value to the `Integer` variable `sum`.

Stepping Through a Collection

The program in Listing 12-1 uses a `for` loop with indexes to step through a collection. The code does what it's supposed to do, but it's a bit awkward. When you're piling objects into a collection, you shouldn't have to worry about which object is first in the collection, which is second, and which is third, for example.

Java has a few features that make it easier to step through a collection of objects. This section covers those features.

Using an iterator

If you have an `ArrayList` or some other kind of collection, you can make an *iterator* from that collection. Listing 12-5 shows you how an iterator works.

LISTING 12-5: Iterating through a Collection

```
package com.allmycode.a12_05;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;
```

```
import java.util.ArrayList;
import java.util.Iterator;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    ArrayList arrayList = new ArrayList();
    arrayList.add("Hello");
    arrayList.add(", ");
    arrayList.add("readers");
    arrayList.add("!");

    textView.setText("");

    Iterator<String> iterator = arrayList.iterator();

    while (iterator.hasNext()) {
      textView.append(iterator.next());
    }
  }
}
```

The output from running Listing 12-5 is shown earlier, in Figure 12-1.

When you have a collection (such as an `ArrayList`), you can create an iterator to go along with that collection. In Listing 12-5, you create an iterator to go along with the `arrayList` collection, by calling

```
Iterator<String> iterator = arrayList.iterator();
```

After you've made this call, the variable `iterator` refers to something that can step through all values in the `arrayList` collection. Then, to step from one value to the next, you call `iterator.next()` repeatedly. And, to find out whether another `iterator.next()` call will yield results, you call `iterator.hasNext()`. The call to `iterator.hasNext()` returns a `boolean` value: `true` when there are more values in the collection and `false` when you've already stepped through all the values in the collection.

The enhanced for statement

An even nicer way to step through a collection is with Java's *enhanced* `for` *statement*. Listing 12-6 shows you how to use it.

LISTING 12-6: **Using the Enhanced `for` Statement**

```
package com.allmycode.a12_06;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.widget.TextView;

import java.util.ArrayList;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    ArrayList<String> arrayList = new ArrayList<>();
    arrayList.add("Hello");
    arrayList.add(", ");
    arrayList.add("readers");
    arrayList.add("!");

    textView.setText("");

    for (String string : arrayList) {
      textView.append(string);
    }
  }
}
```

An enhanced `for` statement doesn't have a counter. Instead, the statement has the format shown in Figure 12-2.

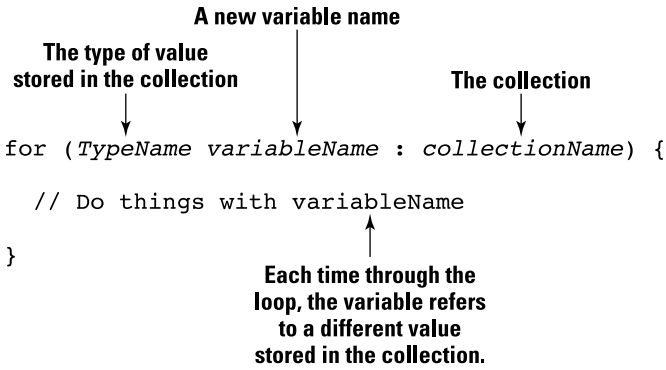


FIGURE 12-2: The anatomy of an enhanced `for` statement.

The enhanced `for` statement in Listing 12-6 achieves the same effect as the iterator in Listing 12-5 and the ordinary `for` statement in Listing 12-1. That is, the enhanced `for` statement steps through the values stored in the `arrayList` collection.

The enhanced `for` statement was introduced in Java 5.0. It's "enhanced" because, for stepping through a collection, it's easier to use than a pre-Java 5.0 `for` statement.

A cautionary tale

In an enhanced `for` statement, the variable that repeatedly stands for different values in the collection never refers directly to any of those values. Instead, this variable always contains a copy of the value in the collection. So, if you assign a value to that variable, you don't change any values inside the collection.

Here's a quiz. (Don't be scared. The quiz isn't graded.) What do you see when you run the following code?

```
package com.allmycode.badcode;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.widget.TextView;

import java.util.ArrayList;

public class MainActivity extends AppCompatActivity {
  TextView textView;
```

```
    @Override
    protected void onCreate(Bundle savedInstanceState) {
      super.onCreate(savedInstanceState);
      setContentView(R.layout.activity_main);

      textView = (TextView) findViewById(R.id.textView);

      ArrayList<String> arrayList = new ArrayList<>();
      arrayList.add("Hello");
      arrayList.add(", ");
      arrayList.add("readers");
      arrayList.add("!");

      textView.setText("");

      // THIS IS PRETTY BAD CODE
      for (String string : arrayList) {
        string = "Oops!";
        textView.append(string);
      }

      textView.append("\n");

      for (String string : arrayList) {
        textView.append(string);
      }
    }
}
```

A run is shown in Figure 12-3.

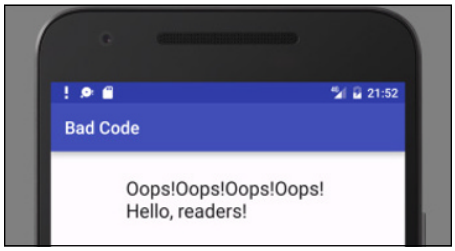


FIGURE 12-3: Running this section's bad code.

In the first `for` statement, the variable `string` is reassigned to refer to the word `"Oops!"` each time through the loop. Calls to `textView.append` display that word `"Oops!"` four times. But these reassignments to the string variable have no effect

on the values in the `arrayList`. The `arrayList` still contains the values `"Hello"`, `", "`, `"readers"`, and `"!"`.

So, when Java executes the second `for` loop, that loop displays the words `Hello, readers!`.

Functional programming techniques

With Java 8 comes yet another way to step through a collection. Check the code in Listing 12-7.

LISTING 12-7: **Using a Stream**

```
package com.allmycode.a12_07;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.widget.TextView;

import java.util.ArrayList;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    ArrayList<String> arrayList = new ArrayList<>();
    arrayList.add("Hello");
    arrayList.add(", ");
    arrayList.add("readers");
    arrayList.add("!");

    textView.setText("");

    arrayList.stream().forEach(string -> textView.append(string));
  }
}
```

A *stream* is a little bit like a person working in a bucket brigade. A stream takes things in, makes few changes to the things if necessary, and then sends things out the other end. A stream modifies what it receives and then passes the modified goods on to the next stream in the line.

In Listing 12-7, the expression `arrayList.stream()` represents a stream. It's a stream that sends out the things in the `arrayList`. Those things end up in the lap of the `forEach` method call. And the `forEach` method call does something with each of those things.

What does the `forEach` method call do with each thing that it receives? To each thing, the `forEach` method call applies the lambda expression `string -> textView.append(string)`.

CROSS-REFERENCE

Lambda expressions pop up in the conversation in Chapter 11.

The lambda expression `string -> textView.append(string)` takes whatever it receives, calls that thing by the parameter name `string`, and then applies the `textView.append` method to `string`. In other words, the lambda expression displays (in the activity's `textView` component) whatever you give it.

Java's streams are an example of the *functional programming* style. With functional programming, you avoid *do this, then do that* solutions to problems. Instead, you call methods, which hand their results to other methods, which in turn may hand their results to other methods, and so on. You chain method calls one after another until the result that you want pops out in the end.

WARNING

Streams work only on devices running Android SDK 24 or higher. If you intend to use Java streams in a project, then, when you create the project, set the Minimum SDK to 24. If you've already created a project with Minimum SDK less than 24, open the project's `Gradle Scripts/build.grade (Module: app) file`. In that file, look for a number after the word `minSdkVersion`. Change that number to `24`.

Java's Many Collection Classes

The `ArrayList` class that I use in many of this chapter's examples is only the tip of the Java collections iceberg. The Java library contains many collections classes, each with its own advantages. Table 12-1 contains an abbreviated list.

TABLE 12-1 Some Collection Classes

Class Name	Characteristic
`ArrayList`	A resizable array.
`LinkedList`	A list of values, each having a field that points to the next one in the list.
`Stack`	A structure (which grows from bottom to top) that's optimized for access to the topmost value. You can easily add a value to the top or remove it from the top.
`Queue`	A structure (which grows at one end) that's optimized for adding values to one end (the rear) and removing values from the other end (the front).
`PriorityQueue`	A structure, like a queue, that lets certain (higher-priority) values move toward the front.
`HashSet`	A collection containing no duplicate values.
`HashMap`	A collection of key/value pairs.

Each collection class has its own set of methods (in addition to the methods that it inherits from `AbstractCollection`, the ancestor of all collection classes).

ON THE WEB

To find out which collection classes best meet your needs, visit the Android API documentation pages at `http://developer.android.com/reference`.

Arrays

In the "Stepping Through a Collection" section, earlier in this chapter, I cast aspersions on the use of an index in Listing 12-1. "You shouldn't have to worry about which object is first in the collection, which is second, and which is third," I write. Well, that's my story and I'm sticking to it, except in the case of an array. An array is a particular kind of collection that's optimized for indexing. That is, you can easily and efficiently find the 100th value stored in an array, the 1,000th value stored in an array, or the 1,000,000th value stored in an array.

The array is a venerable, tried-and-true feature of many programming languages, including newer languages such as Java and older languages such as FORTRAN. In fact, the array's history goes back so far that most languages (including Java) have special notation for dealing with arrays. Listing 12-8 illustrates the notation for arrays in a simple Java program.

LISTING 12-8: **Creating and Using an Array**

```
package com.allmycode.a12_08;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    String[] myArray = new String[4];
    myArray[0] = "Hello";
    myArray[1] = ", ";
    myArray[2] = "readers";
    myArray[3] = "!";

    textView.setText("");

    for(int i = 0; i < 4; i++) {
      textView.append(myArray[i]);
    }

    textView.append("\n");

    for (String string : myArray) {
      textView.append(string);
    }
  }
}
```

Figure 12-4 shows the output of a run of the code in Listing 12-8. Both the ordinary `for` loop and the enhanced `for` loop display the same output.

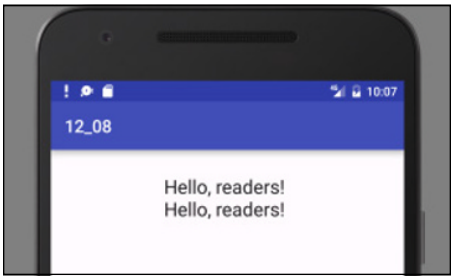


FIGURE 12-4: Running the code in Listing 12-8.

In Listing 12-8, the ordinary `for` loop uses indexes, with each index marked by square brackets. As it is with all Java collections, the initial value's index is 0, not 1. Notice also the number `4` in the array's declaration — it indicates that "you can store `4` values in the array." The number 4 *doesn't* indicate that "you can assign a value to `myArray[4]`." In fact, if you add a statement such as `myArray[4] = "Oops!"` to the code in Listing 12-8, you get a nasty error message (`ArrayIndexOutOfBoundsException`) when you run the program.

REMEMBER

The statement `String[] myArray = new String[4]` creates an empty array and makes the `myArray` variable refer to that empty array. The array can potentially store as many as four values. But, initially, that variable refers to an array that contains no values. It's not until Java executes the first assignment statement (`myArray[0] = "Hello"`) that the array contains any values.

You can easily and efficiently find the 100th value stored in an array (`myArray[100]`) or the 1,000,000th value stored in an array (`myArray[1000000]`). Not bad for a day's work. So, what's the downside of using an array? The biggest disadvantage of an array is that each array has a fixed limit on the number of values it can hold. When you create the array in Listing 12-8, Java reserves space for as many as four `String` values. If, later in the program, you decide that you want to store a fifth element in the array, you need some clumsy, inefficient code to make yourself a larger array. You can also overestimate the size you need for an array, as shown in this example:

```
String[] myArray = new String[20000000];
```

When you overestimate, you probably waste a lot of memory space.

Another unpleasant feature of an array is the difficulty you can have in inserting new values. Imagine having a wooden box for each year in your collection of *Emperor Constantine Comics*. The series dates back to the year 307 A.D., when Constantine became head of the Roman Empire. You have only 1,700 boxes because you're missing about six years (mostly from the years 1150 to 1155). The boxes aren't numbered, but they're stacked one next to another in chronological order in a line that's 200 meters long. (The line is as long as the 55th floor of a skyscraper is tall.)

At a garage sale in Istanbul, you find a rare edition of *Emperor Constantine Comics* from March 1152. After rejoicing over your first comic from the year 1152, you realize that you have to insert a new box into the pile between the years 1151 and 1153, which involves moving the year 2016 box about ten centimeters to the right, and then moving the 2015 box in place of the 2016 box, and then moving the 2014 box in place of the 2015 box. And so on. Life for the avid *Emperor Constantine Comics* collector is about to become tiresome! Inserting a value into the middle of a large array is equally annoying.

String resource arrays

In Chapter 11, I introduce Android's string resource feature. You put a string of characters into an `app/res/values/strings.xml` file. Then, in your Java code, you refer to that string with an `R.string.`*`something_or_other`* expression.

You can do the same kind of thing with an entire array of strings. First, you put a `string-array` element in your `strings.xml` file:

```
<resources>
    <string name="app_name">12_08</string>
    <string-array name="greeting_words">
        <item>Hello</item>
        <item>, </item>
        <item>readers</item>
        <item>!</item>
    </string-array>
</resources>
```

Then, in Listing 12-8, you can replace

```
String[] myArray = new String[4];
myArray[0] = "Hello";
myArray[1] = ", ";
myArray[2] = "readers";
myArray[3] = "!";
```

with the following code:

```
Resources res = getResources();
String[] myArray = res.getStringArray(R.array.greeting_words);
```

Java's varargs

In an app of some kind, you need a method that displays a bunch of words as a full sentence. How do you create such a method? You can pass a bunch of words to the sentence. In the method's body, you display each word, followed by a blank space, as shown here:

```
for (String word : words) {
  System.out.print(word);
  System.out.print(" ");
}
```

To pass words to the method, you create an array of `String` values:

```
String[] stringsE = { "Goodbye,", "kids." };
displayAsSentence(stringsE);
```

Notice the use of the curly braces in the initialization of `stringsE`. In Java, you can initialize any array by writing the array's values, separating the values from one another by commas, and surrounding the entire bunch of values with curly braces. When you do this, you create an *array initializer.*

Listing 12-9 contains an entire program to combine words into sentences.

LISTING 12-9: **A Program without Varargs**

```
package com.allmycode.a12_09;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    String[] stringsA = { "Hello,", "I", "must", "be", "going." };
    String[] stringsB = { "    ", "–Groucho" };
```

(continued)

LISTING 12-9: *(continued)*

```
    String[] stringsC = { "Say", "Goodnight,", "Gracie." };
    String[] stringsD = { "    ", "–Nathan Birnbaum" };
    String[] stringsE = { "Goodbye,", "kids." };
    String[] stringsF = { "    ", "–Clarabell" };

    textView.setText("");

    displayAsSentence(stringsA);
    displayAsSentence(stringsB);
    displayAsSentence(stringsC);
    displayAsSentence(stringsD);
    displayAsSentence(stringsE);
    displayAsSentence(stringsF);
  }

  void displayAsSentence(String[] words) {
    for (String word : words) {
      textView.append(word);
      textView.append(" ");
    }
    textView.append("\n");
  }
}
```

When you run the code in Listing 12-9, you see the output shown in Figure 12-5.

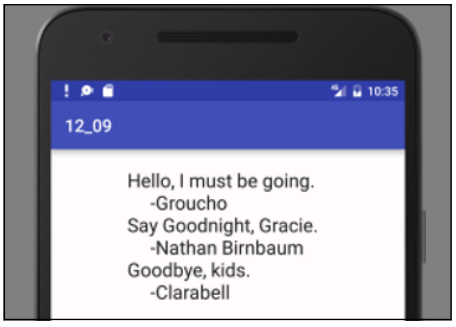


FIGURE 12-5: Running the code in Listing 12-9.

The code in Listing 12-9 is awkward because you have to declare six different arrays of `String` values. You can't combine the variable declarations and the method call. A statement such as

```
displayAsSentence("Say", "Goodnight,", "Gracie.");
```

is illegal because the call's parameter list has three values, and because the `displayAsSentence` method (in Listing 12-9) has only one parameter (one array). You can try fixing the problem by declaring `displayAsSentence` with three parameters:

```
void displayAsSentence(String word0, String word1, String word2) {
```

But then you're in trouble when you want to pass five words to the method.

To escape from this mess, Java 5.0 introduces varargs. A parameter list with *varargs* has a type name followed by three dots. The dots represent any number of parameters, all of the same type. Listing 12-10 shows you how it works.

LISTING 12-10: **A Program with *Varargs***

```
package com.allmycode.a12_10;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    textView = (TextView) findViewById(R.id.textView);

    textView.setText("");

    displayAsSentence("Hello,", "I", "must", "be", "going.");
    displayAsSentence("    ", "-Groucho");
    displayAsSentence("Say", "Goodnight,", "Gracie.");
    displayAsSentence("    ", "-Nathan Birnbaum");
    displayAsSentence("Goodbye,", "kids.");
    displayAsSentence("    ", "-Clarabell");
  }

  void displayAsSentence(String... words) {
    for (String word : words) {
```

(continued)

LISTING 12-10: ***(continued)***

```
            textView.append(word);
            textView.append(" ");
        }
        textView.append("\n");
    }
}
```

In Listing 12-10, the parameter list `(String... words)` stands for any number of `String` values — one `String` value, one hundred `String` values, or even no `String` values. So, in Listing 12-10, I can call the `displayAsSentence` method with two parameters `("Goodbye,", "kids.")`, with three parameters `("Say", "Good night,", "Gracie.")`, and with five parameters `("Hello,", "I", "must", "be", "going.")`.

In the body of the `displayAsSentence` method, I treat the collection of parameters as an array. I can step through the parameters with an enhanced `for` statement, or I can refer to each parameter with an array index. For example, in Listing 12-10, during the first call to the `displayAsSentence` method, the expression `words[0]` stands for `"Hello"`. During the second call to the `displayAsSentence` method, the expression `words[2]` stands for `"Goodnight"`. And so on.

Using Collections in an Android App

If you look at the Palette in Android Studio's Designer tool, you can find the *Spinner* component. You can drag a Spinner component from the Palette onto one of your app's preview screens. A Spinner component is a drop-down list — a bunch of alternatives for the user to choose from. (See Figures 12-6, 12-7, and 12-8.) That "bunch" of alternatives is a collection of some sort. In this section, I use an array to implement the collection.

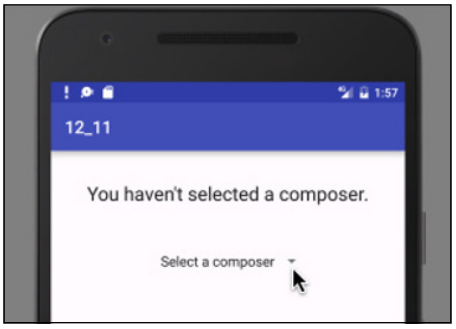


FIGURE 12-6: A TextView component and a spinner.

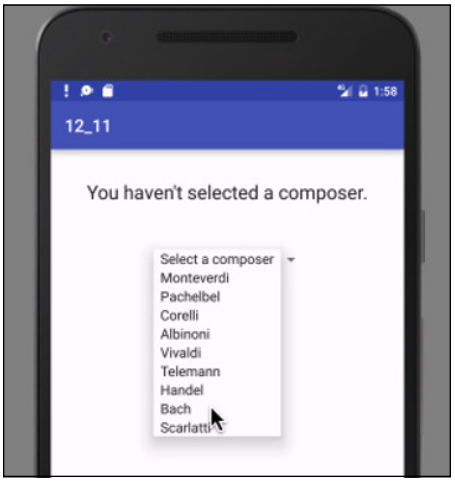


FIGURE 12-7: The user expands the spinner's choices.

FIGURE 12-8: The user has selected Bach.

Listing 12–11 has the code.

LISTING 12-11: Creating a Spinner

```
package com.allmycode.a12_11;

import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.view.View;
import android.widget.AdapterView;
import android.widget.AdapterView.OnItemSelectedListener;
import android.widget.ArrayAdapter;
import android.widget.Spinner;
import android.widget.TextView;

public class MainActivity extends AppCompatActivity {
```

(continued)

LISTING 12-11: ***(continued)***

```
  TextView textView;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    Spinner spinner = (Spinner) findViewById(R.id.spinner);
    textView = (TextView) findViewById(R.id.textView);
    String[] choices =
        {"Select a composer",
            "Monteverdi", "Pachelbel", "Corelli", "Albinoni",
            "Vivaldi", "Telemann", "Handel","Bach", "Scarlatti"};

    ArrayAdapter<String> adapter =
      new ArrayAdapter<>(this, android.R.layout.simple_spinner_item, choices);

    spinner.setAdapter(adapter);
    spinner.setOnItemSelectedListener(new MyItemSelectedListener());
  }

  class MyItemSelectedListener implements OnItemSelectedListener {

    @Override
    public void onItemSelected(AdapterView<?> adapterView, View view,
                               int position, long id) {

      if (position == 0) {
        textView.setText("You haven't selected a composer.");
      } else {
        textView.setText(adapterView.getItemAtPosition(position).toString());
      }
    }

    @Override
    public void onNothingSelected(AdapterView<?> adapterView) {
      // Do nothing
    }
  }
}
```

To make a spinner do its job, you create a listener and an adapter.

The listener

A spinner's listener is much like a button's listener. It's a piece of code that listens for user actions and responds when an appropriate action occurs. (See Chapter 11.)

In Listing 12-11, I create a listener (an instance of my own `MyItemSelectedListener` class). I tell Android to notify the listener when the user selects one of the spinner's items:

```
spinner.setOnItemSelectedListener(new MyItemSelectedListener());
```

The `MyItemSelectedListener` class's `onItemSelected` method must tell Android what to do in response to the user's selection.

The adapter

You may guess that you add an item to a spinner with a call like this:

```
// Don't do this:
spinner.addRow("Monteverdi");
```

But that's not the way it works. When an Android developer thinks about a spinner, the developer thinks about two different concepts:

- **A spinner has data.**

  In Figure 12-7, the spinner's data consists of the values `"Select a composer"`, `"Monteverdi"`, `"Pachelbel"`, and so on.

- **A spinner has a "look."**

  This section's spinner has a simple look. In Figure 12-6, the spinner has text on the left side and a tiny downward arrow on the right side. In Figure 12-7, each of the spinner's items has text on the left side.

A spinner's incarnation on the screen (the "look") is an object in and of itself. It's an instance of Android's `AdapterView` class. A similar-sounding thing, an instance of the `SpinnerAdapter` class, connects a spinner's data with a spinner's "look." See Figure 12-9.

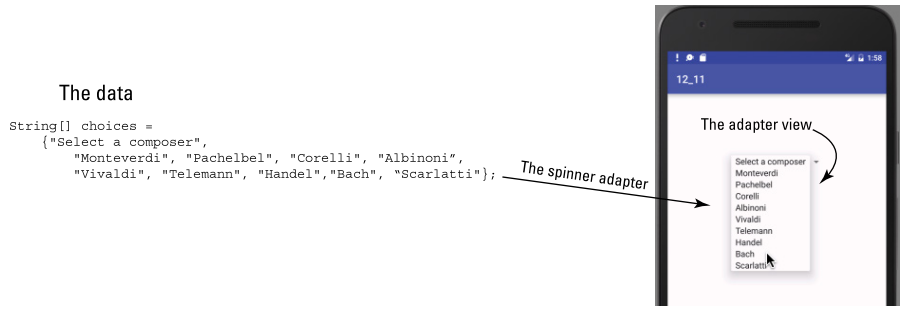


FIGURE 12-9: How a spinner works.

There are several kinds of spinner adapter, including the `ArrayAdapter` and `CursorAdapter` classes:

- An `ArrayAdapter` gets data from a collection, such as an array or an `ArrayList`.
- A `CursorAdapter` gets data from a database query.

In Listing 12-11, I use an `ArrayAdapter`. The `ArrayAdapter` constructor has three parameters:

- **The first parameter is a context.**

  I use `this` for the context. As in Chapter 9, the word `this` represents whatever object contains the current line of code. In Listing 12-11, `this` refers to the `MainActivity`.

- **The second parameter is a layout.**

  In Listing 12-11, the name `android.R.layout.simple_spinner_item` refers to a standard layout for one of the items in Figure 12-7.

- **The third parameter is the source of the data.**

  In Listing 12-11, I provide `choices`, which I declare to be an array of `String` values.

In Listing 12-11, notice the `onItemSelected` method's `position` parameter. When the user selects the topmost item in the spinner's list (the Select a Composer item in Figure 12-7), Android gives that `position` parameter the value 0. When the user selects the next-to-topmost item (the Monteverdi item in Figure 12-7), Android gives that `position` parameter the value 1. And so on.

In the `onItemSelected` method's body, the code checks to make sure that `position` isn't 0. If `position` isn't 0, the code plugs that `position` value into the `adapterView.getItemAtPosition` method to get the string on whatever item the user clicked. The code displays that string (`Monteverdi`, `Pachelbel`, or whichever) in a `textView` component.

IN THIS CHAPTER

- Posting on Twitter with Android code
- Tweeting with your app on a user's behalf
- Using Java exceptions to get out of a jam

Chapter 13
An Android Social Media App

A reader from Vancouver (in British Columbia, Canada) writes:

> "Hello, Barry. I just thought I would ask that you include the area that seems to get attention from app developers: programs connecting with social sites. I look forward to reading the new book! Best regards, David."

Well, David, you've inspired me to create a Twitter app. This chapter's example does two things: Post a new tweet and get a twitter user's timeline. The app can perform many more Twitter tasks — for example, search for tweets, look for users, view trends, check friends and followers, gather suggestions, and do lots of other things that Twitter users want done. For simplicity, though, I have the app perform only two tasks: tweet and display a timeline.

I can summarize the essence of this chapter's Twitter code in two short statements. To post a tweet, the app executes

```
twitter.updateStatus("This is my tweet.");
```

And, to display a user's timeline, the app executes

```
List<twitter4j.Status> statuses = twitter.getUserTimeline("allmycode");
```

Of course, these two statements only serve as a summary, and a summary is never the same as the material it summarizes. Imagine standing on the street in Times Square and shouting this statement: "Twitter dot update status: 'This is my tweet.'" Nothing good happens because you're issuing the correct command in the wrong context. In the same way, the context surrounding a call to `twitter.updateStatus` in an app matters an awful lot.

This chapter covers all the context surrounding your calls to `twitter.updateStatus` and `twitter.getUserTimeline`. In the process, you can read about Java's exceptions — a vital feature that's available to all Java programmers.

The Twitter App's Files

You can download this chapter's code from my website (`http://allmycode.com/Java4Android`) by following the instructions in Chapter 2. As is true for any Android app, this chapter's Android Studio project contains hundreds of files. In this chapter, I concentrate on the project's `MainActivity.java` file. But a few other files require some attention.

The Twitter4J API jar file

Android has no built-in support for communicating with Twitter. Yes, the raw materials are contained in Android's libraries, but to deal with all of Twitter's requirements, someone has to paste together those raw materials in a useful way. Fortunately, several developers have done all the pasting and made their libraries available for use by others. The library that I use in this chapter is Twitter4J. Its website is `http://twitter4j.org`.

A `.jar` file is a compressed archive file containing a useful bunch of Java classes. For this chapter's example to work, your project must include a `.jar` file containing the Twitter4J libraries. If you've successfully imported this book's code into Android Studio, the `13_01` project contains the necessary `.jar` file.


TIP

You can view the contents of a `.jar` file by using WinZip or StuffIt Expander or the operating system's built-in unzipping utility. To do so, you may or may not have to change the filename from *`whatever`*`.jar` to *`whatever`*`.zip`.

If you're creating this chapter's example on your own, or if you're having trouble with the project's existing `.jar` files, you can add Twitter4J libraries to your project. The following instructions worked for me in mid-2016.

WARNING

Google changes these steps once in a while. So if these steps don't work for you, send me an email — the address is `Java4Android@allmycode.com`.

1. **Visit `http://twitter4j.org`.**
2. **Find the link to download the latest stable version of Twitter4J.**

   To run this chapter's example, I use Twitter4J version 4.0.4. If you download a later version, it'll probably work. But I make no promises about the backward compatibility, forward compatibility, or sideward compatibility of the various Twitter4J versions. If my example doesn't run properly for you, you can search the Twitter4J site for a download link to version 4.0.4.
3. **Click the link to download the Twitter4J software.**

   The file that I downloaded is `twitter4j-4.0.4.zip`.
4. **Look for a `twitter4j-core.jar` file inside the downloaded `.zip` file.**

   In the `.zip` file that I downloaded, I found a file named `twitter4j-core-4.0.4.jar`.
5. **Extract the `twitter4j-core.jar` file to this project's `app/libs` directory.**

   Use your operating system's File Explorer or Finder to do the extracting and copying.
6. **On Android Studio's main menu, choose File ➪ Project Structure.**

   The Project Structure dialog box appears.
7. **In the panel on the left side of the dialog box, select App.**
8. **In the main body of the dialog box, select the Dependencies tab.**

   A list of dependencies appears. Look for a plus sign that's associated with the list of dependencies.
9. **Click the plus sign.**

   A context menu appears.
10. **On the context menu, select File Dependency.**

    Android Studio displays the Select Path dialog box.
11. **In the Select Path dialog box, navigate to the directory containing your `twitter4j-core.jar` file.**

REMEMBER

What I refer to as your `twitter4j-core.jar` file is probably named `twitter4j-core-4.0.4.jar` or similar.

12. **Select the `twitter4j-core.jar` file and click OK.**

    Doing so adds your `twitter4j-core.jar` file to the Dependencies tab's list.

13. **Click OK to dismiss the Project Structure dialog box.**

    Your project can now use the Twitter4J library's code.

The manifest file

Every Android app has an `AndroidManifest.xml` file. Listing 13-1 contains the `AndroidManifest.xml` file for this chapter's Twitter app.

LISTING 13-1: The AndroidManifest.xml File

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
          package="com.allmycode.a13_01">

    <uses-permission android:name="android.permission.INTERNET"/>

    <application
        android:allowBackup="true"
        android:icon="@mipmap/ic_launcher"
        android:label="@string/app_name"
        android:supportsRtl="true"
        android:theme="@style/AppTheme">
        <activity
            android:name=".MainActivity"
            android:windowSoftInputMode="adjustPan">
            <intent-filter>
                <action android:name="android.intent.action.MAIN"/>
                <category android:name="android.intent.category.LAUNCHER"/>
            </intent-filter>
        </activity>
    </application>

</manifest>
```

When you create a new Android application project, Android Studio writes most of the code in Listing 13-1 automatically. For this chapter's project, I have to add two additional snippets of code:

» **The `windowSoftInputMode` attribute tells Android what to do when the user activates the onscreen keyboard.**

  The `adjustPan` value tells Android how to adjust the screen's components when the keyboard appears. (Take my word for it: The app looks ugly without this `adjustPan` value.)

» **The `uses-permission` element warns Android that my app requires Internet connectivity.**

  If you forget to add this `uses-permission` element (as I often do), the app doesn't obey any of your Twitter commands. And when your app fails to contact the Twitter servers, Android often displays only cryptic, unhelpful error messages.

REMEMBER

The error messages from an unsuccessful run of this chapter's Android app range from extremely helpful to extremely unhelpful. One way or another, it never hurts to read these messages. You can find most of the messages on Android Studio's Logcat pane.

CROSS-REFERENCE

For more information about `AndroidManifest.xml` files, see Chapter 4.

The main activity's layout file

Chapter 3 introduces the use of a layout file to describe the look of an activity on the screen. The layout file for this chapter's example has no extraordinary qualities. I include it in Listing 13-2 for completeness. As usual, you can import this chapter's code from my website (`http://allmycode.com/Java4Android`). But if you're living large and creating the app on your own from scratch, you can copy the contents of Listing 13-2 to the project's `res/layout/activity_main.xml` file. Alternatively, you can use Android Studio's toolset to drag and drop, point and click, or type and tap your way to the graphical layout shown in Figure 13-1.

LISTING 13-2: The Layout File

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
                xmlns:tools="http://schemas.android.com/tools"
                android:layout_width="match_parent"
                android:layout_height="match_parent"
                android:paddingBottom="@dimen/activity_vertical_margin"
                android:paddingLeft="@dimen/activity_horizontal_margin"
                android:paddingRight="@dimen/activity_horizontal_margin"
                android:paddingTop="@dimen/activity_vertical_margin"
                tools:context=".MainActivity" >
```

(continued)

LISTING 13-2: ***(continued)***

```
<TextView
    android:id="@+id/textView2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignBaseline="@+id/editTextUsername"
    android:layout_alignBottom="@+id/editTextUsername"
    android:layout_alignLeft="@+id/editTextTweet"
    android:text="@string/at_sign"
    android:textAppearance="?android:attr/textAppearanceLarge"/>

<EditText
    android:id="@+id/editTextUsername"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/timelineButton"
    android:layout_toRightOf="@+id/textView2"
    android:ems="10"
    android:hint="@string/type_username_here"/>

<TextView
    android:id="@+id/textViewTimeline"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignLeft="@+id/timelineButton"
    android:layout_below="@+id/timelineButton"
    android:maxLines="100"
    android:scrollbars="vertical"
    android:text="@string/timeline_here"/>

<Button
    android:id="@+id/timelineButton"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignLeft="@+id/textView2"
    android:layout_centerVertical="true"
    android:onClick="onTimelineButtonClick"
    android:text="@string/timeline"/>

<Button
    android:id="@+id/tweetButton"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/editTextUsername"
```

```
        android:layout_alignLeft="@+id/editTextTweet"
        android:layout_marginBottom="43dp"
        android:onClick="onTweetButtonClick"
        android:text="@string/tweet"/>

    <EditText
        android:id="@+id/editTextTweet"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_above="@+id/tweetButton"
        android:layout_alignParentLeft="true"
        android:layout_marginLeft="14dp"
        android:ems="10"
        android:hint="@string/type_your_tweet_here"/>

    <TextView
        android:id="@+id/textViewCountChars"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignBaseline="@+id/tweetButton"
        android:layout_alignBottom="@+id/tweetButton"
        android:layout_toRightOf="@+id/timelineButton"
        android:text="@string/zero"/>

</RelativeLayout>
```

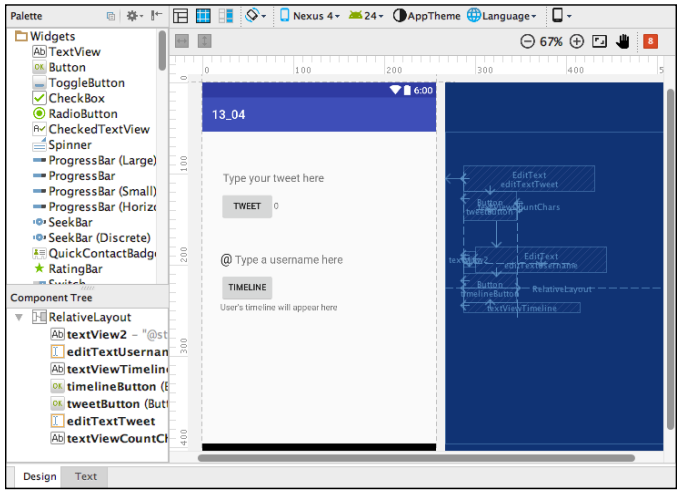


FIGURE 13-1: The graphical layout of the main activity's screen.

How to Talk to the Twitter Server

Listing 13-3 contains a snippet of code from the main activity in this chapter's example.

LISTING 13-3: Some Fake Java Code (Yes, It's Fake!)

```
Twitter twitter;

// ... and later in the code ...

ConfigurationBuilder builder = new ConfigurationBuilder();
builder
    .setOAuthConsumerKey("000000000000000000000000")
    .setOAuthConsumerSecret("111111111111111111111111111111111111111111111111111111")
    .setOAuthAccessToken("222222222-333333333333333333333333333333333333333333")
    .setOAuthAccessTokenSecret("444444444444444444444444444444444444444444444444");

TwitterFactory factory = new TwitterFactory(builder.build());
twitter = factory.getInstance();
```

The code in Listing 13-3 creates an instance of the `Twitter` class.

Here's some information regarding the Twitter4J API:

- **A `Twitter` object is a gateway to the Twitter servers.**

  A call to one of the methods belonging to a `Twitter` object can post a brand-new tweet, get another Twitter user's timeline, make favorites, add friendships, create blocks, search for users, and do other cool things.

- **`TwitterFactory` is a class that helps you create a new `Twitter` object.**

  As the name suggests, `TwitterFactory` is a factory class. In Java, a *factory* class is a class that can call a constructor on your behalf.

- **Calling the `getInstance` method creates a new `Twitter` object.**

  The `getInstance` method's body contains the actual constructor call. That's how factory methods work.

REMEMBER

The `ConfigurationBuilder`, `TwitterFactory`, and `Twitter` classes that I use in Listing 13-3 belong to the Twitter4J API. If, instead of using Twitter4J, you use a different API to communicate with Twitter servers, you'll use different class names. What's more, those classes probably won't match up, one for one, with the Twitter4J classes.

Using OAuth

When you run this chapter's example, the code has to talk to Twitter on your behalf. And normally, to talk to Twitter, you supply a username and password. But should you be sharing your Twitter password with any app that comes your way? Probably not. Your password is similar to the key to your house. You don't want to give copies of your house key to strangers, and you don't want an Android app to remember your Twitter password.

So how can your app post a tweet without having your Twitter password? One answer is *OAuth*, a standardized way to have apps log on to host computers.

The big, ugly strings in Listing 13-3 are OAuth strings. You get strings like this from the Twitter website. If you copy the gobbledygook correctly, your app acquires revocable permission to act on behalf of the Twitter user. And the app never gets hold of the user's password.

Now, here come the disclaimers:

- **A discussion of how OAuth works, and why it's safer than using ordinary Twitter passwords, is far beyond the scope of this book.**

  I don't pretend to explain OAuth and its mysteries in this chapter.

- **True app security requires more than what you see in Listing 13-3.**

  The goal of this chapter is to show how an app can talk to a social media site. In this chapter's code, I use OAuth and Twitter4J commands to achieve that goal as quickly as I can, without necessarily showing you the "right" way to do it. For more comprehensive coverage of OAuth, visit `https://oauth.net/`: the official website for OAuth developers.

- **The long strings of characters in Listing 13-3 don't work.**

  I'm not prepared to share my own OAuth strings with the general public, so to create Listing 13-3, I took the general outline of my real `ConfigurationBuilder` code and then pressed my nose against the keyboard to replace the characters in the OAuth strings.

  To run this chapter's app, you must create your own set of OAuth keys and copy them into your Java code. The later section "Getting OAuth keys and tokens" outlines the steps.

Making a ConfigurationBuilder

In Listing 13-3, the chaining of `set` method calls, one after another, is called the *builder pattern*.

Here's the basic idea. A configuration builder has lots of properties, and you can imagine several different ways of setting those properties. For example, you could have one enormous constructor:

```
// This is not correct Twitter4J code:
ConfigurationBuilder builder = new ConfigurationBuilder(
                        "00000000000000000000", "11111111111111111111",
                        "2222222-33333333333333333", "44444444444444444444");
```

This approach is cumbersome because you must remember which string belongs in which position. In fact, it gets worse. A configuration builder has 46 different properties, and you may want to set more than four of these properties. However, a constructor with 46 parameters would be truly awful.

Another possibility is to create a blank-slate configuration builder and then set each of its properties with separate method calls.

```
// This is not correct Twitter4J code:
ConfigurationBuilder builder = new ConfigurationBuilder();
builder.setOAuthConsumerKey("00000000000000000000");
builder.setOAuthConsumerSecret("11111111111111111111");
builder.setOAuthAccessToken("2222222-33333333333333333");
builder.setOAuthAccessTokenSecret("44444444444444444444");
```

This is less awkward than having a giant constructor, but there's a better way. In the Twitter4J API, the `ConfigurationBuilder` class has 46 `set` methods. Each method applies to an existing `ConfigurationBuilder` instance. And each method returns, as its result, a new `ConfigurationBuilder` instance. So, in Listing 13-3, the statement

```
ConfigurationBuilder builder = new ConfigurationBuilder();
```

creates a blank-slate configuration builder. The next piece of code

```
builder
    .setOAuthConsumerKey("000000000000000000000000")
```

applies to the blank-slate instance. But the value of this piece of code is a `ConfigurationBuilder` instance with a particular OAuth consumer key. To this enhanced instance you apply

```
.setOAuthConsumerSecret("1111111111111111111111111111111111111111111111111111")
```

The combined code's value is an even better `ConfigurationBuilder` instance — one with a particular OAuth consumer key and an OAuth consumer secret.

And so on. Each application of a `set` method takes an existing instance and yields an instance with more and better properties.

Notice how readable Listing 13-3 is compared to the incorrect code snippets in this section. This elegant way of adding properties to an object is the builder pattern.

After adding enough properties to a configuration builder, you call the builder's own `build` method to create a factory. Then you can use the factory to create an instance of the `Twitter` class:

```
TwitterFactory factory = new TwitterFactory(builder.build());
twitter = factory.getInstance();
```

Getting OAuth keys and tokens

For your Android app to communicate with Twitter servers, you need your own OAuth keys and tokens. To get them, follow this section's steps.

WARNING

The following instructions apply to the Twitter web pages for developers at the time of this book's publication. Twitter might change the design of its website at any time without notice. (At any rate, it won't notify me!)

1. **Sign in to your Twitter user account (or register for an account if you don't already have one).**

2. **Visit** `https://dev.twitter.com/apps/new`**.**

   If the stars are aligned harmoniously, you should see Twitter's Create an Application page.

3. **On the Create an Application page, fill in all required fields along with the (misleadingly optional) Callback URL field.**

   When I visit the page, I see the Name field, the Description field, the Website field, and the Callback URL field. All but the Callback URL field are listed as being required.

   Typing your app's name in the Name field is a no-brainer. But what do you use for the other fields? After all, you aren't creating an industrial-strength Android app. You're creating only a test app — an app to help you see how to use Twitter4J.

   The good news is that you can type almost anything in the Description field. The same is true for the Website and Callback URL fields, as long as you type things that look like real URLs.

TIP

I've never tried typing a `twitter.com` URL in either the Website or Callback URL fields, but I suspect that typing a `twitter.com` URL doesn't work.

To communicate with Twitter via an Android app, you need a callback URL. In other words, for this chapter's example, the callback URL isn't optional. Neither the Website field nor the Callback URL field has to point to a real web page. But you must fill in those two fields.

REMEMBER

The Callback URL field isn't marked as being required. Nevertheless, you must type a URL in the Callback URL field.

4. **After agreeing to the terms, and doing the other stuff to prove that you're a good person, click the Create Your Twitter Application button.**

   Doing so brings you to a page where you manage your new application. The page has four tabs, labeled Details, Settings, Keys and Access Tokens, and Permissions.

5. **Near the top of the page, select the Permissions tab.**

6. **On the Permissions page, look for a choice of access types. Change your app's access from Read and Write (the default) to Read, Write and Access Direct Messages.**

   For this toy application, you select Read, Write and Access Direct Messages — the most permissive access model that's available. This option prevents your app from hitting brick walls because of access problems.

REMEMBER

When you develop a real-life application, you do the opposite of what I suggest in this step. For a real-live app, you select the least permissive option that suits your application's requirements.

REMEMBER

First change your app's access level, and then create the app's access token (as explained in Step 9). Don't create the access token before changing the access level. If you try to change the access level after you've created the access token, your app won't work. What's worse, Twitter's app setup page doesn't warn you about the problem. Believe me — I've wasted hours of my life on this Twitter quirk.

7. **Click the button that offers to update your application's settings.**

   Doing so changes your app's access level to Read, Write and Access Direct Messages.

8. **Near the top of the page, select the Keys and Access Tokens tab.**

   You can find a few buttons on that page.

9. **Click the button that offers to create your access token.**

   After doing so, your app's Keys and Access Tokens tab displays your app's access token and the access token secret, in addition to your app's access level, consumer key, and consumer secret.

10. **Copy the four codes (Consumer Key, Consumer Secret, Access Token, and Access Token Secret) from your app's Details tab to the appropriate lines in your `MainActivity` class's code. (See Listing 13-3.)**

    Whew! You're done putting OAuth keys and tokens in your Java code.

In the OAuth world, an app whose code communicates with Twitter's servers is a *consumer.* To identify itself as a trustworthy consumer, an app must send passwords to Twitter's servers. In OAuth terminology, these passwords are called the *consumer key* and the *consumer secret*.

The Application's Main Activity

What's a *Java Programming for Android Developers For Dummies*, 2nd Edition, without some Java code? Listing 13-4 contains the Twitter app's Java code.

LISTING 13-4: The *MainActivity.java* File

```
package com.allmycode.a13_04;

import android.os.AsyncTask;
import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.text.Editable;
import android.text.TextWatcher;
import android.text.method.ScrollingMovementMethod;
import android.view.View;
import android.widget.EditText;
import android.widget.TextView;

import java.util.List;

import twitter4j.Twitter;
import twitter4j.TwitterException;
import twitter4j.TwitterFactory;
import twitter4j.conf.ConfigurationBuilder;

public class MainActivity extends AppCompatActivity {
  TextView textViewCountChars, textViewTimeline;
  EditText editTextTweet, editTextUsername;
  Twitter twitter;
```

(continued)

LISTING 13-4: ***(continued)***

```
@Override
protected void onCreate(Bundle savedInstanceState) {
  super.onCreate(savedInstanceState);
  setContentView(R.layout.activity_main);
  editTextTweet = (EditText) findViewById(R.id.editTextTweet);
  editTextTweet.addTextChangedListener(new MyTextWatcher());
  textViewCountChars = (TextView) findViewById(R.id.textViewCountChars);
  editTextUsername = (EditText) findViewById(R.id.editTextUsername);
  textViewTimeline = (TextView) findViewById(R.id.textViewTimeline);
  textViewTimeline.setMovementMethod(new ScrollingMovementMethod());
  ConfigurationBuilder builder = new ConfigurationBuilder();
  builder
      .setOAuthConsumerKey("000000000000000000000000")
      .setOAuthConsumerSecret("1111111111111111111111111111111111111111")
      .setOAuthAccessToken("222222222-3333333333333333333333333333333")
      .setOAuthAccessTokenSecret("444444444444444444444444444444444444");
  TwitterFactory factory = new TwitterFactory(builder.build());
  twitter = factory.getInstance();
}

// Button click listeners

public void onTweetButtonClick(View view) {
  new MyAsyncTaskTweet().execute(editTextTweet.getText().toString());
}

public void onTimelineButtonClick(View view) {
  new MyAsyncTaskTimeline().execute(editTextUsername.getText().toString());
}

// Count characters in the Tweet field

class MyTextWatcher implements TextWatcher {
  @Override
  public void afterTextChanged(Editable s) {
    textViewCountChars.setText("" + editTextTweet.getText().length());
  }

  @Override
  public void beforeTextChanged
      (CharSequence s, int start, int count, int after) {
  }
```

```
  @Override
  public void onTextChanged
      (CharSequence s, int start, int before, int count) {
  }
}

// The AsyncTask classes

public class MyAsyncTaskTweet extends AsyncTask<String, Void, String> {
  @Override
  protected String doInBackground(String... tweet) {
    String result = "";
    try {
      twitter.updateStatus(tweet[0]);
      result = getResources().getString(R.string.success);
    } catch (TwitterException twitterException) {
      result = getResources().getString(R.string.twitter_failure);
    } catch (Exception e) {
      result = getResources().getString(R.string.general_failure);
    }
    return result;
  }

  @Override
  protected void onPostExecute(String result) {
    editTextTweet.setHint(result);
    editTextTweet.setText("");
  }
}

public class MyAsyncTaskTimeline extends AsyncTask<String, Void, String> {
  @Override
  protected String doInBackground(String... username) {
    String result = new String("");
    List<twitter4j.Status> statuses = null;
    try {
      statuses = twitter.getUserTimeline(username[0]);
    } catch (TwitterException twitterException) {
      result = getResources().getString(R.string.twitter_failure);
    } catch (Exception e) {
      result = getResources().getString(R.string.general_failure);
    }
    for (twitter4j.Status status : statuses) {
      result += status.getText();
```

(continued)

LISTING 13-4: *(continued)*

```
        result += "\n";
      }
      return result;
    }

    @Override
    protected void onPostExecute(String result) {
      editTextUsername.setText("");
      textViewTimeline.setText(result);
    }
  }
}
```

WARNING

Twitter's network protocols require that the device that runs this chapter's app is set to the correct time. I don't know how correct the "correct time" has to be, but I've had lots of trouble running the app on emulators. Either my emulator is set to get the time automatically from the network (and it gets the time incorrectly) or I set the time manually and the *seconds* part of the time isn't close enough. One way or another, the error message that comes back from Twitter (usually specifying a null authentication challenge) isn't helpful. So I avoid emulators whenever I test this code. Rather than run an emulator, I set my phone to get the network time automatically. Then I run this chapter's app on that phone. If you have trouble running this section's app, try running the app on a real phone.

When you run the app, you see two areas. One area contains a Tweet button; the other area contains a Timeline button, as shown in Figure 13-2.

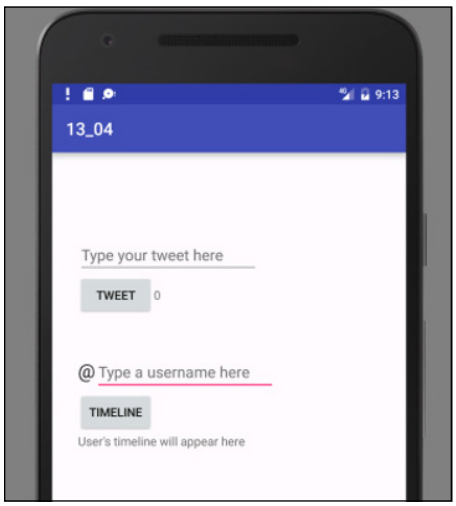


FIGURE 13-2: The main activity, in its pristine state.

In Figure 13-2, the words *Type your tweet here* and *Type a username here* are light gray. This happens because I use `android:hint` attributes with the `EditText` components in Listing 13-2. A *hint* is a bunch of characters that appear only when a text field is otherwise empty. When the user clicks inside the text field, or types any text inside the text field, the hint disappears.

Type a tweet into the text field on top, and then press the Tweet button, as shown in Figure 13-3. If your attempt to tweet is successful, the message `Success!` replaces the tweet in the text field, as shown in Figure 13-4. If, for one reason or another, your tweet can't be posted, the message `Call to Twitter failed` replaces the tweet in the text field, as shown in Figure 13-5.

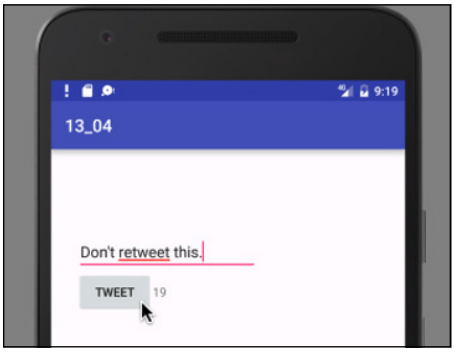


FIGURE 13-3: The user types a tweet.

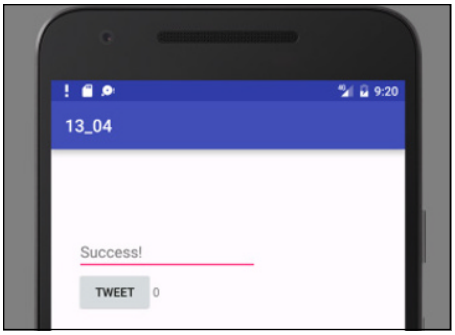


FIGURE 13-4: The app indicates a successful tweet.

Next, type a username in the lower text field, and then click Timeline. If all goes well, a list of the user's most recent tweets appears below the Timeline button, as shown in Figure 13-6. You can scroll the list to see more of the user's tweets.

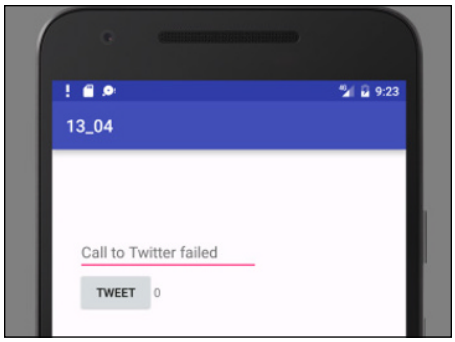


FIGURE 13-5: The app brings bad tidings to the user.

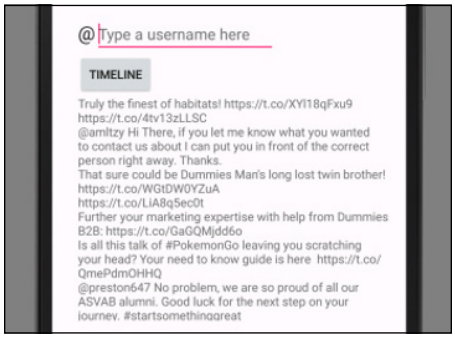


FIGURE 13-6: The @fordummies timeline.

The onCreate method

The `onCreate` method in Listing 13-4 calls `findViewById` to locate some of the components declared in Listing 13-2.

CROSS-REFERENCE

For insight into the workings of Android's `findViewById` method, see Chapter 3.

The `onCreate` method also creates a `MyTextWatcher` instance to listen for changes in the field where the user types a tweet. Android notifies the `MyTextWatcher` instance whenever the user types a character in (or deletes a character from) the app's `editTextTweet` field. The `MyTextWatcher` class's `afterTextChanged` method counts the number of characters in the `editTextTweet` field. The method displays the count in the tiny `textViewCountChars` field.

The count includes the characters in Twitter handles even though Twitter no longer counts such things toward the 140-character limit. Also, the app doesn't do anything special if a user types more than 140 characters into the `editTextTweet`

field. In a real-life app, I'd add code to deal with these issues. But when I create sample apps, I like to keep the code as uncluttered as possible.

Android actually notifies the `MyTextWatcher` instance three times for each text change in the `editTextTweet` field: once before changing the text, once during the change of the text, and once after changing the text. In Listing 13-4, I don't make `MyTextWatcher` execute any statements before or during the changing of the text. In `MyTextWatcher`, the only method whose body contains statements is the `afterTextChanged` method. Even so, in order to implement Android's `TextWatcher` interface, the `MyTextWatcher` class must provide bodies for the `beforeTextChanged` and the `onTextChanged` methods.

Finally, in the `onCreate` method, the call to `setMovementMethod(new ScrollingMovementMethod())` permits scrolling on the list of items in a user's timeline.

The button listener methods

Listing 13-2 describes two buttons, each with its own `onClick` method. I declare the two methods in Listing 13-4: the `onTweetButtonClick` method and the `onTimelineButtonClick` method. Each of the methods has a single statement in its body — a call to execute a newly constructed `AsyncTask` of some kind. Believe me, this is where the fun begins!

The trouble with threads

Imagine that you're talking to a poorly designed robot. The robot executes only one set of instructions at a time. You give this robot the following set of instructions:

```
1. Visit allmycode.com/Java4Android.
2. Download the code listings.
3. Uncompress the downloaded file.
```

You have a slow Internet connection, so the robot takes a long time to download the code listings. (The robot stares vacantly into the air during the download.) In the middle of the download, you have a craving for a glass of orange juice. So you say the following:

```
1. Go to the refrigerator.
2. Pour a glass of orange juice.
3. Bring the glass to me.
```

The robot continues to stare vacantly because the robot executes only one set of instructions at a time. You wave your hands in front of the robot's glassy eyes, but nothing happens. You robot seems to be paralyzed during the long, laborious download.

Life would be better if the robot could perform two *threads* of execution at once. With two threads of execution, the robot would share its time between two different sets of instructions:

```
1. Visit allmycode.com/Java4Android.
2. Download the code listings.            1. Go to the refrigerator.
3. Uncompress the downloaded file.        2. Pour a glass of orange juice.
                                          3. Bring the glass to me.
```

How would the robot manage to perform two threads of execution at the same time? It doesn't matter how. In one possible scenario, the robot has two brains and each brain works on one of the threads. In another scenario, the robot's single brain jumps back and forth from one thread to the other, devoting a bit of time to one thread, and then some time to the other thread, and then some time to the first thread again, and so on.

Creating more than one thread means executing more than one piece of code at the same time. For the Java developer, things become very complicated very quickly. Juggling several simultaneous pieces of code is like juggling several raw eggs: One way or another, you're sure to end up with egg on your face.

To help fix all this, the creators of Android developed a multi-threading framework. Within this framework, you bundle all your delicately timed code into a carefully defined box. This box contains all the ready-made structure for managing threads in a well-behaved way. Rather than worry about where to put your Internet request and display the result in a timely fashion, you simply plug certain statements into certain places in the box and let the box's ready-made structure take care of all the routine threading details.

This marvelous box belongs to Android's `AsyncTask` classes. To understand these classes, you need a bit of terminology explained:

- **Thread:** A bunch of statements to be executed in the order prescribed by the code
- **Multi-threaded code:** A bunch of statements in more than one thread

Java executes each thread's statements in the prescribed order. But if your program contains two threads, Java might not execute all the statements in one thread before executing all the statements in the other thread. Instead, Java might intermingle execution of the statements in the two threads. For example, I ran the following code several times:

```
new OneThread().start();
new AnotherThread().start();

class OneThread extends Thread {
  public void run() {
    for (int i = 0; i < 2000; i++) {
      output(i);
    }
  }
}

class AnotherThread extends Thread {
  public void run() {
    for (int i = 2000; i < 4000; i++) {
      output(i);
    }
  }
}
```

(I didn't really use a method named *output*. Instead, I used an elaborate bunch of statements that aren't worth worrying about here.)

The first time I ran the code, the output looked like this:

```
0 1 2 ... 189 2000 2001 ... 2144 190 191 ...
```

The second time, the output looked like this:

```
2000 2001 ... 2650 0 1 2 ...
```

The third time, the output looked like this:

```
0 1 2 ... 48 2000 49 50 ... 58 2001 59 60 2002 ...
```

The output `0` always comes before the output `1` because the statements to output `0` and `1` are in the same thread. But you can't predict whether Java will display `0` or `2000` first, because the statements to output `0` and `2000` are in two different threads.

- **The UI thread:** The thread that displays components on the screen

  In an Android program, your main activity runs primarily in the UI thread.

  The *UI* in *UI thread* stands for user interface. Another name for the UI thread is the *main thread*. The use of this terminology predates the notion of a main activity in Android.

- **A background thread:** Any thread other than the UI thread

  In an Android program, when you create an `AsyncTask` class, some of that class's code runs in a background thread.

In addition to all the terminology, you should know about two rules concerning threads:

- **Any time-consuming code should be in a background thread — not in the UI thread.**

  This chapter's example reaches out on the Internet and posts a tweet or grabs a Twitter user's timeline. Either of these chores might take a noticeable amount of time. As a result, all the app's components may come to a standstill while the app waits for a response from the Internet. The entire user interface is temporarily frozen. The app looks like my poorly designed, paralyzed robot. You don't want that to happen.

- **Any code that modifies a property of the screen must be in the UI thread.**

  If, in a background thread, you have code that modifies text on the screen, you're either gumming up the UI thread or creating code that doesn't compile. Either way, you don't want to do it.

Understanding Android's AsyncTask

A class that extends Android's `AsyncTask` looks like the outline in Listing 13-5.

LISTING 13-5: The Outline of an *AsyncTask* Class

```
public class MyAsyncTaskName extends AsyncTask<Type1, Type2, Type3> {

  @Override
  protected void onPreExecute () {
    // Execute statements in the UI thread before starting background thread.
    // For example, display an empty progress bar.
  }
```

```
  @Override
  protected Type3 doInBackground(Type1... param1) {
    // Execute statements in the background thread.
    // For example, get info from Twitter.

    return resultValueOfType3;
  }

  @Override
  protected void onProgressUpdate(Type2... param) {
    // Update a progress bar (or some other kind of progress indicator) during
    // execution of the background thread.
  }

  @Override
  protected void onPostExecute(Type3 resultValueOfType3) {
    // Execute statements in the UI thread after finishing the statements in the
    // background thread. For example, display info from Twitter in the
    // activity's components.
  }
}
```

When you create an `AsyncTask` class, Android executes each method in its appropriate thread. In the `doInBackground` method (refer to Listing 13-5), you put code that's too time-consuming for the UI thread. So Android executes the `doInBackground` method in the background thread. (Big surprise!) In Listing 13-5's other three methods (`onPreExecute`, `onProgressUpdate`, and `onPostExecute`), you put code that updates the components on the device's screen. Android executes these methods in the UI thread, as shown in Figure 13-7.

Android also makes your life easier by coordinating the execution of an `AsyncTask` class's methods. For example, `onPostExecute` doesn't change the value of a screen component until after the execution of `doInBackground`. (See Figure 13-7.) In this chapter's Twitter app, the `onPostExecute` method doesn't update the screen until after the `doInBackground` method has fetched a user's timeline from Twitter. The user doesn't see a timeline until the timeline is ready to be seen.

You'd think that with all this coordination of method calls, you lose any benefit from having more than one thread. But that's not the case. Because the `doInBackground` method runs outside the UI thread, your activity can respond to the user's clicks and drags while the `doInBackground` method waits for a response from the Twitter servers. It's all good.

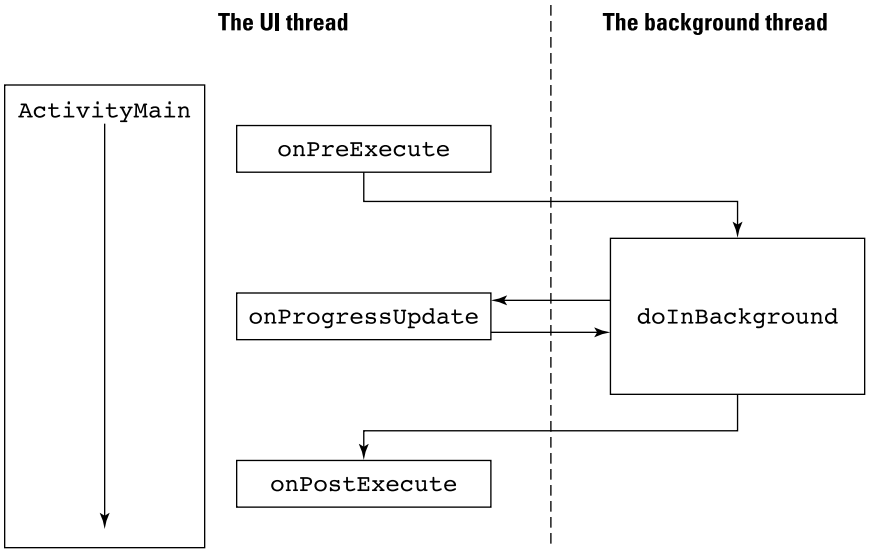


FIGURE 13-7: The UI thread and the background thread run simultaneously.

My Twitter app's AsyncTask classes

Listing 13-5 contains four methods. But in Listing 13-4, I override only two of the methods: `doInBackground` and `onPostExecute`. The `MyAsyncTaskTweet` and `MyAsyncTaskTimeline` classes in Listing 13-4 inherit the other two methods from their superclass.

Notice (in Listings 13-4 and 13-5) the use of generic type names in an `AsyncTask` class. An `AsyncTask` is versatile enough to deal with all types of values. In Listing 13-4, the first generic parameter of `MyAsyncTaskTweet` has type `String` because a tweet is a string of as many as 140 characters. But someone else's `AsyncTask` might accept an image or a music file as its input.

When you create an `AsyncTask` class, you "fill in the blanks" by putting the following three type names inside the angle brackets:

- **The first type name (*Type1* in Listing 13-5) stands for a value (or values) that you pass to the `doInBackground` method.**

  The `doInBackground` method, with its varargs parameter, uses these values to decide what has to be done.

- **The second type name (*Type2* in Listing 13-5) stands for a value (or values) that mark the background thread's progress in completing its work.**

TECHNICAL STUFF

This chapter's example has no progress bar, nor a progress indicator of any kind. So in Listing 13-4, the second type name is `Void`.

In Java, the `Void` class is a wrapper class for the `void` value. Put that in your black hole of nothingness!

» **The third type name (*Type3* in Listing 13-5) stands for a value that the `doInBackground` method returns and that the `onPostExecute` method takes as a parameter.**

In the `doInBackground` method of Listing 13-4, this third type name is `String`. It's `String` because the `doInBackground` method returns the word `"Success!"` or the words `"Call to Twitter failed"`, and the `onPostExecute` method displays these words in the screen's `editTextTweet` field.

Figure 13-8 summarizes the way generic type names influence the methods' types in Listing 13-4, and Figure 13-9 summarizes how values move from one place to another in the `MyAsyncTaskTweet` class of Listing 13-4.

```
new MyAsyncTaskTweet().execute(editTextTweet.getText().toString());

public class MyAsyncTaskTweet extends AsyncTask<String, Void, String> {
  @Override
  protected String doInBackground(String... tweet) {
    String result = "";

    try {
      twitter.updateStatus(tweet[0]);
      result = getResources().getString(R.string.success);
    } catch (TwitterException twitterException) {
      result = getResources().getString(R.string.twitter_failure);
    } catch (Exception e) {
      result = getResources().getString(R.string.general_failure);
    }
    return result;
  }

  @Override
  protected void onPostExecute(String result) {
    editTextTweet.setHint(result);
    editTextTweet.setText("");
  }
}
```

FIGURE 13-8: The use of types in an AsyncTask class.

An `AsyncTask` can be fairly complicated. But when you compare Android's `AsyncTask` to the do-it-yourself threading alternatives, the `AsyncTask` idea isn't bad at all. In fact, when you get a little practice and create a few of your own `AsyncTask` classes, you get used to thinking that way. The whole business starts to feel quite natural.

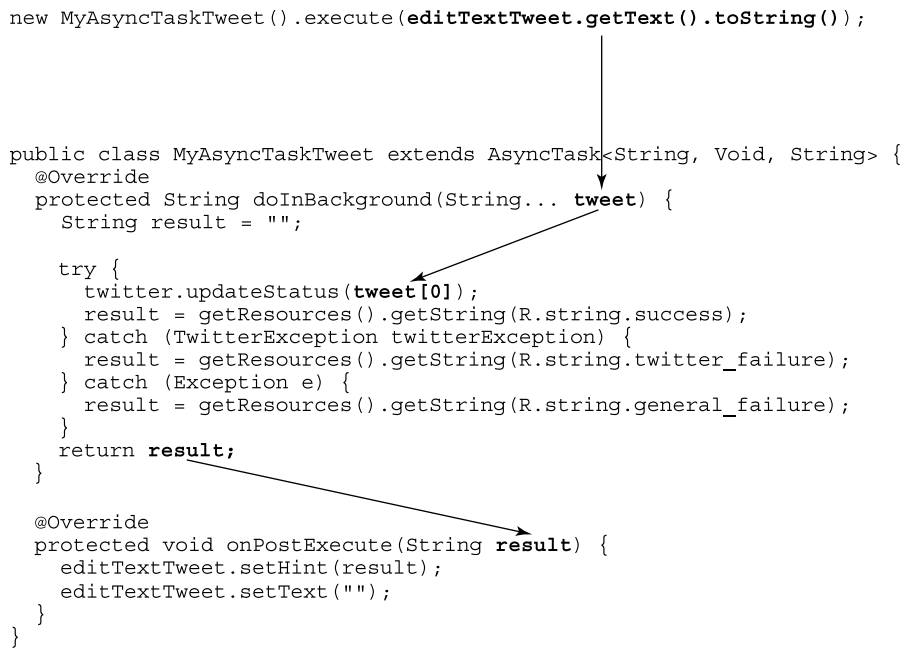


FIGURE 13-9: The flow of values in an AsyncTask class.

WARNING

Despite my glowing remarks in this chapter, Android's AsyncTask isn't a cure-all for your multitasking problems. An AsyncTask doesn't always give you the kind of control you need over your code. And, if your activity gets destroyed in the middle of an AsyncTask execution, you may have some trouble. But when you first write code that makes network requests, AsyncTask is a good place to start.

Cutting to the chase, at last

At the beginning of this chapter, I promise that a statement like

```
twitter.updateStatus("This is my tweet.");
```

lies at the heart of the code to post a tweet. You can see this by looking at the code in Listing 13-4. Here's a summary:

```
Twitter twitter;
...

ConfigurationBuilder builder = new ConfigurationBuilder();
builder
    .setOAuthConsumerKey // ... Etc.
```

```
TwitterFactory factory = new TwitterFactory(builder.build());
twitter = factory.getInstance();
...

twitter.updateStatus(tweet[0]);
```

In the Twitter4J API,

- **A `ConfigurationBuilder` helps you create a `TwitterFactory`.**
- **The `TwitterFactory` class helps you create a new `Twitter` object.**

  A call to the factory's `getInstance` method calls a `Twitter` constructor on your behalf. This creates a new `Twitter` object for you to use.
- **A `Twitter` object is a gateway to the Twitter servers.**
- **A call to the `Twitter` object's `updateStatus` method posts a brand-new tweet.**

In Listing 13-4, the parameter to the `updateStatus` method is an array element. That's because, in the `doInBackground` method's header, `tweet` is a varargs parameter. You can pass as many values to `doInBackground` as you want. In the body of the method, you treat `tweet` as though it's an ordinary array. The first `tweet` value is `tweet[0]`. If there were a second `tweet` value, it would be `tweet[1]`. And so on.

CROSS-REFERENCE

For the lowdown on varargs parameters, see Chapter 12.

In Listing 13-4, the code to fetch a user's timeline looks something like this:

```
List<twitter4j.Status> statuses = null;
...
statuses = twitter.getUserTimeline(username[0]);
```

A fellow named Yusuke Yamamoto developed Twitter4J (or at least, Yusuke Yamamoto was the Twitter4J project leader), and at some point Mr. Yamamoto decided that the `getUserTimeline` method returns a collection of `twitter4J.Status` objects. (Each `twitter4J.Status` instance contains one tweet.) To honor the contract set by calling the `getUserTimeline` method, the code in Listing 13-4 declares `statuses` to be a collection of `twitter4J.Status` objects.

A few lines later in the code, an enhanced `for` statement steps through the collection of `statuses` values and appends each value's text to a big result string. The loop adds `"\n"` (Java's go-to-the-next-line character) after each tweet for good measure. In the `onPostExecute` method, the code displays the big result string in the screen's `textViewTimeline` field.

TECHNICAL STUFF

In Listing 13-4, in the second `doInBackground` method, I use the fully qualified name `twitter4j.Status`. I do this to distinguish the `twitter4J.Status` class from Android's own `AsyncTask.Status` class (an inner class of the `AsyncTask` class).

CROSS-REFERENCE

For insight into Java's inner classes, refer to Chapter 11.

Java's Exceptions

Have I ever had something go wrong during the run of a program? (***Hint:*** The answer is yes.) Have you ever tried to visit a website and been unable to pull up the page? (Indubitably, the answer is yes.) Is it possible that Java statements can fail when they try to access the Twitter server? (Absolutely!)

In Java, most of the things that go wrong during the execution of a program are *exceptions.* When something goes wrong, your code *throws* an exception. If your code provides a way to respond to an exception, your code *catches* the exception.

Like everything else in Java, an exception is an object. Every exception is an instance of Java's `Exception` class. When your code tries to divide by zero (which is always a "no-no"), your code throws an instance of the `ArithmeticException` class. When your code can't read from a stored file, your code throws an instance of the `IOException` class. When your code can't access a database, your code throws an instance of the `SQLException` class. And when your Twitter4J code gets a bad response from the Twitter servers, your code throws an instance of the `TwitterException` class.

The classes `ArithmeticException`, `IOException`, `SQLException`, `TwitterException`, and many, many others are subclasses of Java's `Exception` class. Each of the classes `Exception`, `ArithmeticException`, `IOException`, and `SQLException` is part of Java's standard API library. The class `TwitterException` is declared separately in the Twitter4J API.

Java has two kinds of exceptions: unchecked exceptions and checked exceptions. The easiest way to tell one kind of exception from the other is to watch Android Studio's response when you type and run your code:

» **When you execute a statement that can throw an *unchecked* exception, you don't have to add additional code.**

For example, an `ArithmeticException` is an unchecked exception. You can write and run the following (awful) Java code:

```
// Don't do this:
int i = 3 / 0;
```

When you try to run this code, the program crashes. In Android Studio's Logcat pane, you see a message like the one shown in Figure 13-10.

FIGURE 13-10: Shame on you! You divided by zero.

» **When you execute a statement that can throw a *checked* exception, you must add code.**

A `TwitterException` is an example of a checked exception, and a call to `getUserTimeline` can throw a `TwitterException`. To find out what happens when you call `getUserTimeline` without adding code, see a portion of Android Studio's editor in Figure 13-11.

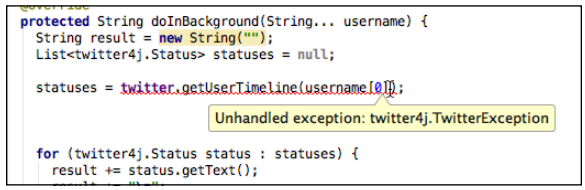


FIGURE 13-11: Java insists that you add code to acknowledge an exception.

In Figure 13-11, the error message indicates that by calling the `getUserTimeline` method, you run the risk of throwing a `TwitterException`. The word *Unhandled* means that `TwitterException` is one of Java's checked exceptions and that you haven't provided any code to address the possibility of the exception's being thrown. That is, if the app can't communicate with the Twitter servers, and Java throws a `TwitterException`, your code has no "Plan B."

In Listing 13-4, I add Java's `try` / `catch` statement to my `getUserTimeline` call. Here's the translation of the `try` / `catch` statement:

```
try to execute the following statement(s): {
    statuses = twitter.getUserTimeline(username[0]);

} If you throw a TwitterException while you're trying, {
    set the result to whatever string R.string.twitter_failure represents.
} If you throw some other kind of exception while you're trying, {
    set the result to whatever string R.string.general_failure represents.
}
```

Eventually, my code displays the `result` string in one of the activity's `TextView` components.

Catch clauses

A `try` / `catch` statement can have many `catch` clauses. To help illustrate `catch` clauses, I've added a few new lines to one of the `try` / `catch` statements in Listing 13-4:

```
try {
  count = numberOfTweets / averagePerDay;
  statuses = twitter.getUserTimeline(username[0]);
} catch (TwitterException twitterException) {
  result = getResources().getString(R.string.twitter_failure);
} catch (ArithmeticException a) {
  result = getResources().getString(R.string.divide_by_zero);
} catch (Exception e) {
  result = getResources().getString(R.string.general_failure);
}

result += "\n";
```

When an exception is thrown inside a `try` clause, Java examines the accompanying list of `catch` clauses. Every `catch` clause has a parameter list, and every parameter list contains a type of exception.

Java starts at whatever `catch` clause appears immediately after the `try` clause and works its way down the program's text. For each `catch` clause, Java asks: Is the exception that was just thrown an instance of the class in this clause's parameter list?

- **If it isn't,** Java skips the `catch` clause and moves on to the next `catch` clause in line.
- **If it is,** Java executes the `catch` clause and then skips past all other `catch` clauses that come with this `try` clause.

Java goes on and executes whatever statements come after the whole `try` / `catch` statement.

Look at this section's code snippet. Java starts executing the `numberOfTweets / averagePerDay` calculation. If `averagePerDay` is zero, the calculation fails and the code throws an `ArithmeticException`. As a result, Java skips past the `statuses = twitter...` statement. If there were any other statements between the failed calculation and the word `catch`, Java would skip those statements too.

Java goes directly to the `catch` clauses, starting with the topmost `catch` clause. The topmost catch clause is for `TwitterException` instances, but dividing by zero doesn't throw a `TwitterException`. So Java marches onward to the next `catch` clause.

The next `catch` clause is for `ArithmeticException` instances. Yes, dividing by zero threw an `ArithmeticException`. So Java executes the statement inside that `catch` clause. Java sets `result` to the string that `R.string.divide_by_zero` represents.

Then Java jumps out of the `try` / `catch` statement. Java executes the statement immediately after the `try` / `catch` statement, adding the end-of-line character (`"\n"`) to the `result` string. Then Java executes any other statements after the `result += "\n"` statement.


TIP

In the sample code with three `catch` clauses, I end the chain of `catch` clauses with an `Exception e` clause. Java's `Exception` class is an ancestor of `TwitterException` and `ArithmeticException` and all the other exception classes. No matter what kind of exception your code throws inside a `try` clause, that exception matches the `Exception e` catch clause. You can always rely on an `Exception e` clause as a last resort for handling a problem.

A finally clause

In addition to tacking on `catch` clauses, you can also tack a `finally` clause on to your `try` / `catch` statement. Java's `finally` keyword says, in effect, "Execute the `finally` clause's statements whether the code threw an exception or not." For example, in the following code snippet, Java always adds `"\n"` to the `result` variable, whether or not the call to `getUserTimeline` throws an exception:

```
try {
  statuses = twitter.getUserTimeline(username[0]);
} catch (TwitterException e) {
  result = getResources().getString(R.string.twitter_failure);
} finally {
  result += "\n";
}
```

Passing the buck

Here's a handy response to use whenever something goes wrong: "Don't blame me — tell my supervisor to deal with the problem." (I should have added the Tip icon to this paragraph!) When dealing with an exception, a Java method can do the same thing and say, "Don't expect me to have a `try` / `catch` statement — pass the exception on to the method that called me."

Here's how it works: In the `MyAsyncTaskTimeline` class of Listing 13-4, move the code that creates a `result` to a method of its own. (See Listing 13-6.)

LISTING 13-6: Nipping an Exception in the Bud

```
public class MyAsyncTaskTimeline extends AsyncTask<String, Void, String> {

  @Override
  protected String doInBackground(String... username) {
    String result = new String("");
    result = getResult(username);
    return result;
  }

  String getResult(String... username) {
    String result = new String("");
    List<twitter4j.Status> statuses = null;
    try {
      statuses = twitter.getUserTimeline(username[0]);
    } catch (TwitterException twitterException) {
      result = getResources().getString(R.string.twitter_failure);
    }
    for (twitter4j.Status status : statuses) {
      result += status.getText();
      result += "\n";
    }
    return result;
  }
```

```
  @Override
  protected void onPostExecute(String result) {
    editTextUsername.setText("");
    textViewTimeline.setText(result);
  }
}
```

In Listing 13-6, the `getResult` method says "Try to get a user's timeline. If you get a bad response from the Twitter server, handle it by displaying the `R.string.twitter_failure` message." To keep things simple, I have only one `catch` clause in Listing 13-6.

You can get rid of the `try` / `catch` statement in the `getResult` method, as long as the next method upstream acknowledges the exception's existence. To see what I mean, look at Listing 13-7.

LISTING 13-7: Make the Calling Method Handle the Exception

```
public class MyAsyncTaskTimeline extends AsyncTask<String, Void, String> {

  @Override
  protected String doInBackground(String... username) {
    String result = new String("");
    try {
      result = getResult(username);
    } catch (TwitterException twitterException) {
      result = getResources().getString(R.string.twitter_failure);
    }
    return result;
  }

  String getResult(String... username) throws TwitterException {
    String result = new String("");
    List<twitter4j.Status> statuses = null;

    statuses = twitter.getUserTimeline(username[0]);

    for (twitter4j.Status status : statuses) {
      result += status.getText();
      result += "\n";
    }
    return result;
  }
```

(continued)

LISTING 13-7: *(continued)*

```
    @Override
    protected void onPostExecute(String result) {
      editTextUsername.setText("");
      textViewTimeline.setText(result);
    }
}
```

In Listing 13-7, the `getResult` method's header contains a `throws` clause. With this `throws` clause, the `getResult` method says "If I experience a `TwitterException`, I won't deal with the exception in my own `try` / `catch` statement. Instead, I'll pass the exception on to whichever method called me." Because the `doInBackground` method calls `getResult`, Java insists that the `doInBackground` method contain code to acknowledge the possibility of a `TwitterException`. To fulfill this responsibility, the `doInBackground` method surrounds the `getResult` call with a `try` / `catch` statement.

In this example, the buck must stop with my `doInBackground` method. My `doInBackground` method's header can't have a `throws TwitterException` clause. Instead, the `doInBackground` method must contain a `catch` clause for the `TwitterException`. My code's `doInBackground` method overrides Android's own `doInBackground` method, and Android's `doInBackground` method doesn't throw a `TwitterException`. Here's the general rule: Imagine some exception that I'll call `XYZException`. If a method's header doesn't say `throws XYZException`, you can't override that method with a header that says `throws XYZException`.

Of course, the buck doesn't always have to stop after the first `throws` clause. You could say, "Don't blame me — tell my supervisor to deal with the problem." And then your supervisor could say, "Don't blame me — tell *my* supervisor to deal with the problem." (Where my wife works, things like this happen all the time.) Listing 13-8 has an admittedly contrived example.

LISTING 13-8: **Keep Passing the Hot Potato**

```
public class MyAsyncTaskTimeline extends AsyncTask<String, Void, String> {

  @Override
  protected String doInBackground(String... username) {
    String result = new String("");
    try {
      result = getResult(username);
    } catch (TwitterException twitterException) {
```

```
      result = getResources().getString(R.string.twitter_failure);
    }
    return result;
  }

  String getResult(String... username) throws TwitterException {
    String result = new String("");
    List<twitter4j.Status> statuses = null;

    statuses = getStatuses(username);

    for (twitter4j.Status status : statuses) {
      result += status.getText();
      result += "\n";
    }
    return result;
  }

  List<twitter4j.Status> getStatuses(String[] username)
                                                  throws TwitterException {
    List<twitter4j.Status> statuses;
    statuses = twitter.getUserTimeline(username[0]);
    return statuses;
  }

  @Override
  protected void onPostExecute(String result) {
    editTextUsername.setText("");
    textViewTimeline.setText(result);
  }
}
```

If you get a bad response from the Twitter server, the `getStatuses` method passes the exception to the `getResult` method, which in turn passes the exception to the `doInBackground` method. The `doInBackground` method takes the ultimate responsibility by surrounding the `getResult` call in a `try` / `catch` statement.

IN THIS CHAPTER

- Coding an Android game
- Using Android animation
- Saving data from one run to another

Chapter 14

Hungry Burds: A Simple Android Game

What started as a simple pun involving the author's last name has turned into Chapter 14 — the most self-indulgent writing in the history of technical publishing.

The scene takes place in south Philadelphia in the early part of the 20th century. My father (then a child) sees his father (my grandfather) handling an envelope. The envelope has just arrived from the old country. My grandmother grabs the envelope out of my grandfather's hands. The look on her face is one of superiority. "I open the letters around here," she says with her eyes.

While my grandmother opens the letter, my father glances at the envelope. The last name on the envelope is written in Cyrillic characters, so my father can't read it. But he notices a short last name in the envelope's address. Whatever the characters are, they're more likely to be a short name like Burd than a longer name like Burdinsky or Burdstakovich.

The Russian word for *bird* is *ptitsa*, so there's no etymological connection between my last name and our avian friends. But as I grew up, I would often hear kids yell, "Burd is the word" or "Hey, Burdman" from across the street. Today, my one-person Burd Brain Consulting firm takes in a small amount of change every year.

Introducing the Hungry Burds Game

When the game begins, the screen is blank. Then, for a random amount of time (averaging one second), a Burd fades into view, as shown in Figure 14-1.

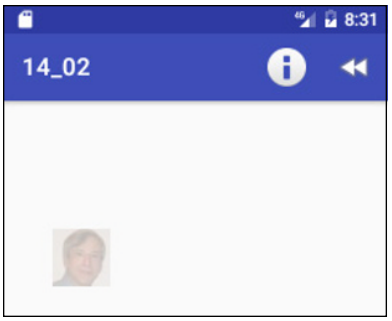


FIGURE 14-1: A Burd fades into view.

If the user does nothing, the Burd disappears after fading into full view. But if the user touches the Burd before it disappears, the Burd gets a cheeseburger and remains onscreen, as shown in Figure 14-2.

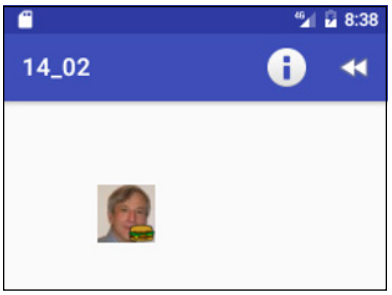


FIGURE 14-2: You've fed this Burd.

After ten Burds have faded in (and the unfed ones have disappeared), the screen displays a `Game Over` pop-up message. (See Figure 14-3.)

Two icons serve as menu items at the top of the screen. If the user selects the Info icon, a pop-up message shows the number of fed Burds in the current run of the game. The message also shows the high score for all runs of the game. (See Figure 14-4.) If the user selects the Rewind icon, the game begins again.

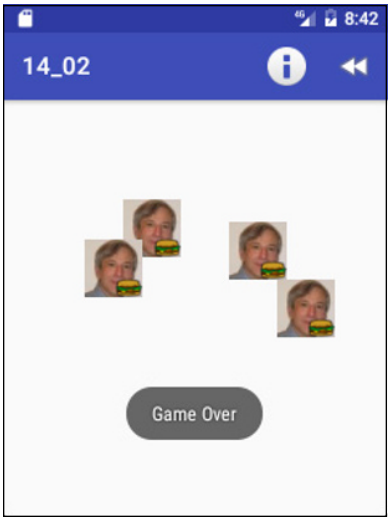


FIGURE 14-3:
The game ends.

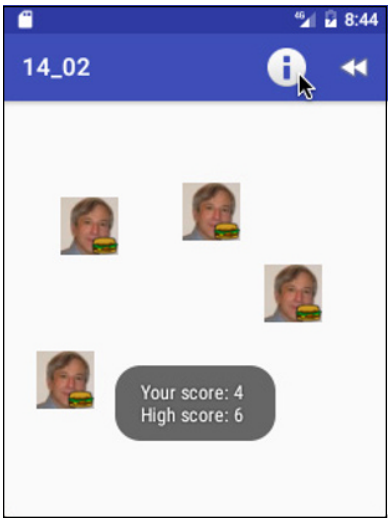


FIGURE 14-4:
The score sheet.

The Hungry Burds Java code is about 150 lines long. (Compare this with one of the Android game developer's books that I bought. In that book, the simplest example has 2,300 lines of Java code.) To keep the Hungry Burds code from consuming dozens of pages, I've omitted some features that you might see in a more realistically engineered game:

- **The Hungry Burds game doesn't access data over a network.**

  The game's high-score display doesn't tell you how well you scored compared with your friends or with other players around the world. The high-score display applies to only one device — the one you're using to play the game.

- **The game restarts whenever you change the device's orientation.**

  If you tilt the device from Portrait mode to Landscape mode, or from Landscape mode to Portrait mode, Android calls the main activity's lifecycle methods. Android calls the activity's `onPause`, `onStop`, and `onDestroy` methods. Then it reconstitutes the activity by calling the activity's `onCreate`, `onStart`, and `onResume` methods. As a result, whatever progress you've made in the game disappears and the game starts itself over again from scratch.

  
  CROSS-REFERENCE

  For an introduction to an activity's lifecycle methods, see Chapter 4.

- **The screen measurements that control the game are crude.**

  Creating a visual app that involves drawing, custom images, or motion of any kind involves some math. You need math to make measurements, estimate distances, detect collisions, and complete other tasks. To do the math, you produce numbers by making Android API calls, and you use the results of your calculations in Android API library calls.

  To help me cut to the chase, my Hungry Burds game does only a minimal amount of math, and it makes only the API calls I believe to be absolutely necessary. As a result, some items on the screen don't always look their best.

- **The game has no settings.**

  The number of Burds displayed, the minimum length of time for each Burd's display, and the maximum additional time of each Burd's display are all hardcoded in the game's Java file. In the code, these constants are `NUMBER_OF_BURDS`, `MINIMUM_DURATION`, and `MAXIMUM_ADDITIONAL_DURATION`. As a developer, you can change the values in the code and reinstall the game. But the ordinary player can't change these numbers.

- **The game may not be challenging with the default `NUMBER_OF_BURDS`, `MINIMUM_DURATION`, and `MAXIMUM_ADDITIONAL_DURATION` values.**

  I admit it: On this front, I'm at a distinct disadvantage. I'm a lousy game player. I remember competing in video games against my kids when they were young. I lost every time. At first it was embarrassing; in the end it was ridiculous. I could never avoid being shot, eaten, or otherwise squashed by my young opponents' avatars.

  I don't presume to know what values of `NUMBER_OF_BURDS`, `MINIMUM_DURATION`, and `MAXIMUM_ADDITIONAL_DURATION` are right for you. And if no values are right for you (and the game isn't fun to play no matter which values you have), don't despair. I've created Hungry Burds as a teaching tool, not as a replacement for Pokémon GO.


TIP

If changing the `AVERAGE_SHOW_TIME` and `MINIMUM_SHOW_TIME` doesn't make Hungry Burds feel like a real game, try running the game on a real-life device.

The Main Activity

I start with an outline of the main activity's code. The outline is in Listing 14-1. (If outlines don't work for you and you want to see the code in its entirety, refer to Listing 14-2, a little later in this chapter.)

LISTING 14-1: An Outline of the App's Java Code

```
package com.allmycode.a14_02;

public class MainActivity extends AppConpatActivity
    implements OnClickListener, AnimationListener {

  // Declare fields

  /* Activity lifecycle methods */

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    // Find the layout

    // Get the size of the device's screen
  }

  @Override
  public void onResume() {
    startPlaying();
  }

  /* Game play methods */
  void startPlaying() {
    // Set this run's score (countClicked) to zero
    // Remove any images from the previous game

    showABurd();
  }

  void showABurd() {
    // Add a Burd in some random place
    // At first, the Burd is invisible
```

(continued)

LISTING 14-1: ***(continued)***

```
    // Create an AlphaAnimation to make the Burd
    //     fade in (from invisible to fully visible)

    burd.startAnimation(animation);
  }

  /* OnClickListener method */

  public void onClick(View view) {
    countClicked++;

    // Change the image to a Burd with a cheeseburger
  }

  /* AnimationListener methods */

  public void onAnimationEnd(Animation animation) {
    if (++countShown < NUMBER_OF_BURDS) {
      showABurd(); // Again!
    } else {
      // Display the "Game Over" message
    }
  }

  /* Menu methods */

  public boolean onCreateOptionsMenu(Menu menu) {
    // Make the menu
  }

  public boolean onOptionsItemSelected(MenuItem item) {
    // Show the scores or start a new game
  }

  private void showScores() {
    // Get high score from SharedPreferences
    // If this score is greater than the high score, update SharedPreferences
    // Display high score and this run's score
  }
}
```

The heart of the Hungry Burds code is the code's game loop. Here's a sneak preview of the full Hungry Burds app's code:

```
@Override
public void onResume() {
  super.onResume();
  startPlaying();
}

void startPlaying() {
  countClicked = countShown = 0;
  layout.removeAllViews();
  showABurd();
}

void showABurd() {
  // Add a Burd in some random place.
  // At first, the Burd is invisible ...

  burd.setVisibility(View.INVISIBLE);

  // ... but the animation will make the Burd visible.

  AlphaAnimation animation = new AlphaAnimation(0.0F, 1.0F);
  animation.setDuration(duration);
  animation.setAnimationListener(this);
  burd.startAnimation(animation);
}

public void onAnimationEnd(Animation animation) {
  if (++countShown < NUMBER_OF_BURDS) {
    showABurd(); // Again!
  } else {
    // Display the "Game Over" message
  }
}
```

When Android executes the `onResume` method, the code calls the `startPlaying` method, which in turn calls the `showABurd` method. The `showABurd` method does what its name suggests, by animating an image from alpha level 0 to alpha level 1. (Alpha level 0 is fully transparent; alpha level 1 is fully opaque.)

When the animation ends, the `onAnimationEnd` method checks the number of Burds that have already been displayed. If the number is less than ten, the `onAnimationEnd` method calls `showABurd` again, and the game loop continues.

By default, a Burd returns to being invisible when the animation ends. But the main activity implements `OnClickListener`, and when the user touches a Burd, the class's `onClick` method makes the Burd permanently visible, as shown in the following snippet:

```
public void onClick(View view) {
  countClicked++;
  ((ImageView) view).setImageResource(R.drawable.burd_burger);
  view.setVisibility(View.VISIBLE);
}
```


TECHNICAL STUFF

In an activity's `onCreate` method, you put code that runs when the activity comes into existence. In contrast, in the `onResume` method, you put code that runs when the user begins interacting with the activity. The user isn't aware of the difference because the app starts running so quickly. But for you, the developer, the distinction between an app's coming into existence and starting to interact is important. In Listings 14-1 and 14-2, the `onCreate` method contains code to restore any previous state, set the activity's layout, and measure the screen size. The `onResume` method is different. With the `onResume` method, the user is about to touch the device's screen. So In Listings 14-1 and 14-2, the `onResume` method displays something for the user to touch: the first of several hungry Burds.


TECHNICAL STUFF

When you override Android's `onResume` method, the first statement in the method body must be `super.onResume()`. A similar rule holds for Android's `onCreate` method, and for all of Android's activity lifecycle methods.

The code, all the code, and nothing but the code

Following the basic outline of the game's code in the earlier section "The Main Activity," Listing 14-2 contains the entire text of the game's `MainActivity.java` file.

LISTING 14-2: The App's Java Code

```
package com.allmycode.a14_02;

import android.content.SharedPreferences;
import android.graphics.Point;
```

```
import android.os.Bundle;
import android.support.v7.app.AppCompatActivity;
import android.view.Display;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.view.View.OnClickListener;
import android.view.animation.AlphaAnimation;
import android.view.animation.Animation;
import android.view.animation.Animation.AnimationListener;
import android.widget.ImageView;
import android.widget.RelativeLayout;
import android.widget.RelativeLayout.LayoutParams;
import android.widget.Toast;

import java.util.Random;

public class MainActivity extends AppCompatActivity
    implements OnClickListener, AnimationListener {

  final int NUMBER_OF_BURDS = 10;
  final int MINIMUM_DURATION = 500;
  final int MAXIMUM_ADDITIONAL_DURATION = 1000;
  int countShown = 0, countClicked = 0;
  Random random = new Random();

  RelativeLayout layout;
  int displayWidth, displayHeight;

  /* Activity lifecycle methods */

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    layout = (RelativeLayout) findViewById(R.id.relativeLayout);

    Display display = getWindowManager().getDefaultDisplay();
    Point size = new Point();
    display.getSize(size);
    displayWidth = size.x;
    displayHeight = size.y;
  }
```

(continued)

LISTING 14-2: *(continued)*

```
@Override
public void onResume() {
  super.onResume();
  startPlaying();
}

/* Game play methods */

void startPlaying() {
  countClicked = countShown = 0;
  layout.removeAllViews();
  showABurd();
}

void showABurd() {

  long duration =
      MINIMUM_DURATION + random.nextInt(MAXIMUM_ADDITIONAL_DURATION);

  LayoutParams params = new LayoutParams
      (LayoutParams.WRAP_CONTENT, LayoutParams.WRAP_CONTENT);

  params.leftMargin = random.nextInt(displayWidth) * 3 / 4;
  params.topMargin = random.nextInt(displayHeight) * 5 / 8;

  ImageView burd = new ImageView(this);
  burd.setImageResource(R.drawable.burd);
  burd.setLayoutParams(params);
  burd.setOnClickListener(this);
  burd.setVisibility(View.INVISIBLE);

  layout.addView(burd);

  AlphaAnimation animation = new AlphaAnimation(0.0F, 1.0F);
  animation.setDuration(duration);
  animation.setAnimationListener(this);
  burd.startAnimation(animation);
}

/* OnClickListener method */

public void onClick(View view) {
  countClicked++;
  ((ImageView) view).setImageResource(R.drawable.burd_burger);
```

```
    view.setVisibility(View.VISIBLE);
  }

  /* AnimationListener methods */

  public void onAnimationEnd(Animation animation) {
    if (++countShown < NUMBER_OF_BURDS) {
      showABurd();
    } else {
      Toast.makeText(this, "Game Over", Toast.LENGTH_LONG).show();
    }
  }

  public void onAnimationRepeat(Animation arg0) {
  }

  public void onAnimationStart(Animation arg0) {
  }

  /* Menu methods */

  @Override
  public boolean onCreateOptionsMenu(Menu menu) {
    getMenuInflater().inflate(R.menu.menu_main, menu);
    return true;
  }

  @Override
  public boolean onOptionsItemSelected(MenuItem item) {
    switch (item.getItemId()) {
      case R.id.show_scores:
        showScores();
        return true;
      case R.id.play_again:
        startPlaying();
        return true;
    }
    return super.onOptionsItemSelected(item);
  }

  private void showScores() {
    SharedPreferences prefs = getPreferences(MODE_PRIVATE);
    int highScore = prefs.getInt("highScore", 0);
```

(continued)

LISTING 14-2: ***(continued)***

```
    if (countClicked > highScore) {
      highScore = countClicked;
      SharedPreferences.Editor editor = prefs.edit();
      editor.putInt("highScore", highScore);
      editor.commit();
    }

    Toast.makeText(this, "Your score: " + countClicked +
        "\nHigh score: " + highScore, Toast.LENGTH_LONG).show();
  }
}
```

Measuring the display

You want to randomly choose places on the device's screen to display Burd images. To do this, it may help to know the size of the device's screen. How complicated can that be? You can measure the screen size with a ruler, and you can determine a device's resolution by reading the specs in the user manual.

Of course, Android programs don't have opposable thumbs, so they can't use plastic rulers. And a layout's characteristics can change, depending on several runtime factors, including the device's orientation (portrait or landscape) and the amount of screen space reserved for Android's notification bar and buttons. If you don't play your cards right, you can easily call methods that prematurely report a display's width and height as zero values.

Fortunately, the `android.view.Display` class's `getSize` method gives you useful answers without too much coding. So, here and there in Listing 14-2, you find the following code:

```
public class MainActivity extends AppCompatActivity {

  int displayWidth, displayHeight;

  public void onCreate(Bundle savedInstanceState) {

    Display display = getWindowManager().getDefaultDisplay();
    Point size = new Point();
    display.getSize(size);
    displayWidth = size.x;
    displayHeight = size.y;
  }
```

```
void showABurd() {

  LayoutParams params = new LayoutParams
      (LayoutParams.WRAP_CONTENT, LayoutParams.WRAP_CONTENT);

  params.leftMargin = random.nextInt(displayWidth) * 3 / 4;
  params.topMargin = random.nextInt(displayHeight) * 5 / 8;

}
```

An instance of Android's `Point` class is basically an object with two components: an `x` component and a `y` component. In the Hungry Burds code, a call to `getWindowManager().getDefaultDisplay()` retrieves the device's display. The resulting display's `getSize` method takes an instance of the `Point` class and fills its `x` and `y` fields. The `x` field's value is the display's width, and the `y` field's value is the display's height, as shown in Figure 14-5.

A `LayoutParams` object stores information about the way a component should appear as part of an activity's layout. (Each kind of layout has its own `LayoutParams` inner class, and the code in Listing 14-2 imports the `RelativeLayout.LayoutParams` inner class.) A `LayoutParams` instance has a life of its own, apart from any component whose appearance the instance describes. In Listing 14-2, I construct a new `LayoutParams` instance before applying the instance to any particular component. Later in the code, I call

```
burd.setLayoutParams(params);
```

to apply the new `LayoutParams` instance to one of the Burds.

Constructing a new `LayoutParams` instance with a double dose of `LayoutParams.WRAP_CONTENT` (one `LayoutParams.WRAP_CONTENT` for width and one `LayoutParams.WRAP_CONTENT` for height) indicates that a component should shrink-wrap itself around whatever content is drawn inside it. Because the code eventually applies this `LayoutParams` instance to a Burd, the Burd will be only wide enough and only tall enough to contain a picture of yours truly from the project's `res/drawable` directory.

The alternative to `WRAP_CONTENT` is `MATCH_PARENT`. With two `MATCH_PARENT` parameters in the `LayoutParams` constructor, a Burd's width and height would expand to fill the activity's entire relative layout. In this example, that layout would fill most of the device's screen.

A `LayoutParams` instance's `leftMargin` field stores the number of pixels between the left edge of the display and the left edge of the component. Similarly, a `LayoutParams` instance's `topMargin` field stores the number of pixels between the top edge of the display and the top edge of the component. (See Figure 14-5.)

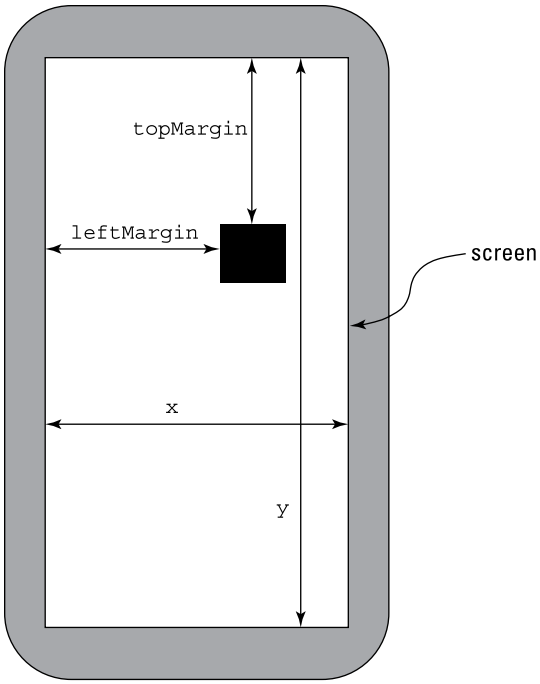


FIGURE 14-5: Measuring distances on the screen.

In Listing 14-2, I generate values randomly to position a new Burd. A Burd's left edge (`params.leftMargin`) is no farther than ¾ths of the way across the screen, and the Burd's top edge (`params.topMargin`) is no lower than ⅝ths of the way down the screen. If you don't multiply the screen's width by ¾ (or some such fraction), an entire Burd can be positioned beyond the right edge of the screen. The user sees nothing while the Burd comes and goes. The same kind of thing can happen if you don't multiply the screen's height by ⅝.

TECHNICAL STUFF

The fractions ¾ and ⅝, which I use to determine each component's position, are crude guesstimates of a portrait screen's requirements. A more refined app would carefully measure the available turf and calculate the optimally sized region for positioning new Burds.

In Listing 14-2, I also generate numbers randomly to decide how many milliseconds each Burd takes to fade into full view. The `MAXIMUM_ADDITIONAL_DURATION` is 1000, so the expression `random.nextInt(MAXIMUM_ADDITIONAL_DURATION)` stands for a value from `0` to `999`. By adding `MINIMUM_DURATION` (refer to Listing 14-2), I make `duration` be a number between 500 and 1499. So a Burd takes between 500 and 1499 milliseconds to fade into view.

CROSS-REFERENCE

I introduce the `java.util.Random` class in Chapter 8.

Constructing a Burd

Android's `ImageView` class represents objects that contain images. Normally, you put an image file (a `.png` file, a `.jpg` file, or a `.gif` file) in your project's `res/drawable` directory, and a call to the `ImageView` object's `setImageResource` method associates the `ImageView` object with the image file. In Listing 14-2, the following lines fulfill this role:

```
ImageView burd = new ImageView(this);
burd.setImageResource(R.drawable.burd);
```

Because of the `R.drawable.burd` parameter, Android looks in the project's *app*`/res/drawable` directory for a file named `burd.png`, `burd.jpg`, or `burd.gif`.

You can find `burd.png` in the stuff that you download from this book's website (`www.allmycode.com/Java4Android`).

The statement

```
burd.setVisibility(View.INVISIBLE);
```

makes the Burd be completely transparent. The next statement

```
layout.addView(burd);
```

normally makes a component appear on the user's screen. But with the `View.INVISIBLE` property, the Burd doesn't show up. It's not until I start the code's fade-in animation that the user begins seeing a Burd on the screen.

When the user clicks on a Burd, Android calls the `onClick` method in Listing 14-2. The `onClick` method's `view` parameter represents the `ImageView` object that the user clicked. In the body of the `onClick` method, the statement

```
((ImageView) view).setImageResource(R.drawable.burd_burger);
```

assures Java that `view` is indeed an `ImageView` instance and changes the picture on the face of that instance from a hungry author to a well-fed author. (In the *app*`/res/drawable` directory, Android grabs a file named `burd_burger.png`, `burd_burger.jpg`, or `burd_burger.gif`.) The `onClick` method also sets the `ImageView` instance's visibility to `View.VISIBLE`. That way, when this Burd's animation ends, the happy Burd remains visible on the user's screen.

DISPLAYING THINGS ON THE DEVICE'S SCREEN

When you create an Android activity, you fill most of the activity's screen with something called a view group. A *view group* holds components such as `Button` components, `EditText` components, `TextView` components, `ImageView` components, and other such things. To make a particular component appear on an activity's screen, you add that component to the activity's view group.

The Android API has several kinds of view groups, including these:

- `LinearLayout`**:** Arranges components in a line across the screen, or in a column down the screen.
- `GridLayout`**:** Arranges components in a rectangular grid (that is, in the cells of a table whose borders are invisible).
- `RelativeLayout`**:** Arranges components by describing their positions relative to one another. For example, you can place `button2` to the right of `button1` or make the top of `button2` be 50 pixels below the bottom of `button1`.
- `ConstraintLayout`**:** Has more features than `RelativeLayout` for describing components' relative positions. For example, you can center a component in a layout by constraining the component to the top, bottom, left, and right of the layout. You can move the component from the center by assigning a bias constraint.

To add a component to a view group, you have two alternatives:

- **In a file such as** `activity_main.xml`**, you can use XML code to describe the component.**

  I do that in most of this book's examples without making a big fuss about it.

- **In a file such as** `MainActivity.java`**, you can use Java code to describe the component.**

  I do that in Listing 14-2 because each component (each Burd) appears at a different time during the app's run.

With Android Studio's Designer tool, you drag components onto a preview screen. When you do, Android Studio composes the `activity_main.xml` file for you. You see the `activity_main.xml` file's code when you switch to the Designer tool's Text tab.

The layout file (`activity_main.xml`) for this chapter's app is quite short:

```
<?xml version="1.0" encoding="utf-8"?>

   <RelativeLayout xmlns:android= "http://schemas.android.com/apk/res/
      android"
                   xmlns:tools="http://schemas.android.com/tools"
                   android:id="@+id/relativeLayout"
                   android:layout_width="match_parent"
                   android:layout_height="match_parent"
                   tools:context=".MainActivity">
   </RelativeLayout>
```

The file tells Android that most of the screen is taken up with a `RelativeLayout`, and that the RelativeLayout's id is `relativeLayout`. You can create this file (or a file very much like this file) on the Designer tool's Design tab. To do so, follow these steps:

1. **Remove any `TextView` components or other components from inside the preview screens.**
2. **At the top of the component tree, look for the word *RelativeLayout*.**

   If you see the word *RelativeLayout*, go to Step 3.

   If you see some other word (such as *ConstraintLayout* or *LinearLayout*), drag a RelativeLayout item from the Palette to one of the preview screens. Then select the new RelativeLayout in the component tree and look at the Properties pane. In the Properties pane, make sure that both the `layout_width` and `layout_height` properties have the value `match_parent`.
3. **If you haven't already done so, select the RelativeLayout in the component tree.**
4. **In the Properties pane's ID field, type `relativeLayout`.**

   Android Studio may have already filled this field with the name `activity_main`. But I find this name confusing because, with this name, the app has two things — one named `R.layout.activity_main` and another named `R.id.activity_main` — and they're not quite the same thing. In Listing 14-2, I refer to `R.id.relativeLayout`. And in the Designer tool, I set the ID accordingly.

In Listing 14-2, the statement

```
layout = (RelativeLayout) findViewById(R.id.relativeLayout);
```

(continued)

(continued)

makes the variable `layout` refer to the activity's one and only view group. Later in Listing 14-2, the statement

```
layout.addView(burd)
```

adds a Burd to the activity's view group, setting the stage for displaying the Burd on the screen. Elsewhere in Listing 14-2, the statement

```
layout.removeAllViews();
```

removes all Burds from the activity's view group in preparation for the start of the Hungry Burds game.

Android animation

Android has two types of animation:

- **View animation:** A system that comes in two different flavors:
  - *Tweening:* You tell Android how an object should look initially and how the object should look eventually. You also tell Android how to change from the initial appearance to the eventual appearance. (Is the change gradual or sudden? If the object moves, does it move in a straight line or in a curve of some sort? Will it bounce a bit when it reaches the end of its path?)

    With tweening, Android considers all your requirements and figures out exactly how the object looks *between* the start and the finish of the object's animation.
  - *Frame-by-frame animation:* You provide several snapshots of the object along its path. Android displays these snapshots in rapid succession, one after another, giving the appearance of movement or of another change in the object's appearance.

    Movie cartoons are the classic example of frame-by-frame animation, even though, in modern moviemaking, graphics specialists use tweening to create sequences of frames.
- **Property animation:** A system in which you can modify any property of an object over a period of time.

  With property animation, you can change anything about any kind of object, whether the object appears on the device's screen or not. For example, you can increase an `earth` object's average temperature from 15° Celsius to 18° Celsius over a period of ten minutes. Rather than display the `earth` object,

you can watch the way average temperature affects water levels and plant life, for example.

Unlike view animation, the use of property animation changes the value stored in an object's field. For example, you can use property animation to change a component from being invisible to being visible. When the property animation finishes, the component remains visible.

The Hungry Burds code uses view animation, which includes these specialized animation classes:

- `AlphaAnimation`: Fades into view or fades out of view
- `RotateAnimation`: Turns around
- `ScaleAnimation`: Changes size
- `TranslateAnimation`: Moves from one place to another

In particular, the Hungry Burds code uses `AlphaAnimation`. In the statement

```
AlphaAnimation animation = new AlphaAnimation(0.0F, 1.0F);
```

the alpha level of 0.0 indicates complete transparence, and the alpha level of 1.0 indicates complete opaqueness. (The `AlphaAnimation` constructor expects its parameters to be float values, so I plug the `float` values `0.0F` and `1.0F` into the constructor call.)

The call

```
animation.setAnimationListener(this);
```

tells Java that the code to respond to the animation's progress is in this main activity class. Indeed, the class header at the top of Listing 14-2 informs Java that the `HungryBurds` class implements the `AnimationListener` interface. And to make good on the implementation promise, Listing 14-2 contains bodies for the methods `onAnimationEnd`, `onAnimationRepeat`, and `onAnimationStart`. (Nothing happens in the `onAnimationRepeat` and `onAnimationStart` methods. That's okay.)

The `onAnimationEnd` method does what I describe earlier in this chapter: The method checks the number of Burds that have already been displayed. If the number is less than ten, the `onAnimationEnd` method calls `showABurd` again and the game loop continues.

REMEMBER

An object's `visibility` property doesn't change when a view animation makes the object fade in or fade out. In this chapter's example, a Burd starts off with `View.INVISIBLE`. A fade-in animation makes the Burd appear slowly on the screen. But when the animation finishes, the Burd's `visibility` field still contains the original `View.INVISIBLE` value. Normally, when the animation ends, the Burd simply disappears. It's only when the user touches a hungry Burd that the code's `onClick` method calls `view.setVisibility(View.VISIBLE)`, making the Burd image remain on the screen.

Creating menus

A strip at the top of the screen shown earlier, in Figure 14-1, is the activity's *action bar* (also known as the *app bar*). The right side of the action bar displays *action buttons*. The Hungry Burds game has two action buttons: an Info button and a Rewind button.

Defining the XML file

To describe your activity's action bar, you create an XML file in your project's *app*`/res/menu` directory. Listing 14-3 contains the XML file for the Hungry Burds game.

LISTING 14-3: **Description of a Menu**

```
<menu xmlns:android="http://schemas.android.com/apk/res/android"
      xmlns:app="http://schemas.android.com/apk/res-auto"
      xmlns:tools="http://schemas.android.com/tools"
      tools:context="com.allmycode.a14_02.MainActivity">

    <item
        android:id="@+id/show_scores"
        android:icon="@drawable/ic_dialog_info"
        android:title="@string/scores"
        app:showAsAction="ifRoom|withText"
        />

    <item
        android:id="@+id/play_again"
        android:icon="@drawable/ic_media_rew"
        android:title="@string/again"
        app:showAsAction="ifRoom|withText"
        />
</menu>
```

In Listing 14-3, each `item` element describes an action button. Each `item` element has four attributes:

- **The `android:id` attribute gives the action button a name.**

  You refer to this name in the main activity's Java code.

- **The `android:icon` attribute points to a file containing an image.**

  The file lives in your project's *app*`/res/drawable` directory. If there's room, Android displays this image on the action bar. (Refer to Figure 14-1.)

  If there's no room, the action appears only when the user selects the action bar's Overflow icon. (See Figures 14-6 and 14-7.)

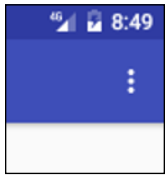


FIGURE 14-6: This phone's Overflow icon has three dots aligned vertically.

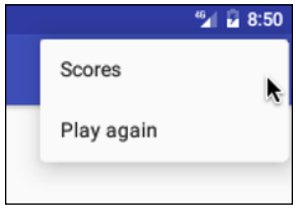


FIGURE 14-7: Expanding the Overflow icon.

- **The `android:title` attribute points to some helpful text.**

  That text may or may not appear along with the icon, depending on the size of the screen and the next attribute's options.

In Listing 14-3, the attribute `android:showAsAction="ifRoom|withText"` tells Android two things:

- `ifRoom`: **Show this icon on the action bar if there's room for it.**

  If there isn't enough room, reveal this icon when the user presses the Overflow icon.

- `withText`: **Show this item's title on the action bar if there's room for it.**

  Figure 14-8 shows each icon along with the icon's title.

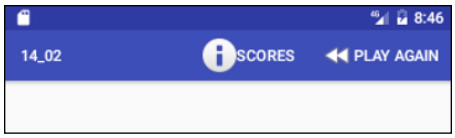


FIGURE 14-8: There's room for the icons' titles.

REMEMBER

Use Java's bitwise or operator (|) to separate the word `ifRoom` from the word `withText`.

Listing 14-3 is very nice, but the XML file in Listing 14-3 isn't enough to put items on your app's action bar. For that, you need to inflate the XML file. That's why I put the following method in Listing 14-2:

```
@Override
public boolean onCreateOptionsMenu(Menu menu) {
  getMenuInflater().inflate(R.menu.menu_main, menu);
  return true;
}
```

When you *inflate* an XML document, Android turns the XML code into something resembling Java code (a Java object, perhaps).

In the preceding code, you get a `MenuInflater` that's capable of inflating menus from XML resources. Then you inflate the XML code to get a real, live Java object.

REMEMBER

When you implement the `onCreateOptionsMenu` method, you must return either `true` or `false`. If you return `false`, Android doesn't display the menu. How rude!

Handling user actions

In the menu's XML file (refer to Listing 14-3), you describe how the menu items look. And in the `onOptionsItemSelected` method (refer to Listing 14-2), you describe what happens when the user clicks any of those menu items.

Take a gander at the `onOptionsItemSelected` method in Listing 14-2. When the user clicks an item, the code calls the item's `getItemId` method. Depending on the `getItemId` method's return value, the code calls either the `showScores` method or the `startPlaying` method.

The `onOptionsItemSelected` method returns a `boolean` value. A `true` return value tells Android that you've finished handling the user's selection. If you return `false`, Android passes the selection event to whatever other code might be waiting for it.

Shared preferences

When a user selects the Scores menu item (the Info icon), the app displays the score for the current game and the high score for all games. (Refer to Figure 14-3.) The high score display applies to only one device — the device that's running the current game. To remember the high score from one run to another, I use Android's Shared Preferences feature.

Android provides several ways to store information from one run of an app to the next. In addition to using shared preferences, you can store information in the device's SQLite database. (Every Android device has SQLite database software.) You can also store information in an ordinary Linux file or on a network host of some kind.

Here's how you wield a set of shared preferences:

- **To create shared preferences, you call the activity's `getSharedPreferences` method.**

  In fact, the `getSharedPreferences` method belongs to Android's `Context` class, and the `Activity` class is a subclass of the `Context` class.

  In Listing 14-2, I call `getSharedPreferences` in the activity's `showScores` method. The call's parameter, `MODE_PRIVATE`, tells Android that no other app can read from or write to this app's shared preferences. (I know — there's nothing "shared" about something that no other app can use. But that's the way Android's terminology works.)

  Aside from `MODE_PRIVATE`, the alternatives are described in this list:

  - `MODE_WORLD_READABLE`: Other apps can read from these preferences.
  - `MODE_WORLD_WRITEABLE`: Other apps can write to these preferences.
  - `MODE_MULTI_PROCESS`: Other apps can write to these preferences even while an app is in the middle of a read operation. Weird things can happen with this much concurrency. If you use `MODE_MULTI_PROCESS`, watch out!

  You can combine modes with Java's bitwise *or* operator (`|`). A call such as

  ```
  getSharedPreferences(MODE_WORLD_READABLE | MODE_WORLD_WRITEABLE);
  ```

  makes your preferences both readable and writable for all other processes.

- **To start adding values to a set of shared preferences, you use an instance of the `SharedPreferences.Editor` class.**

  In Listing 14-2, I make a new editor object. Then I use the editor to add `("highScore", highScore)` to the shared preferences. Taken together, `("highScore", highScore)` is a *key/value pair.* The *value* (whatever number

my highscore variable holds) is the actual information. The *key* (the string "highScore") identifies that particular piece of information. (Every value has to have a key. Otherwise, if you've stored several different values in your app's shared preferences, you have no way to retrieve any particular value.)

In Listing 14-2, I call putInt to store an int value in shared preferences. Android's Editor class (an inner class of the SharedPreferences class) has methods such as putInt, putFloat, putString, and putStringSet.

» **To finish adding values to a set of shared preferences, you call the editor's commit method.**

In the showScores method in Listing 14-2, the statement editor.commit() does the job.

» **To read values from an existing set of shared preferences, you call getBoolean, getInt, getFloat, or one of the other get methods belonging to the SharedPreferences class.**

In the showScores method in Listing 14-2, the call to getInt takes two parameters. The first parameter (the string "highscore") is the key that identifies a particular piece of information. The second parameter (the int value 0) is a default value. So when you call prefs.getInt("highScore", 0), the following applies:

- If prefs has no pair with key "highscore", the method call returns 0.
- If prefs has a previously stored "highscore" value, the method returns that value.

Informing the user

Near the bottom of Figure 14-3, a capsule-shaped pop-up contains the words *Game Over.* Figure 14-4 has a similar pop-up. These pop-ups illustrate the use of Android's Toast class. A *toast* is an unobtrusive little view that displays some useful information for a brief period. A Toast view pops up on the screen the way a hot piece of bread pops up from a toaster. (Rumor has it that the Android class name Toast comes from this goofy analogy.)

The Toast class has two extremely useful methods: makeText and show.

» **The static Toast.makeText method creates an instance of the Toast class.**

The makeText method has three parameters:

- The first parameter is a context (the word this in the makeText calls in Listing 14-2).

- The second parameter is either a resource (such as `R.string.scores`) or a `String` expression (such as `"Game Over"`).

  If you call `makeText` with a `String` expression, the user sees the `String` when Android displays the toast. If you call `makeText` with a resource, Android looks for the resource in your project's *app*`/res/values/strings.xml` file. In Listing 14-2, the code calls `makeText` twice with a `String` expression in each call.


REMEMBER

  If you use an `int` value (42, for example) for the second parameter of the `makeText` method, Android doesn't display the characters *42* in the `Toast` view. Instead, Android looks for a resource whose value in `R.java` is 42. Your `R.java` file probably doesn't contain the number 42. So, instead of a `Toast` view, you get a `ResourceNotFound` exception. Your app crashes, and you groan in dismay.

- The `makeText` method's third parameter is either `Toast.LENGTH_LONG` or `Toast.LENGTH_SHORT`. With `LENGTH_LONG`, the `Toast` view appears for 3.5 seconds. With `LENGTH_SHORT`, the `Toast` view appears for 2 seconds.

» **The `show` method tells Android to display the `Toast` view.**

In Listing 14-2, notice that I call both `makeText` and `show` in one Java statement. If you forget to call the `show` method, the `Toast` view doesn't appear. You stare in disbelief wondering why you don't see the `Toast` view. ("Who stole my toast?" you ask.) When you finally figure out that you forgot to call the `show` method, you feel foolish. (At least that's the way I felt when I forgot earlier today.)


TIP

To display the `Toast` view for more than 3.5 seconds, put the `Toast` statement inside a loop. For example, to display the word *Hello* for ten seconds, use the following code:

```
for (int i = 0; i < 5; i++) {
  Toast.makeText(this, "Hello", Toast.LENGTH_SHORT).show();
}
```

It's Been Fun

This chapter has been fun, and this book has been fun! I love writing about Android and Java. And I love hearing from readers. Remember that you can send email to me at `java4android@allmycode.com`, and you can reach me on Twitter (`@allmycode`) and on Facebook (`/allmycode`).

Occasionally, I hear from a reader who says something like this: "If I read your whole book, will I know everything I have to know about Java?" The answer is always "No, no, no!" (That's not only one "no." It's "no" times three.) No matter what topic you study, there's always more to learn. So keep reading, keep practicing, keep learning, and, by all means, keep in touch.

5 The Part of Tens

IN THIS PART . . .

Preventing mistakes

Mining the web for more information

IN THIS CHAPTER

- Checking your capitalization and value comparisons
- Watching out for fall-through
- Putting methods, listeners, and constructors where they belong
- Using static and nonstatic references
- Avoiding other heinous errors

Chapter 15
Ten Ways to Avoid Mistakes

"The only people who never make mistakes are the people who never do anything at all." One of my college professors said that. I don't remember the professor's name, so I can't give him proper credit. I guess that's my mistake.

Putting Capital Letters Where They Belong

Java is a case-sensitive language, so you really have to mind your *p*s and *q*s — along with every other letter of the alphabet. Here are some concepts to keep in mind as you create Java programs:

- Java's keywords are all completely lowercase. For instance, in a Java `if` statement, the word *if* can't be *If* or *IF*.
- When you use names from Android's Application Programming Interface (API), the case of the names has to match what appears in the API.

» The names you make up yourself must be capitalized the same way throughout the entire program. If you declare a `myAccount` variable, you can't refer to it as `MyAccount`, `myaccount`, or `Myaccount`. If you capitalize the variable name two different ways, Java thinks you're referring to two completely different variables.

For more info on Java's case-sensitivity, see Chapter 4.

Breaking Out of a switch Statement

If you don't break out of a `switch` statement, you get fall-through. For instance, if the value of `roll` is `7`, the following code prints all three words — `win`, `continue`, and `lose`:

```
switch (roll) {
case 7:
  textView.setText("win");
case 10:
  textView.setText("continue");
case 12:
  textView.setText("lose");
}
```

For the full story, see Chapter 8.

Comparing Values with a Double Equal Sign

When you compare two values, you use a double equal sign. The line

```
if (inputNumber == randomNumber)
```

is correct, but the line

```
if (inputNumber = randomNumber)
```

is not correct. For a full report, see Chapter 5.

Adding Listeners to Handle Events

You want to know when the user clicks a widget, when an animation ends, or when something else happens, so you create listeners:

```
public class MainActivity extends Activity
    implements OnClickListener, AnimationListener {
  ...
  public void onClick(View view) {
    ...
  }
  public void onAnimationEnd(Animation animation) {
    ...
  }
```

When you create listeners, you must remember to set the listeners:

```
  ImageView widget = new ImageView(this);
  widget.setOnClickListener(this);
  ...
  AlphaAnimation animation = new AlphaAnimation(0.0F, 1.0F);
  animation.setAnimationListener(this);
  ...
```

If you forget the call to `setOnClickListener`, nothing happens when you click the widget. Clicking the widget harder a second time doesn't help.

For the rundown on listeners, see Chapter 11.

Defining the Required Constructors

When you define a constructor with parameters, as in

```
public Temperature(double number)
```

Java no longer creates a default parameterless constructor for you. In other words, you can no longer call

```
Temperature roomTemp = new Temperature();
```

unless you explicitly define your own parameterless `Temperature` constructor. For all the gory details on constructors, see Chapter 9.

Fixing Nonstatic References

If you try to compile the following code, you get an error message:

```
class WillNotWork {
  String greeting = "Hello";

  static void show() {
      textView.setText(greeting);
  }
}
```

You get an error message because the `show` method is static, but `greeting` isn't static. For the complete guide to finding and fixing this problem, see Chapter 9.

Staying within Bounds in an Array

When you declare an array with ten components, the components have indexes 0 through 9. In other words, if you declare

```
int guests[] = new int[10];
```

you can refer to the `guests` array's components by writing `guests[0]`, `guests[1]`, and so on, all the way up to `guests[9]`. You can't write `guests[10]`, because the `guests` array has no component with index 10.

For the latest gossip on arrays, see Chapter 12.

Anticipating Null Pointers

A `NullPointerException` comes about when you call a method on an expression that has no "legitimate" value. Here's an example:

```
public class MainActivity extends AppCompatActivity {
  TextView textView;
```

```
  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    // You forget the findViewById line.
  }

  public void onButtonClick(View view) {
      textView.setText("Hello");
  }
}
```

In Java, a reference type variable that doesn't point to anything has the value `null`. So in this example, the `textView` variable's value is `null`.

You can't call the `setText` method on the `null` value. For that matter, you can't call any method on the `null` value. When Java tries to execute `textView.setText("Hello")`, the app crashes. The user sees an *Application has stopped* message. If you're testing the app using Android Studio, you see `NullPointerException` in the Logcat pane.

To avoid this kind of calamity, think twice about any method call in your code. If the expression before the dot can possibly be `null`, add exception-handling code to your program:

```
public void onButtonClick(View view) {
  try {
    textView.setText("Hello");
  } catch(NullPointerException e) {
    Toast.makeText(this, "The app has recovered from an error.",
                                          Toast.LENGTH_LONG).show();
  }
}
```

For the story on handling exceptions, see Chapter 13.

Using Permissions

Some apps require explicit permissions. For example, the app in Chapter 13 talks to Twitter's servers over the Internet. This doesn't work unless you add a `<uses-permission>` element to the app's `AndroidManifest.xml` file:

```
<uses-permission android:name= "android.permission.INTERNET"/>
```

If you forget to add the `<uses-permission>` element to your `AndroidManifest.xml` file, the app can't communicate with Twitter's servers. The app fails without displaying a useful error message. Too bad!

The Activity Not Found

If you create a second activity for your app, you must add a new `<activity>` element in the app's `AndroidManifest.xml` file. The element can be as simple as

```
<activity android:name=".MySecondActivity"/>
```

but, in most cases, the element is a bit more complicated.

If you don't add this `<activity>` element, Android can't find the `MySecondActivity` class, even though the `MySecondAcitivity.java` file is in the app's project directory. Your app crashes with an `ActivityNotFoundException`.

And that makes all the difference.

IN THIS CHAPTER

- Checking out this book's website
- Finding resources from Oracle
- Reading more about Java

Chapter 16
Ten Websites for Developers

This chapter lists ten useful and fun websites. Each one has resources to help you use Java more effectively. And as far as I know, none of these sites uses adware or pop-ups or other grotesque programs.

This Book's Websites

For all matters related to the technical content of this book, visit `www.allmycode.com/Java4Android`.

For business issues (for example, "How can I purchase 100 copies of *Java Programming for Android Developers For Dummies*, 2nd Edition?"), simply go to `www.dummies.com` and type Java programming for Android developers in the Search box. If a list of titles is returned, click on the second edition of this book.

The Horse's Mouth

Oracle's official website for Java is `www.oracle.com/technetwork/java`.

Programmers and developers interested in sharing Java technology can go to `www.java.net`.

For everything an Android developer needs to know, visit `http://developer.android.com`.

Finding News and Reviews

For the latest info about Android, visit Android Authority at `www.androidauthority.com`.

For articles by the tech experts, visit The Server Side at `www.theserverside.com`, InfoQ at `www.infoq.com`, and TechCrunch at `http://techcrunch.com`.

For discussions by everyone (including many very smart people), visit JavaRanch at `www.javaranch.com`.

Check it out!

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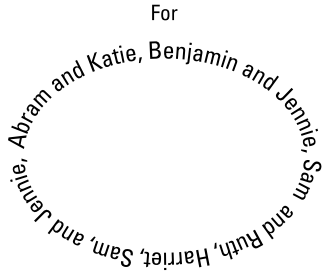
About the Author

Barry Burd received a master of science degree in computer science at Rutgers University and a PhD in mathematics at the University of Illinois. As a teaching assistant in Champaign-Urbana, Illinois, he was elected five times to the university-wide List of Teachers Ranked As Excellent By Their Students.

Since 1980, Dr. Burd has been a professor in the Department of Mathematics and Computer Science at Drew University in Madison, New Jersey. He has lectured at conferences in the United States, Europe, Australia, and Asia. He hosts podcasts and videos about software and other technology topics. He is the author of many articles and books, including *Java For Dummies*, *Beginning Programming with Java For Dummies*, and *Android Application Development All-in-One For Dummies*, all from Wiley.

Dr. Burd lives in Madison, New Jersey, with his wife of n years, where $n > 35$. In his spare time, he enjoys being a workaholic.

Dedication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Abram and Katie, Benjamin and Jennie, Sam and Ruth, Harriet, Sam, and Jennie

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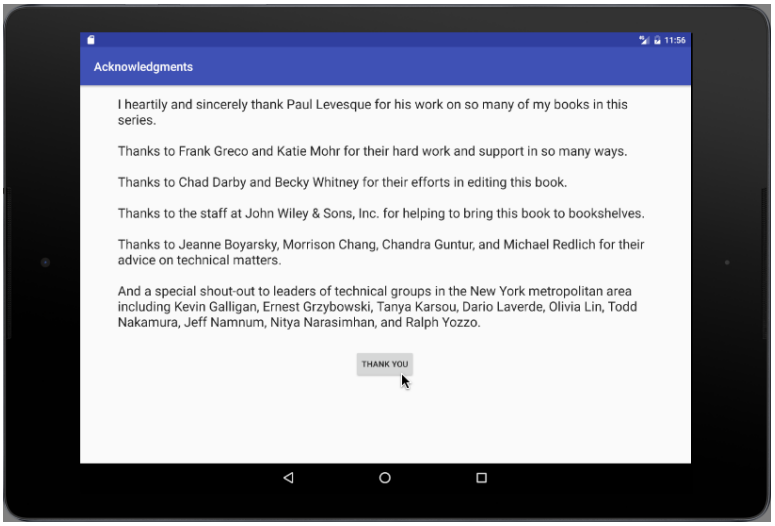

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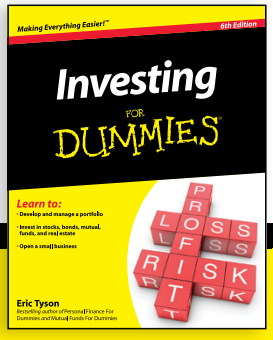

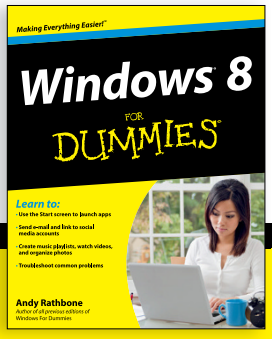

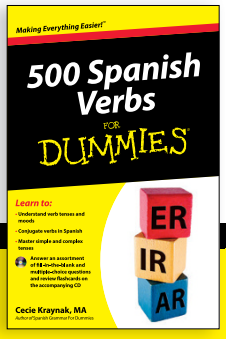

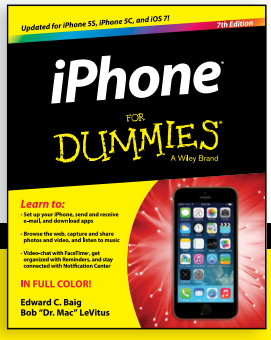

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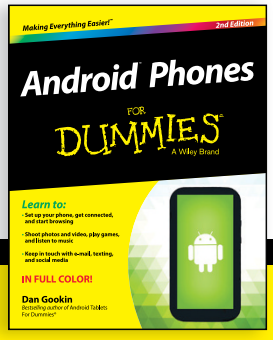

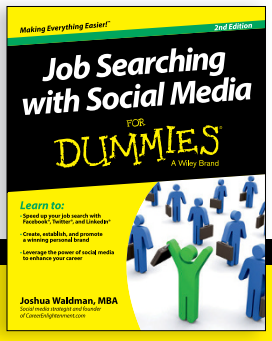

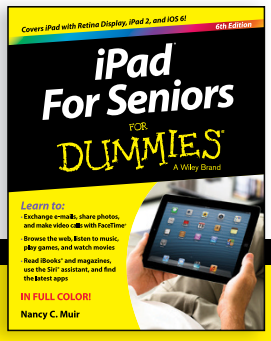

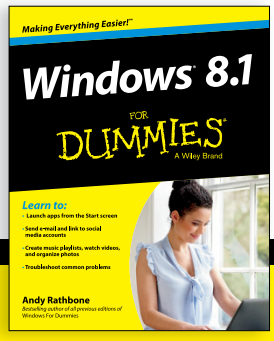

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