The Busy Coder's Guide to
Android
Development

Mark L. Murphy

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Preface

Welcome to the Book!

Thanks!

Thanks for your interest in developing applications for Android! Increasingly, people will access Internet-based services using so-called "non-traditional" means, such as mobile devices. The more we do in that space now, the more that people will help invest in that space to make it easier to build more powerful mobile applications in the future. Android is new – Android-powered devices appeared on the scene first in late 2008 – but it likely will rapidly grow in importance due to the size and scope of the Open Handset Alliance.

And, most of all, thanks for your interest in this book! I sincerely hope you find it useful and at least occasionally entertaining.

Prerequisites

If you are interested in programming for Android, you will need at least basic understanding of how to program in Java. Android programming is done using Java syntax, plus a class library that resembles a subset of the Java SE library (plus Android-specific extensions). If you have not programmed in Java before, you probably should learn how that works before attempting to dive into programming for Android. Here are a list of concepts in Java with which you should be familiar, with links to coverage of the concept in the Java programming WikiBook:

- Language fundamentals (flow control, etc.)
- Classes and objects
- Methods and data members
- Public, private, and protected access modifiers
- Static and instance scope
- Exceptions
- Threads and concurrency control
- Collections
- Generics
- File I/O
- Reflection
- Interfaces

The book does not cover in great detail how to download or install the Android development tools, either the Eclipse IDE flavor or the standalone flavor. The Android Web site covers this quite nicely. The material in the book should be relevant whether you use an IDE or not. You should download, install, and test out the Android development tools from the Android Web site before trying any of the examples listed in this book.

Some chapters may reference material in previous chapters, though usually with a link back to the preceding section of relevance. Also, not every sample shown has the complete source code in the book, lest this book get

too large. If you wish to compile the samples, download the source code from the CommonsWare Web site.

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- Typographical errors

- Sample applications that do not work as advertised, in the environment described in the book

- Factual errors that cannot be open to interpretation

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- Samples that do not work due to "shifting sands" of the underlying environment (e.g., changed APIs with new releases of an SDK)

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If you wish to use the source code from the CommonsWare Web site, bear in mind a few things:

1. The projects are set up to be built by Ant, not by Eclipse. If you wish to use the code with Eclipse, you will need to create a suitable Android Eclipse project and import the code and other assets.

2. You should delete build.xml, then run `android update project -p ...` (where ... is the path to a project of interest) on those projects you wish to use, so the build files are updated for your Android SDK version.

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Acknowledgments

I would like to thank the Android team, not only for putting out a good product, but for invaluable assistance on the Android Google Groups.

Icons used in the sample code were provided by the Nuvola icon set.

PART I – Core Concepts

The Big Picture

Android devices, by and large, will be mobile phones. While the Android technology is being discussed for use in other areas (e.g., car dashboard "PCs"), for the most part, you can think of Android as being used on phones.

For developers, this has benefits and drawbacks.

On the plus side, Android-style smartphones are sexy. Offering Internet services over mobile devices dates back to the mid-1990's and the Handheld Device Markup Language (HDML). However, only in recent years have phones capable of Internet access taken off. Now, thanks to trends like text messaging and to products like Apple's iPhone, phones that can serve as Internet access devices are rapidly gaining popularity. So, working on Android applications gives you experience with an interesting technology (Android) in a fast-moving market segment (Internet-enabled phones), which is always a good thing. Plus, Android is being deployed to tablets, televisions, and other types of products beyond phones.

The problem comes when you actually have to program the darn things.

Anyone with experience in programming for PDAs or phones has felt the pain of phones simply being *small* in all sorts of dimensions:

- Screens are small (you will not get comments like, "is that a 24-inch LCD in your pocket, or...?")

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- Keyboards, if they exist, are small

- Pointing devices, if they exist, are annoying (as anyone who has lost their stylus will tell you) or inexact (large fingers and "multi-touch" LCDs are not a good mix)

- CPU speed and memory are tight compared to desktops and servers you may be used to

- And so on

Moreover, applications running on a phone have to deal with the fact that they're *on a phone*.

People with mobile phones tend to get very irritated when those phones do not work. Similarly, those same people will get irritated at you if your program "breaks" their phone:

- ...by tying up the CPU such that calls can't be received

- ...by not working properly with the rest of the phone's OS, such that your application does not quietly fade to the background when a call comes in or needs to be placed

- ...by crashing the phone's operating system, such as by leaking memory like a sieve

Hence, developing programs for a phone is a different experience than developing desktop applications, Web sites, or back-end server processes. You wind up with different-looking tools, different-behaving frameworks, and "different than you are used to" limitations on what you can do with your program.

What Android tries to do is meet you halfway:

- You get a commonly-used programming language (Java) with some commonly used libraries (e.g., some Apache Commons APIs), with support for tools you may be used to (Eclipse)

- You get a fairly rigid and uncommon framework in which your programs need to run so they can be "good citizens" on the phone

and not interfere with other programs or the operation of the phone itself

As you might expect, much of this book deals with that framework and how you write programs that work within its confines and take advantage of its capabilities.

What Androids Are Made Of

When you write a desktop application, you are "master of your own domain". You launch your main window and any child windows – like dialog boxes – that are needed. From your standpoint, you are your own world, leveraging features supported by the operating system, but largely ignorant of any other program that may be running on the computer at the same time. If you do interact with other programs, it is typically through an API, such as using JDBC (or frameworks atop it) to communicate with MySQL or another database.

Android has similar concepts, but packaged differently, and structured to make phones more crash-resistant.

Activities

The building block of the user interface is the **activity**. You can think of an activity as being the Android analogue for the window or dialog in a desktop application.

While it is possible for activities to not have a user interface, most likely your "headless" code will be packaged in the form of content providers or services, described below.

Services

Activities are short-lived and can be shut down at any time. Services, on the other hand, are designed to keep running, if needed, independent of any

activity. You might use a service for checking for updates to an RSS feed, or to play back music even if the controlling activity is no longer operating.

Intents

Intents are system messages, running around the inside of the device, notifying applications of various events, from hardware state changes (e.g., an SD card was inserted), to incoming data (e.g., an SMS message arrived), to application events (e.g., your activity was launched from the device's main menu). Not only can you respond to intents, but you can create your own, to launch other activities, or to let you know when specific situations arise (e.g., raise such-and-so `Intent` when the user gets within 100 meters of this-and-such location).

Content Providers

Content providers provide a level of abstraction for any data stored on the device that is accessible by multiple applications. The Android development model encourages you to make your own data available to other applications, as well as your own – building a content provider lets you do that, while maintaining complete control over how your data gets accessed.

Stuff At Your Disposal

Storage

You can package data files with your application, for things that do not change, such as icons or help files. You also can carve out a small bit of space on the device itself, for databases or files containing user-entered or retrieved data needed by your application. And, if the user supplies bulk storage, like an SD card, you can read and write files on there as needed.

Network

Android devices will generally be Internet-ready, through one communications medium or another. You can take advantage of the Internet access at any level you wish, from raw Java sockets all the way up to a built-in WebKit-based Web browser widget you can embed in your application.

Multimedia

Android devices have the ability to play back and record audio and video. While the specifics may vary from device to device, you can query the device to learn its capabilities and then take advantage of the multimedia capabilities as you see fit, whether that is to play back music, take pictures with the camera, or use the microphone for audio note-taking.

GPS

Android devices will frequently have access to location providers, such as GPS, that can tell your applications where the device is on the face of the Earth. In turn, you can display maps or otherwise take advantage of the location data, such as tracking a device's movements if the device has been stolen.

Phone Services

And, of course, Android devices are typically phones, allowing your software to initiate calls, send and receive SMS messages, and everything else you expect from a modern bit of telephony technology.

Projects and Targets

As noted in the preface, this book assumes you have downloaded the SDK (and perhaps the ADT plugin for Eclipse) and have it basically working in your environment. That being said, this chapter covers what is involved in starting and building an Android application.

Pieces and Parts

To create an Android application, you will need to create a corresponding Android project. This could be an Eclipse project, if you are using Eclipse for Android development, or not. The project will hold all of your source code, "resources" (e.g., internationalized strings), third-party Java code (JARs), and related materials. The Android build tools, whether Eclipse-integrated or standalone, will then turn the contents of your project into an APK file, which is the Android application. Those tools will also help you get your APK onto an Android emulator or an actual Android device for testing purposes.

One key element of a project is the "manifest" (`AndroidManifest.xml`). This file contains the "table of contents" for your application, listing all of the major application components, permissions, and so on. The manifest is used by Android at runtime to tie your application into the operating system. The manifest contents are also used by the Android Market (and perhaps other independent "app stores"), so applications needing Android 2.0 will not be presented to people with Android 1.5 devices, and so on.

To test your application with the emulator, you will need to create an Android virtual device, or AVD. Most likely, you will create several of these, as each AVD emulates an Android device with a particular set of hardware. So you might have different AVDs for different screen sizes, or different AVDs for different Android versions, and so on.

When creating projects and creating AVDs, you will need to indicate to Android what "API level" you are working with. The API level is a simple integer that maps to an Android version, so API level 3 means Android 1.5, and so on. When creating a project, you will be able to tell Android the minimum and maximum API levels your application supports. When creating an AVD, you will tell Android which API level the AVD should emulate, so you can see how your application runs on different (fake) devices implementing different versions of Android.

All of these concepts will be described in greater detail later in this chapter.

Creating a Project

To create a project from the command line, for use with the command line build tools (e.g., `ant`), you will need to run the `android create project` command. This command takes a number of switches to indicate the Java package that the application's code will reside in, the API level the application is targeting, and so on. The result of running this command will be a directory containing all of the files necessary to build a "hello, world" Android application.

Here is an example of running `android create project`:

```
android create project --target 2 --path ./FirstApp --activity FirstApp
--package apt.tutorial
```

If you are intending on developing for Android using Eclipse, rather than `android create project`, you will use the Eclipse new-project wizard to create a new Android application.

The source code that accompanies this book was set up to be built using the command line build tools. It is possible to create empty Eclipse Android projects and import the code into those projects, should you wish to build any of the samples using Eclipse.

We will cover the notion of "targets" and "API levels" – which you will need to create your projects – later in this chapter.

Project Structure

The Android build system is organized around a specific directory tree structure for your Android project, much like any other Java project. The specifics, though, are fairly unique to Android and what it all does to prepare the actual application that will run on the device or emulator. Here's a quick primer on the project structure, to help you make sense of it all, particularly for the sample code referenced in this book.

Root Contents

When you create a new Android project (e.g., via `android create project`), you get several items in the project's root directory, including:

- `AndroidManifest.xml`, which is an XML file describing the application being built and what components – activities, services, etc. – are being supplied by that application

- `build.xml`, which is an Ant script for compiling the application and installing it on the device

- `default.properties` and `local.properties`, property files used by the Ant build script

- `assets/`, which hold other static files you wish packaged with the application for deployment onto the device

- `bin/`, which holds the application once it is compiled

- `gen/`, where Android's build tools will place source code that they generate

- `libs/`, which holds any third-party Java JARs your application requires

- `src/`, which holds the Java source code for the application

- `res/`, which holds "resources", such as icons, GUI layouts, and the like, that get packaged with the compiled Java in the application

The Sweat Off Your Brow

When you created the project (e.g., via `android create project`), you supplied the fully-qualified class name of the "main" activity for the application (e.g., `com.commonsware.android.SomeDemo`). You will then find that your project's `src/` tree already has the namespace directory tree in place, plus a stub `Activity` subclass representing your main activity (e.g., `src/com/commonsware/android/SomeDemo.java`). You are welcome to modify this file and add others to the `src/` tree as needed to implement your application.

The first time you compile the project (e.g., via `ant`), out in the "main" activity's namespace directory, the Android build chain will create `R.java`. This contains a number of constants tied to the various resources you placed out in the `res/` directory tree. You should not modify `R.java` yourself, letting the Android tools handle it for you. You will see throughout many of the samples where we reference things in `R.java` (e.g., referring to a layout's identifier via `R.layout.main`).

And Now, The Rest of the Story

You will also find that your project has a `res/` directory tree. This holds "resources" – static files that are packaged along with your application, either in their original form or, occasionally, in a preprocessed form. Some of the subdirectories you will find or create under `res/` include:

- `res/drawable/` for images (PNG, JPEG, etc.)

- `res/layout/` for XML-based UI layout specifications

- `res/menu/` for XML-based menu specifications

- `res/raw/` for general-purpose files (e.g,. a CSV file of account information)
- `res/values/` for strings, dimensions, and the like
- `res/xml/` for other general-purpose XML files you wish to ship

We will cover all of these, and more, in later chapters of this book.

What You Get Out Of It

When you compile your project (via `ant` or the IDE), the results go into the `bin/` directory under your project root. Specifically:

- `bin/classes/` holds the compiled Java classes
- `bin/classes.dex` holds the executable created from those compiled Java classes
- `bin/yourapp.ap_` holds your application's resources, packaged as a ZIP file (where `yourapp` is the name of your application)
- `bin/yourapp-*.apk` is the actual Android application (where * varies)

The `.apk` file is a ZIP archive containing the `.dex` file, the compiled edition of your resources (`resources.arsc`), any un-compiled resources (such as what you put in `res/raw/`) and the `AndroidManifest.xml` file. If you build a debug version of the application – which is the default – you will have `yourapp-debug.apk` and `yourapp-debug-aligned.apk` as two versions of your APK. The latter has been optimized with the `zipalign` utility to make it run faster.

Inside the Manifest

The foundation for any Android application is the manifest file: `AndroidManifest.xml` in the root of your project. Here is where you declare what is inside your application – the activities, the services, and so on. You also indicate how these pieces attach themselves to the overall Android

system; for example, you indicate which activity (or activities) should appear on the device's main menu (a.k.a., launcher).

When you create your application, you will get a starter manifest generated for you. For a simple application, offering a single activity and nothing else, the auto-generated manifest will probably work out fine, or perhaps require a few minor modifications. On the other end of the spectrum, the manifest file for the Android API demo suite is over 1,000 lines long. Your production Android applications will probably fall somewhere in the middle.

Most of the interesting bits of the manifest will be described in greater detail in the chapters on their associated Android features. For example, the `service` element will be described in greater detail in the chapter on creating services. For now, we just need to understand what the role of the manifest is and its general overall construction.

In The Beginning, There Was the Root, And It Was Good

The root of all manifest files is, not surprisingly, a `manifest` element:

```
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.commonsware.android.search">
...
</manifest>
```

Note the namespace declaration. Curiously, the generated manifests only apply it on the attributes, not the elements (e.g., it's `manifest`, not `android:manifest`). However, that pattern works, so unless Android changes, stick with their pattern.

The biggest piece of information you need to supply on the `manifest` element is the `package` attribute (also curiously not-namespaced). Here, you can provide the name of the Java package that will be considered the "base" of your application. Then, everywhere else in the manifest file that needs a class name, you can just substitute a leading dot as shorthand for the package. For example, if you needed to refer to

com.commonsware.android.search.Snicklefritz in this manifest shown above, you could just use .Snicklefritz, since com.commonsware.android.search is defined as the application's package.

Permissions, Instrumentations, and Applications (Oh, My!)

Underneath the manifest element, you will find:

- uses-permission elements, to indicate what permissions your application will need in order to function properly – see the chapter on permissions for more details

- permission elements, to declare permissions that activities or services might require other applications hold in order to use your application's data or logic – again, more details are forthcoming in the chapter on permissions

- instrumentation elements, to indicate code that should be invoked on key system events, such as starting up activities, for the purposes of logging or monitoring

- uses-library elements, to hook in optional Android components, such as mapping services

- possibly a uses-sdk element, to indicate what version of the Android SDK the application was built for

- an application element, defining the guts of the application that the manifest describes

```
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.commonsware.android">
  <uses-permission
    android:name="android.permission.ACCESS_LOCATION" />
  <uses-permission
    android:name="android.permission.ACCESS_GPS" />
  <uses-permission
    android:name="android.permission.ACCESS_ASSISTED_GPS" />
  <uses-permission
    android:name="android.permission.ACCESS_CELL_ID" />
  <application>
...
```

```
   </application>
</manifest>
```

In the preceding example, the manifest has `uses-permission` elements to indicate some device capabilities the application will need – in this case, permissions to allow the application to determine its current location. And, there is the `application` element, whose contents will describe the activities, services, and whatnot that make up the bulk of the application itself.

Permissions will be covered in greater detail later in this book.

One attribute of the `application` element that you may need in select circumstances is the `android:debuggable` attribute. This needs to be set to `true` if you are installing the application on an actual device and you are using Eclipse (or another debugger) and if your device precludes debugging without this flag. For example, the Nexus One requires `android:debuggable` = `"true"`, according to some reports.

Your Application Does Something, Right?

The children of the `application` element represent the core of the manifest file.

By default, when you create a new Android project, you get a single `activity` element:

```
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="com.commonsware.android.skeleton">
    <application>
        <activity android:name=".Now" android:label="Now">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
    </application>
</manifest>
```

This element supplies `android:name` for the class implementing the activity, `android:label` for the display name of the activity, and (frequently) an

intent-filter child element describing under what conditions this activity will be displayed. The stock activity element sets up your activity to appear in the launcher, so users can choose to run it. As we'll see later in this book, you can have several activities in one project, if you so choose.

You may also have one or more receiver elements, indicating non-activities that should be triggered under certain conditions, such as when an SMS message comes in.

You may have one or more provider elements, indicating content providers – components that supply data to your activities and, with your permission, other activities in other applications on the device. These wrap up databases or other data stores into a single API that any application can use.

Finally, you may have one or more service elements, describing services – long-running pieces of code that can operate independent of any activity. The quintessential example is the MP3 player, where you want the music to keep playing even if the user pops open other activities and the MP3 player's user interface is "misplaced".

Achieving the Minimum

Android, like most operating systems, goes through various revisions, versions, and changes. Some of these affect the Android SDK, meaning there are new classes, methods, or parameters you can use that you could not in previous versions of the SDK.

If you want to ensure your application is only run on devices that have a certain version (or higher) of the Android environment, you will want to add a uses-sdk element, as a child of the root <manifest> element in your AndroidManifest.xml file. The <uses-sdk> element has one attribute, minSdkVersion, indicating which SDK version your application requires:

```
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.commonsware.android.search">
  <uses-sdk android:minSdkVersion="2" />
```

```
  ...
</manifest>
```

At the time of this writing, there are many possible `minSdkVersion` values:

- 1, indicating the original Android 1.0 SDK

- 2, indicating the Android 1.1 SDK

- 3, indicating the Android 1.5 SDK

- 4, indicating the Android 1.6 SDK

- 5, indicating the Android 2.0 SDK

- 6, indicating the Android 2.0.1 SDK

- 7, indicating the Android 2.1 SDK

- 8, indicating the Android 2.2 SDK

If you leave the `<uses-sdk>` element out entirely, it will behave as though `minSdkVersion` is set to 1. Note, however, that the Android Market seems to insist that you specifically state your `minSdkVersion`, so be certain to have a proper `<uses-sdk>` element if you are going to distribute via that channel.

If you set `<uses-sdk>`, the application will only install on compatible devices. You do not have to specify the latest SDK, but if you choose an older one, it is up to you to ensure your application works on every SDK version you claim is compatible. For example, if you leave off `<uses-sdk>`, in effect, you are stipulating that your application works on every Android SDK version ever released, and it is up to you to test your application to determine if this is indeed the case.

Also note that a bug in the Android Market means you should make the `<uses-sdk>` element be the first child of your `<manifest>` element.

Version=Control

Particularly if you are going to distribute your application, via the Android Market or other means, you probably should add a pair of other attributes

---

to the root `<manifest>` element: `android:versionCode` and `android:versionName`. These assist in the process of upgrading applications.

The `android:versionName` attribute is some human-readable label for the version name or number of your application. So, you can use `"3.0"` or `"System V"` or `"5000"` or `"3.1"` as you see fit.

The `android:versionCode` attribute is a pure integer indication of the version of the application. This is used by the system to determine if one version of your application is newer than another – "newer" is defined as "has a higher `android:versionCode` value". Whether you attempt to convert your actual version (as found in `android:versionName`) to a number, or you simply increment this value by one for each release, is up to you.

Emulators and Targets

Let's take a moment to discuss the notion of "targets" in Android, since they can be a bit confusing yet are rather important for your long-term application development, particularly as it pertains to your use of the Android emulator for testing your applications.

Virtually There

To use the emulator, you will need to create one or more AVDs. These virtual devices are designed to mimic real Android devices like the T-Mobile G1 or the HTC Magic. You tell the emulator what AVD to use, and the emulator then can pretend it is the device described by that AVD.

When you create an AVD, whether through the `android create avd` command, via Eclipse, or via the AVD Manager (below), you need to specify a target. The target indicates what class of device the AVD will pretend to be. You can find out the available API targets via the `android list targets` command. For example, `android-6` as a target means Android 2.0.1 but without Google Maps support, whereas `Google Inc.:Google APIs:6` as a target means Android 2.0.1 with Google Maps support. The number `6` means API level 6, which corresponds to Android 2.0.1.

You can create as many AVDs as you need and that you have disk space for. Bear in mind, though, that each AVD behaves as a totally distinct device, so installing your app on one AVD does not affect any other AVDs that you have created.

Android 1.6 added a GUI interface for maintaining your AVDs, called the AVD Manager. Simply run the `android` command without any arguments. You will be presented with a list of AVDs already created, New... and Delete... buttons to add and remove AVDs, a Start... button to launch an emulator using a selected AVD, etc.

Figure 1. The AVD Manager GUI, showing a list of available AVDs

When you add an AVD through the GUI (via the New... button on the main window), you will be prompted for a name, target, details about an SD card image, and the size of screen you wish to emulate ("skin").
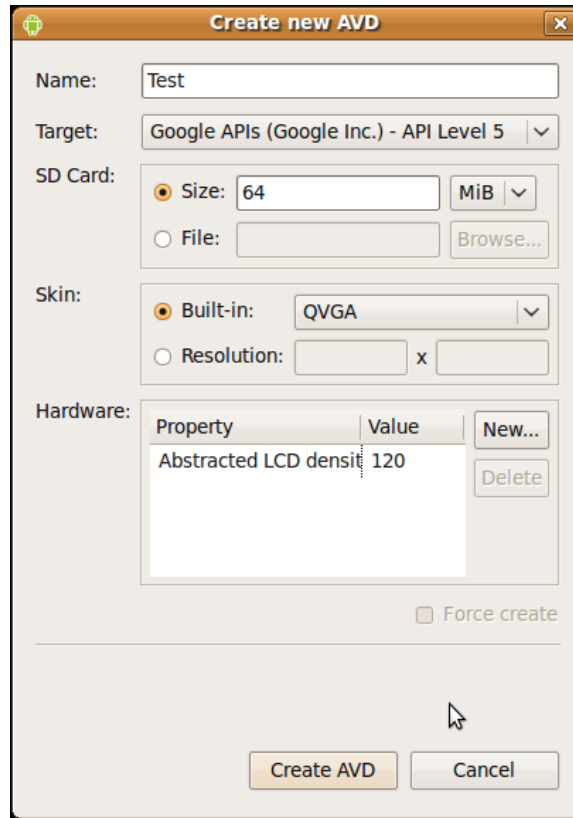
Figure 2. The Add AVD dialog

Aiming at a Target

Similarly, when you create a new project (via `android create project` or Eclipse), you will need to indicate what class of device this project targets. The same values shown above hold, so creating a project with a target of `android-3` indicates Android 1.5. This primarily drives what edition of the tools you use. You probably also want to later specify, in your AndroidManifest.xml file, what versions of Android you support in terms of devices that can run your application (e.g., what is the earliest Android version you are testing against?). This topic will be covered later in this book.

Here are some rules of thumb for dealing with targets:

- Only ask for what you really need. If you are sticking with Android 1.5 APIs, you may as well ask to build with Android 1.5 APIs and maximize the number of devices you can run on.

- Test on as many targets as you can and that are possible. For example, you may be tempted to target `android-1`, to reach the maximum possible range of Android devices. That is fine…but you need to test on a target `android-1` AVD, and a target `android-2` AVD, and so on. Right now, there are very few devices in the world using Android versions earlier than Android 1.5, so it is probably not worthwhile to target earlier versions.

- Check out the new target levels with each Android release. There should be a new value with every Android point-release update (e.g., 2.0 or 1.6), and possibly even for SDK patchlevels (e.g., 2.0 versus 2.0.1). Be sure to test your application on those new targets whenever you can, as some people may start getting devices with the new Android release soon.

- Testing on AVDs, regardless of target, is no substitute for testing on hardware. AVDs are designed to give you disposable environments that let you test a wide range of environments, even those that may not yet exist in hardware. However, you really need to test your application on at least one actual Android device. If nothing else, the speed of your emulator may not match the speed of the device – the emulator may be faster or slower depending on your system.

PART II – Activities

Creating a Skeleton Application

Every programming language or environment book starts off with the ever-popular "Hello, World!" demonstration: just enough of a program to prove you can build things, not so much that you cannot understand what is going on. However, the typical "Hello, World!" program has no interactivity (e.g., just dumps the words to a console), and so is really boring.

This chapter demonstrates a simple project, but one using Advanced Push-Button Technology™ and the current time, to show you how a simple Android activity works.

Begin at the Beginning

As described in the previous chapter, to work with anything in Android, you need a project. If you are using tools that are not Android-enabled, you can use the `android create project` script, found in the `tools/` directory in your SDK installation. You will need to pass to `android create project` the API target (see the previous chapter), the directory where you want the skeleton generated, the name of the default activity, and the Java package where all of this should reside:

```
android create project --target android-4 \
  --path /path/to/my/project/dir --activity Now \
  --package com.commonsware.android.skeleton
```

For the purposes of the samples shown in this book, you can download their project directories in a ZIP file on the CommonsWare Web site. These projects are ready for use; you do not need to run android create project on those unpacked samples.

The Activity

Your project's src/ directory contains the standard Java-style tree of directories based upon the Java package you chose when you created the project (e.g., com.commonsware.android results in src/com/commonsware/android/). Inside the innermost directory you should find a pre-generated source file named Now.java, which is where your first activity will go.

Open Now.java in your editor and paste in the following code:

```java
package com.commonsware.android.skeleton;

import android.app.Activity;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import java.util.Date;

public class Now extends Activity implements View.OnClickListener {
  Button btn;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);

    btn=new Button(this);
    btn.setOnClickListener(this);
    updateTime();
    setContentView(btn);
  }

  public void onClick(View view) {
    updateTime();
  }

  private void updateTime() {
    btn.setText(new Date().toString());
  }
}
```

Or, if you download the source files off the Web site, you can just use the Skeleton/Now project directly.

Dissecting the Activity

Let's examine this piece by piece:

```
package com.commonsware.android.skeleton;

import android.app.Activity;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import java.util.Date;
```

The package declaration needs to be the same as the one you used when creating the project. And, like any other Java project, you need to import any classes you reference. Most of the Android-specific classes are in the android package.

Remember that not every Java SE class is available to Android programs! Visit the Android class reference to see what is and is not available.

```
public class Now extends Activity implements View.OnClickListener {
  Button btn;
```

Activities are public classes, inheriting from the android.app.Activity base class. In this case, the activity holds a button (btn). Since, for simplicity, we want to trap all button clicks just within the activity itself, we also have the activity class implement OnClickListener.

```
@Override
public void onCreate(Bundle icicle) {
  super.onCreate(icicle);

  btn=new Button(this);
  btn.setOnClickListener(this);
  updateTime();
  setContentView(btn);
}
```

The onCreate() method is invoked when the activity is started. The first thing you should do is chain upward to the superclass, so the stock Android activity initialization can be done.

In our implementation, we then create the button instance (new Button(this)), tell it to send all button clicks to the activity instance itself (via setOnClickListener()), call a private updateTime() method (see below), and then set the activity's content view to be the button itself (via setContentView()).

We will discuss that magical Bundle icicle in a later chapter. For the moment, consider it an opaque handle that all activities receive upon creation.

```
public void onClick(View view) {
  updateTime();
}
```

In Swing, a JButton click raises an ActionEvent, which is passed to the ActionListener configured for the button. In Android, a button click causes onClick() to be invoked in the OnClickListener instance configured for the button. The listener is provided the view that triggered the click (in this case, the button). All we do here is call that private updateTime() method:

```
private void updateTime() {
  btn.setText(new Date().toString());
}
```

When we open the activity (onCreate()) or when the button is clicked (onClick()), we update the button's label to be the current time via setText(), which functions much the same as the JButton equivalent.

Building and Running the Activity

To build the activity, either use your IDE's built-in Android packaging tool, or run ant in the base directory of your project. Then, to run the activity:

- Launch the emulator by running the android command, choosing an AVD in the AVD Manager, and clicking the Start button. You should be able to accept the defaults on the Launch Options dialog. Note that the first time you use an AVD with the emulator, it will take substantially longer to start than it will subsequent times.
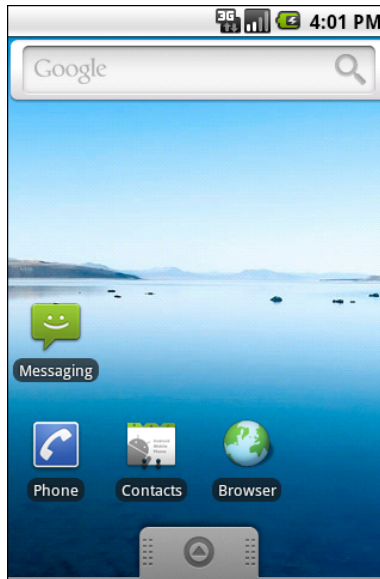
Figure 3. The Android home screen

- Install the package (e.g., run `ant install`)

- View the list of installed applications in the emulator and find the "Now" application
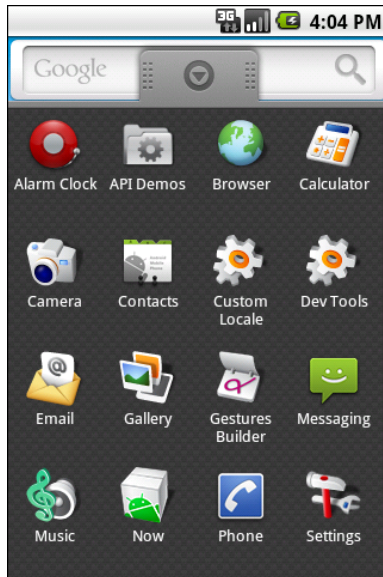
Figure 4. The Android application "launcher"

- Open that application

You should see an activity screen akin to:

Figure 5. The Now demonstration activity

Clicking the button – in other words, pretty much anywhere on the phone's screen – will update the time shown in the button's label.

Note that the label is centered horizontally and vertically, as those are the default styles applied to button captions. We can control that formatting, which will be covered in a later chapter.

After you are done gazing at the awesomeness of Advanced Push-Button Technology™, you can click the back button on the emulator to return to the launcher.

Using XML-Based Layouts

While it is technically possible to create and attach widgets to our activity purely through Java code, the way we did in the preceding chapter, the more common approach is to use an XML-based layout file. Dynamic instantiation of widgets is reserved for more complicated scenarios, where the widgets are not known at compile-time (e.g., populating a column of radio buttons based on data retrieved off the Internet).

With that in mind, it's time to break out the XML and learn how to lay out Android activity views that way.

What Is an XML-Based Layout?

As the name suggests, an XML-based layout is a specification of widgets' relationships to each other – and to containers – encoded in XML format. Specifically, Android considers XML-based layouts to be resources, and as such layout files are stored in the `res/layout` directory inside your Android project.

Each XML file contains a tree of elements specifying a layout of widgets and containers that make up one `View`. The attributes of the XML elements are properties, describing how a widget should look or how a container should behave. For example, if a `Button` element has an attribute value of `android:textStyle = "bold"`, that means that the text appearing on the face of the button should be rendered in a boldface font style.

Android's SDK ships with a tool (`aapt`) which uses the layouts. This tool should be automatically invoked by your Android tool chain (e.g., Eclipse, Ant's `build.xml`). Of particular importance to you as a developer is that `aapt` generates the `R.java` source file within your project's `gen/` directory, allowing you to access layouts and widgets within those layouts directly from your Java code, as will be demonstrated later in this chapter.

Why Use XML-Based Layouts?

Most everything you do using XML layout files can be achieved through Java code. For example, you could use `setTypeface()` to have a button render its text in bold, instead of using a property in an XML layout. Since XML layouts are yet another file for you to keep track of, we need good reasons for using such files.

Perhaps the biggest reason is to assist in the creation of tools for view definition, such as a GUI builder in an IDE like Eclipse or a dedicated Android GUI designer like DroidDraw. Such GUI builders could, in principle, generate Java code instead of XML. The challenge is re-reading the definition in to support edits – that is far simpler if the data is in a structured format like XML than in a programming language. Moreover, keeping the generated bits separated out from hand-written code makes it less likely that somebody's custom-crafted source will get clobbered by accident when the generated bits get re-generated. XML forms a nice middle ground between something that is easy for tool-writers to use and easy for programmers to work with by hand as needed.

Also, XML as a GUI definition format is becoming more commonplace. Microsoft's XAML, Adobe's Flex, Google's GWT, and Mozilla's XUL all take a similar approach to that of Android: put layout details in an XML file and put programming smarts in source files (e.g., Javascript for XUL). Many less-well-known GUI frameworks, such as ZK, also use XML for view definition. While "following the herd" is not necessarily the best policy, it does have the advantage of helping to ease the transition into Android from any other XML-centered view description language.

OK, So What Does It Look Like?

Here is the `Button` from the previous chapter's sample application, converted into an XML layout file, found in the `Layouts/NowRedux` sample project:

```
<?xml version="1.0" encoding="utf-8"?>
<Button xmlns:android="http://schemas.android.com/apk/res/android"
    android:id="@+id/button"
    android:text=""
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"/>
```

The class name of the widget – `Button` – forms the name of the XML element. Since `Button` is an Android-supplied widget, we can just use the bare class name. If you create your own widgets as subclasses of `android.view.View`, you would need to provide a full package declaration as well (e.g., `com.commonsware.android.MyWidget`).

The root element needs to declare the Android XML namespace:

```
xmlns:android="http://schemas.android.com/apk/res/android"
```

All other elements will be children of the root and will inherit that namespace declaration.

Because we want to reference this button from our Java code, we need to give it an identifier via the `android:id` attribute. We will cover this concept in greater detail later in this chapter.

The remaining attributes are properties of this `Button` instance:

- `android:text` indicates the initial text to be displayed on the button face (in this case, an empty string)

- `android:layout_width` and `android:layout_height` tell Android to have the button's width and height fill the "parent", in this case the entire screen – these attributes will be covered in greater detail in a later chapter

Since this single widget is the only content in our activity's view, we only need this single element. Complex views will require a whole tree of elements, representing the widgets and containers that control their positioning. All the remaining chapters of this book will use the XML layout form whenever practical, so there are dozens of other examples of more complex layouts for you to peruse.

What's With the @ Signs?

Many widgets and containers only need to appear in the XML layout file and do not need to be referenced in your Java code. For example, a static label (`TextView`) frequently only needs to be in the layout file to indicate where it should appear. These sorts of elements in the XML file do not need to have the `android:id` attribute to give them a name.

Anything you *do* want to use in your Java source, though, needs an `android:id`.

The convention is to use `@+id/...` as the `id` value, where the ... represents your locally-unique name for the widget in question, for the first occurrence of a given `id` value in your layout file. The second and subsequent occurrences in the same layout file should drop the + sign – a feature we will use in an upcoming chapter. In the XML layout example in the preceding section, `@+id/button` is the identifier for the `Button` widget.

Android provides a few special `android:id` values, of the form `@android:id/...` – we will see some of these in various chapters of this book.

And We Attach These to the Java...How?

Given that you have painstakingly set up the widgets and containers for your view in an XML layout file named `main.xml` stored in `res/layout`, all you need is one statement in your activity's `onCreate()` callback to use that layout:

```
setContentView(R.layout.main);
```

This is the same `setContentView()` we used earlier, passing it an instance of a `View` subclass (in that case, a `Button`). The Android-built `View`, constructed from our layout, is accessed from that code-generated `R` class. All of the layouts are accessible under `R.layout`, keyed by the base name of the layout file – `res/layout/main.xml` results in `R.layout.main`.

To access our identified widgets, use `findViewById()`, passing it the numeric identifier of the widget in question. That numeric identifier was generated by Android in the `R` class as `R.id.something` (where `something` is the specific widget you are seeking). Those widgets are simply subclasses of `View`, just like the `Button` instance we created in the previous chapter.

The Rest of the Story

In the original `Now` demo, the button's face would show the current time, which would reflect when the button was last pushed (or when the activity was first shown, if the button had not yet been pushed).

Most of that logic still works, even in this revised demo (`NowRedux`). However, rather than instantiating the `Button` in our activity's `onCreate()` callback, we can reference the one from the XML layout:

```java
package com.commonsware.android.layouts;

import android.app.Activity;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import java.util.Date;

public class NowRedux extends Activity
  implements View.OnClickListener {
  Button btn;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);

    setContentView(R.layout.main);

    btn=(Button)findViewById(R.id.button);
    btn.setOnClickListener(this);
    updateTime();
```

35

```
  }

  public void onClick(View view) {
    updateTime();
  }

  private void updateTime() {
    btn.setText(new Date().toString());
  }
}
```

The first difference is that rather than setting the content view to be a view we created in Java code, we set it to reference the XML layout (setContentView(R.layout.main)). The R.java source file will be updated when we rebuild this project to include a reference to our layout file (stored as main.xml in our project's res/layout directory).

The other difference is that we need to get our hands on our Button instance, for which we use the findViewById() call. Since we identified our button as @+id/button, we can reference the button's identifier as R.id.button. Now, with the Button instance in hand, we can set the callback and set the label as needed.

The results look the same as with the original Now demo:

Figure 6. The NowRedux sample activity

Employing Basic Widgets

Every GUI toolkit has some basic widgets: fields, labels, buttons, etc. Android's toolkit is no different in scope, and the basic widgets will provide a good introduction as to how widgets work in Android activities.

Assigning Labels

The simplest widget is the label, referred to in Android as a `TextView`. Like in most GUI toolkits, labels are bits of text not editable directly by users. Typically, they are used to identify adjacent widgets (e.g., a "Name:" label before a field where one fills in a name).

In Java, you can create a label by creating a `TextView` instance. More commonly, though, you will create labels in XML layout files by adding a `TextView` element to the layout, with an `android:text` property to set the value of the label itself. If you need to swap labels based on certain criteria, such as internationalization, you may wish to use a string resource reference in the XML instead, as will be described later in this book.

`TextView` has numerous other properties of relevance for labels, such as:

- `android:typeface` to set the typeface to use for the label (e.g., `monospace`)

- `android:textStyle` to indicate that the typeface should be made bold (`bold`), italic (`italic`), or bold and italic (`bold_italic`)

- android:textColor to set the color of the label's text, in RGB hex format (e.g., #FF0000 for red)

For example, in the Basic/Label project, you will find the following layout file:

```
<?xml version="1.0" encoding="utf-8"?>
<TextView xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="wrap_content"
  android:text="You were expecting something profound?"
  />
```

Just that layout alone, with the stub Java source provided by Android's project builder (e.g., android create project), gives you:
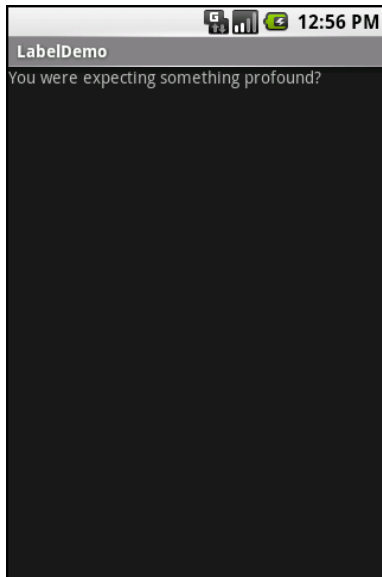
Figure 7. The LabelDemo sample application

Button, Button, Who's Got the Button?

We've already seen the use of the Button widget in the previous two chapters. As it turns out, Button is a subclass of TextView, so everything

discussed in the preceding section in terms of formatting the face of the button still holds.

However, Android 1.6 added a new feature for the declaration of the "on-click" listener for a `Button`. In addition to the classic approach of defining some object (such as the activity) as implementing the `View.OnClickListener` interface, you can now take a somewhat simpler approach:

- Define some method on your `Activity` that holds the button that takes a single `View` parameter, has a `void` return value, and is `public`

- In your layout XML, on the `Button` element, include the `android:onClick` attribute with the name of the method you defined in the previous step

For example, we might have a method on our `Activity` that looks like:

```
public void someMethod(View theButton) {
 // do something useful here
}
```

Then, we could use this XML declaration for the `Button` itself, including `android:onClick`:

```
<Button
 android:onClick="someMethod"
 ...
/>
```

This is enough for Android to "wire together" the `Button` with the click handler.

Fleeting Images

Android has two widgets to help you embed images in your activities: `ImageView` and `ImageButton`. As the names suggest, they are image-based analogues to `TextView` and `Button`, respectively.

Each widget takes an `android:src` attribute (in an XML layout) to specify what picture to use. These usually reference a drawable resource, described in greater detail in the chapter on resources.

`ImageButton`, a subclass of `ImageView`, mixes in the standard `Button` behaviors, for responding to clicks and whatnot.

For example, take a peek at the `main.xml` layout from the `Basic/ImageView` sample project:

```
<?xml version="1.0" encoding="utf-8"?>
<ImageView xmlns:android="http://schemas.android.com/apk/res/android"
    android:id="@+id/icon"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:adjustViewBounds="true"
    android:src="@drawable/molecule"
    />
```

The result, just using the code-generated activity, is simply the image:
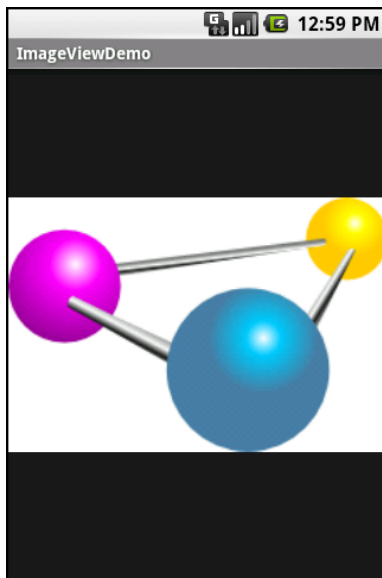
Figure 8. The ImageViewDemo sample application

Fields of Green. Or Other Colors.

Along with buttons and labels, fields are the third "anchor" of most GUI toolkits. In Android, they are implemented via the `EditText` widget, which is a subclass of the `TextView` used for labels.

Along with the standard `TextView` properties (e.g., `android:textStyle`), `EditText` has many others that will be useful for you in constructing fields, including:

- `android:autoText`, to control if the field should provide automatic spelling assistance

- `android:capitalize`, to control if the field should automatically capitalize the first letter of entered text (e.g., first name, city)

- `android:digits`, to configure the field to accept only certain digits

- `android:singleLine`, to control if the field is for single-line input or multiple-line input (e.g., does <Enter> move you to the next widget or add a newline?)

Most of those are also available from the new `android:inputType` attribute, added in Android 1.5 as part of adding "soft keyboards" to Android – this will be discussed in an upcoming chapter.

For example, from the `Basic/Field` project, here is an XML layout file showing an `EditText`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<EditText xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/field"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:singleLine="false"
  />
```

Note that `android:singleLine` is false, so users will be able to enter in several lines of text.

For this project, the `FieldDemo.java` file populates the input field with some prose:

```
package com.commonsware.android.field;

import android.app.Activity;
import android.os.Bundle;
import android.widget.EditText;

public class FieldDemo extends Activity {
  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    EditText fld=(EditText)findViewById(R.id.field);
    fld.setText("Licensed under the Apache License, Version 2.0 " +
            "(the \"License\"); you may not use this file " +
            "except in compliance with the License. You may " +
            "obtain a copy of the License at " +
            "http://www.apache.org/licenses/LICENSE-2.0");
  }
}
```

The result, once built and installed into the emulator, is:
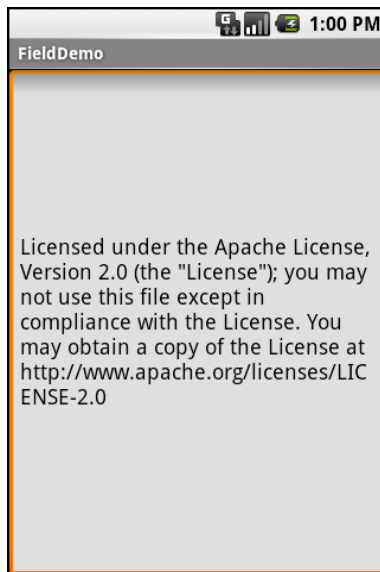
Figure 9. The FieldDemo sample application

Another flavor of field is one that offers auto-completion, to help users supply a value without typing in the whole text. That is provided in Android as the `AutoCompleteTextView` widget, discussed in greater detail later in this book.

Just Another Box to Check

The classic checkbox has two states: checked and unchecked. Clicking the checkbox toggles between those states to indicate a choice (e.g., "Add rush delivery to my order").

In Android, there is a `CheckBox` widget to meet this need. It has `TextView` as an ancestor, so you can use `TextView` properties like `android:textColor` to format the widget.

Within Java, you can invoke:

- `isChecked()` to determine if the checkbox has been checked
- `setChecked()` to force the checkbox into a checked or unchecked state
- `toggle()` to toggle the checkbox as if the user checked it

Also, you can register a listener object (in this case, an instance of `OnCheckedChangeListener`) to be notified when the state of the checkbox changes.

For example, from the `Basic/CheckBox` project, here is a simple checkbox layout:

```
<?xml version="1.0" encoding="utf-8"?>
<CheckBox xmlns:android="http://schemas.android.com/apk/res/android"
    android:id="@+id/check"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:text="This checkbox is: unchecked" />
```

The corresponding `CheckBoxDemo.java` retrieves and configures the behavior of the checkbox:

```java
public class CheckBoxDemo extends Activity
  implements CompoundButton.OnCheckedChangeListener {
  CheckBox cb;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    cb=(CheckBox)findViewById(R.id.check);
    cb.setOnCheckedChangeListener(this);
  }

  public void onCheckedChanged(CompoundButton buttonView,
                                boolean isChecked) {
    if (isChecked) {
      cb.setText("This checkbox is: checked");
    }
    else {
      cb.setText("This checkbox is: unchecked");
    }
  }
}
```

Note that the activity serves as its own listener for checkbox state changes since it implements the `OnCheckedChangeListener` interface (via `cb.setOnCheckedChangeListener(this)`). The callback for the listener is `onCheckedChanged()`, which receives the checkbox whose state has changed and what the new state is. In this case, we update the text of the checkbox to reflect what the actual box contains.

The result? Clicking the checkbox immediately updates its text, as shown below:
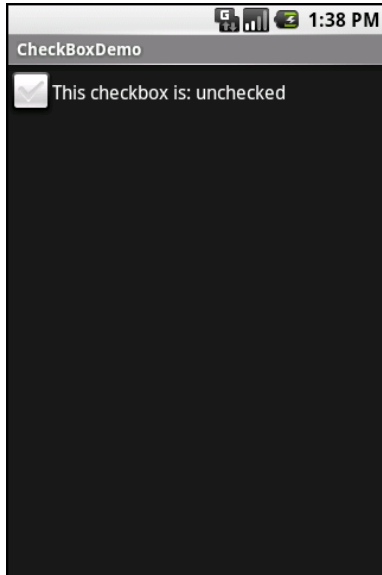
Figure 10. The CheckBoxDemo sample application, with the checkbox unchecked
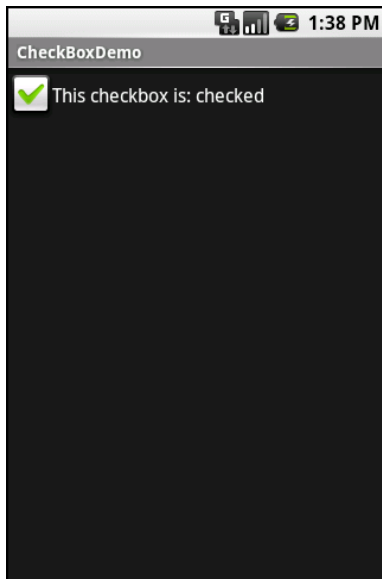
Figure 11. The same application, now with the checkbox checked

Turn the Radio Up

As with other implementations of radio buttons in other toolkits, Android's radio buttons are two-state, like checkboxes, but can be grouped such that only one radio button in the group can be checked at any time.

Like `CheckBox`, `RadioButton` inherits from `CompoundButton`, which in turn inherits from `TextView`. Hence, all the standard `TextView` properties for font face, style, color, etc. are available for controlling the look of radio buttons. Similarly, you can call `isChecked()` on a `RadioButton` to see if it is selected, `toggle()` to select it, and so on, like you can with a `CheckBox`.

Most times, you will want to put your `RadioButton` widgets inside of a `RadioGroup`. The `RadioGroup` indicates a set of radio buttons whose state is tied, meaning only one button out of the group can be selected at any time. If you assign an `android:id` to your `RadioGroup` in your XML layout, you can access the group from your Java code and invoke:

- `check()` to check a specific radio button via its ID (e.g., `group.check(R.id.radio1)`)

- `clearCheck()` to clear all radio buttons, so none in the group are checked

- `getCheckedRadioButtonId()` to get the ID of the currently-checked radio button (or `-1` if none are checked)

Note that the mutual-exclusion feature of `RadioGroup` only applies to `RadioButton` widgets that are immediate children of the `RadioGroup`. You cannot have other containers – discussed in the next chapter – between the `RadioGroup` and its `RadioButton` widgets.

For example, from the `Basic/RadioButton` sample application, here is an XML layout showing a `RadioGroup` wrapping a set of `RadioButton` widgets:

```
<?xml version="1.0" encoding="utf-8"?>
<RadioGroup
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
```

```
  android:layout_height="fill_parent"
  >
    <RadioButton android:id="@+id/radio1"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:text="Rock" />

    <RadioButton android:id="@+id/radio2"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:text="Scissors" />

    <RadioButton android:id="@+id/radio3"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:text="Paper" />
</RadioGroup>
```

Using the stock Android-generated Java for the project and this layout, you get:
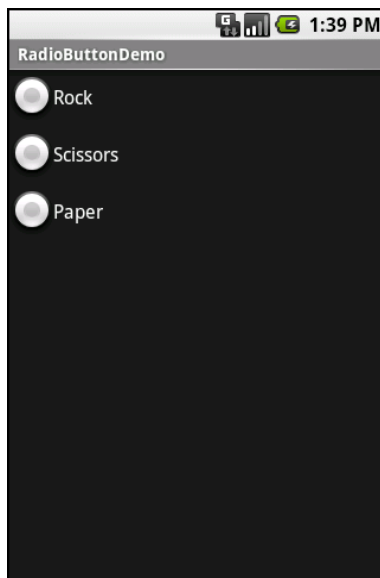
Figure 12. The RadioButtonDemo sample application

Note that the radio button group is initially set to be completely unchecked at the outset. To preset one of the radio buttons to be checked, use either `setChecked()` on the `RadioButton` or `check()` on the `RadioGroup` from within your `onCreate()` callback in your activity.

It's Quite a View

All widgets, including the ones shown above, extend `View`, and as such give all widgets an array of useful properties and methods beyond those already described.

Padding

Widgets have a minimum size, one that may be influenced by what is inside of them. So, for example, a `Button` will expand to accommodate the size of its caption. You can control this size using padding. Adding padding will increase the space between the contents (e.g., the caption of a `Button`) and the edges of the widget.

Padding can be set once in XML for all four sides (`android:padding`) or on a per-side basis (`android:paddingLeft`, etc.). Padding can also be set in Java via the `setPadding()` method.

The value of any of these is a dimension – a combination of a unit of measure and a count. So, `5px` is 5 pixels, or `2mm` is 2 millimeters. We will examine dimension in greater detail in an upcoming chapter.

Other Useful Properties

In addition to those presented in this chapter and in the next chapter, some of the properties on `View` most likely to be used include:

- Controls the focus sequence:
    - `android:nextFocusDown`
    - `android:nextFocusLeft`
    - `android:nextFocusRight`
    - `android:nextFocusUp`
- `android:visibility`, which controls whether the widget is initially visible

Useful Methods

You can toggle whether or not a widget is enabled via `setEnabled()` and see if it is enabled via `isEnabled()`. One common use pattern for this is to disable some widgets based on a `CheckBox` or `RadioButton` selection.

You can give a widget focus via `requestFocus()` and see if it is focused via `isFocused()`. You might use this in concert with disabling widgets as mentioned above, to ensure the proper widget has the focus once your disabling operation is complete.

To help navigate the tree of widgets and containers that make up an activity's overall view, you can use:

- `getParent()` to find the parent widget or container

- `findViewById()` to find a child widget with a certain ID

- `getRootView()` to get the root of the tree (e.g., what you provided to the activity via `setContentView()`)

Colors

There are two types of color attributes in Android widgets. Some, like `android:background`, take a single color (or a graphic image to serve as the background). Others, like `android:textColor` on `TextView` (and subclasses) can take a `ColorStateList`, including via the Java setter (in this case, `setTextColor()`).

A `ColorStateList` allows you to specify different colors for different conditions. For example, when you get to selection widgets in an upcoming chapter, you will see how a `TextView` has a different text color when it is the selected item in a list compared to when it is in the list but not selected. This is handled via the default `ColorStateList` associated with `TextView`.

If you wish to change the color of a `TextView` widget in Java code, you have two main choices:

1. Use `ColorStateList.valueOf()`, which returns a `ColorStateList` in which all states are considered to have the same color, which you supply as the parameter to the `valueOf()` method. This is the Java equivalent of the `android:textColor` approach, to make the `TextView` always a specific color regardless of circumstances.

2. Create a `ColorStateList` with different values for different states, either via the constructor or via an XML drawable resource, a concept discussed in a later chapter

CHAPTER 6

Working with Containers

Containers pour a collection of widgets (and possibly child containers) into specific structures you like. If you want a form with labels on the left and fields on the right, you will need a container. If you want OK and Cancel buttons to be beneath the rest of the form, next to one another, and flush to right side of the screen, you will need a container. Just from a pure XML perspective, if you have multiple widgets (beyond `RadioButton` widgets in a `RadioGroup`), you will need a container just to have a root element to place the widgets inside.

Most GUI toolkits have some notion of layout management, frequently organized into containers. In Java/Swing, for example, you have layout managers like `BoxLayout` and containers that use them (e.g., `Box`). Some toolkits stick strictly to the box model, such as XUL and Flex, figuring that any desired layout can be achieved through the right combination of nested boxes.

Android, through `LinearLayout`, also offers a "box" model, but in addition supports a range of containers providing different layout rules. In this chapter, we will look at three commonly-used containers: `LinearLayout` (the box model), `RelativeLayout` (a rule-based model), and `TableLayout` (the grid model), along with `ScrollView`, a container designed to assist with implementing scrolling containers.

Thinking Linearly

As noted above, LinearLayout is a box model – widgets or child containers are lined up in a column or row, one after the next. This works similar to FlowLayout in Java/Swing, vbox and hbox in Flex and XUL, etc.

Flex and XUL use the box as their primary unit of layout. If you want, you can use LinearLayout in much the same way, eschewing some of the other containers. Getting the visual representation you want is mostly a matter of identifying where boxes should nest and what properties those boxes should have, such as alignment vis a vis other boxes.

Concepts and Properties

To configure a LinearLayout, you have five main areas of control besides the container's contents: the orientation, the fill model, the weight, the gravity, and the padding.

Orientation

Orientation indicates whether the LinearLayout represents a row or a column. Just add the android:orientation property to your LinearLayout element in your XML layout, setting the value to be horizontal for a row or vertical for a column.

The orientation can be modified at runtime by invoking setOrientation() on the LinearLayout, supplying it either HORIZONTAL or VERTICAL.

Fill Model

Let's imagine a row of widgets, such as a pair of radio buttons. These widgets have a "natural" size based on their text. Their combined sizes probably do not exactly match the width of the Android device's screen – particularly since screens come in various sizes. We then have the issue of what to do with the remaining space.

All widgets inside a `LinearLayout` must supply `android:layout_width` and `android:layout_height` properties to help address this issue. These properties' values have three flavors:

- You can provide a specific dimension, such as `125px` to indicate the widget should take up exactly 125 pixels

- You can provide `wrap_content`, which means the widget should fill up its natural space, unless that is too big, in which case Android can use word-wrap as needed to make it fit

- You can provide `fill_parent`, which means the widget should fill up all available space in its enclosing container, after all other widgets are taken care of

The latter two flavors are the most common, as they are independent of screen size, allowing Android to adjust your view to fit the available space.

NOTE: In API level 8 (Android 2.2), `fill_parent` was renamed to `match_parent`, for unknown reasons. You can still use `fill_parent`, as it will be supported for the foreseeable future. However, at such point in time as you are only supporting API level 8 or higher (e.g., `android:minSdkVersion="8"` in your manifest), you should probably switch over to `match_parent`.

Weight

But, what happens if we have two widgets that should split the available free space? For example, suppose we have two multi-line fields in a column, and we want them to take up the remaining space in the column after all other widgets have been allocated their space.

To make this work, in addition to setting `android:layout_width` (for rows) or `android:layout_height` (for columns) to `fill_parent`, you must also set `android:layout_weight`. This property indicates what proportion of the free space should go to that widget. If you set `android:layout_weight` to be the same non-zero value for a pair of widgets (e.g., `1`), the free space will be split evenly between them. If you set it to be `1` for one widget and `2` for

another widget, the second widget will use up twice the free space that the first widget does. And so on.

The weight for a widget is zero by default.

Another pattern for using weights is if you want to allocate sizes on a percentage basis. To use this technique for, say, a horizontal layout:

- Set all the `android:layout_width` values to be `0` for the widgets in the layout
- Set the `android:layout_weight` values to be the desired percentage size for each widget in the layout
- Make sure all those weights add up to `100`

Gravity

By default, everything in a `LinearLayout` is left- and top-aligned. So, if you create a row of widgets via a horizontal `LinearLayout`, the row will start flush on the left side of the screen.

If that is not what you want, you need to specify a gravity. Using `android:layout_gravity` on a widget (or calling `setGravity()` at runtime on the widget's Java object), you can tell the widget and its container how to align it vis a vis the screen.

For a column of widgets, common gravity values are `left`, `center_horizontal`, and `right` for left-aligned, centered, and right-aligned widgets respectively.

For a row of widgets, the default is for them to be aligned so their texts are aligned on the baseline (the invisible line that letters seem to "sit on"), though you may wish to specify a gravity of `center_vertical` to center the widgets along the row's vertical midpoint.

Margins

By default, widgets are tightly packed, one next to the other. You can control this via the use of margins, a concept that is reminiscent of the padding described in a previous chapter.

The difference between padding and margins comes in terms of the background. Widgets with a transparent background – like the default look of a TextView – padding and margins have similar visual effect, increasing the space between the widget and adjacent widgets. However, widgets with a non-transparent background – like a Button – padding is considered inside the background while margins are outside. In other words, adding padding will increase the space between the contents (e.g., the caption of a Button) and the edges, while adding margin increases the empty space between the edges and adjacent widgets.

Margins can be set in XML, though only on a per-side basis (android:layout_marginTop). Once again, the value of any of these is a dimension – a combination of a unit of measure and a count, such as 5px for 5 pixels.

Example

Let's look at an example (Containers/Linear) that shows LinearLayout properties set both in the XML layout file and at runtime.

Here is the layout:

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <RadioGroup android:id="@+id/orientation"
    android:orientation="horizontal"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:padding="5px">
```

```
    <RadioButton
      android:id="@+id/horizontal"
      android:text="horizontal" />
    <RadioButton
      android:id="@+id/vertical"
      android:text="vertical" />
  </RadioGroup>
  <RadioGroup android:id="@+id/gravity"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:padding="5px">
    <RadioButton
      android:id="@+id/left"
      android:text="left" />
    <RadioButton
      android:id="@+id/center"
      android:text="center" />
    <RadioButton
      android:id="@+id/right"
      android:text="right" />
  </RadioGroup>
</LinearLayout>
```

Note that we have a LinearLayout wrapping two RadioGroup sets. RadioGroup is a subclass of LinearLayout, so our example demonstrates nested boxes as if they were all LinearLayout containers.

The top RadioGroup sets up a row (android:orientation = "horizontal") of RadioButton widgets. The RadioGroup has 5px of padding on all sides, separating it from the other RadioGroup. The width and height are both set to wrap_content, so the radio buttons will only take up the space that they need.

The bottom RadioGroup is a column (android:orientation = "vertical") of three RadioButton widgets. Again, we have 5px of padding on all sides and a "natural" height (android:layout_height = "wrap_content"). However, we have set android:layout_width to be fill_parent, meaning the column of radio buttons "claims" the entire width of the screen.

To adjust these settings at runtime based on user input, we need some Java code:

```
package com.commonsware.android.linear;

import android.app.Activity;
import android.os.Bundle;
import android.view.Gravity;
import android.text.TextWatcher;
import android.widget.LinearLayout;
import android.widget.RadioGroup;
import android.widget.EditText;

public class LinearLayoutDemo extends Activity
  implements RadioGroup.OnCheckedChangeListener {
  RadioGroup orientation;
  RadioGroup gravity;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    orientation=(RadioGroup)findViewById(R.id.orientation);
    orientation.setOnCheckedChangeListener(this);
    gravity=(RadioGroup)findViewById(R.id.gravity);
    gravity.setOnCheckedChangeListener(this);
  }

  public void onCheckedChanged(RadioGroup group, int checkedId) {
    switch (checkedId) {
      case R.id.horizontal:
        orientation.setOrientation(LinearLayout.HORIZONTAL);
        break;

      case R.id.vertical:
        orientation.setOrientation(LinearLayout.VERTICAL);
        break;

      case R.id.left:
        gravity.setGravity(Gravity.LEFT);
        break;

      case R.id.center:
        gravity.setGravity(Gravity.CENTER_HORIZONTAL);
        break;

      case R.id.right:
        gravity.setGravity(Gravity.RIGHT);
        break;
    }
  }
}
```

In onCreate(), we look up our two RadioGroup containers and register a listener on each, so we are notified when the radio buttons change state

(setOnCheckedChangeListener(this)). Since the activity implements OnCheckedChangeListener, the activity itself is the listener.

In onCheckedChanged() (the callback for the listener), we see which RadioButton had a state change. Based on the clicked-upon item, we adjust either the orientation of the first LinearLayout or the gravity of the second LinearLayout.

Here is the result when it is first launched inside the emulator:
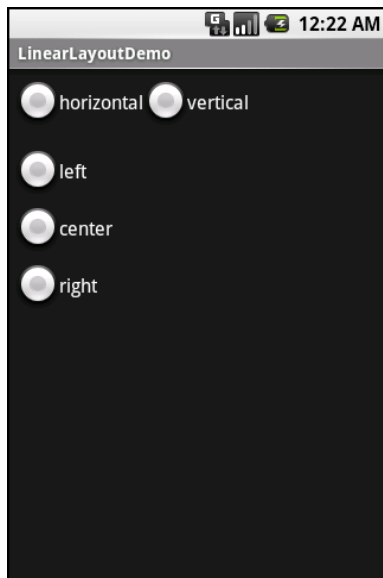
Figure 13. The LinearLayoutDemo sample application, as initially launched

If we toggle on the "vertical" radio button, the top RadioGroup adjusts to match:
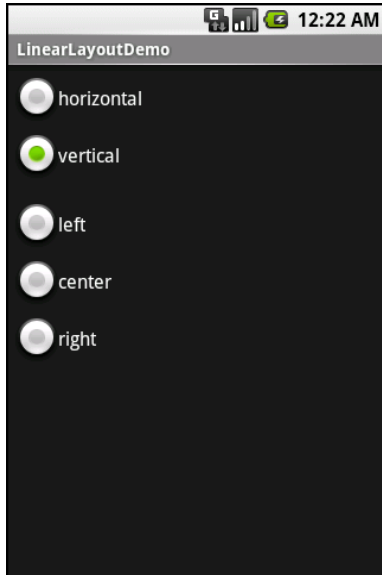
Figure 14. The same application, with the vertical radio button selected

If we toggle the "center" or "right" radio buttons, the bottom RadioGroup adjusts to match:
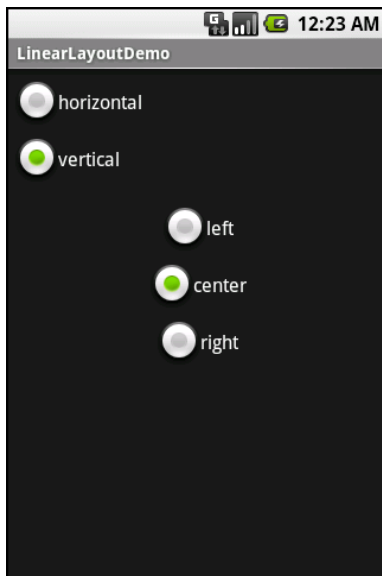
Figure 15. The same application, with the vertical and center radio buttons selected
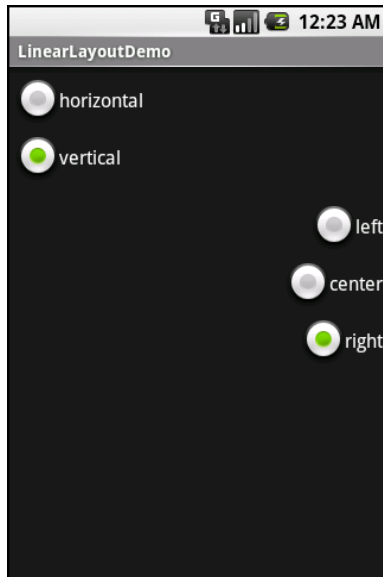
Figure 16. The same application, with the vertical and right radio buttons selected

The Box Model

As noted earlier in this chapter, some GUI frameworks treat everything as boxes – what Android calls `LinearLayout` containers. In Flex and XUL, for example, you create boxes and indicate how big they should be, as a percentage of the available space, then you put widgets in the boxes. A similar pattern exists in Android for `LinearLayout`, as is demonstrated in the `Containers\LinearPercent` project.

Here, we have a layout XML file that contains a vertical `LinearLayout` wrapping three `Button` widgets:

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <Button
    android:text="Fifty Percent"
    android:layout_width="fill_parent"
```

```
   android:layout_height="0px"
   android:layout_weight="50"
  />
  <Button
   android:text="Thirty Percent"
   android:layout_width="fill_parent"
   android:layout_height="0px"
   android:layout_weight="30"
  />
  <Button
   android:text="Twenty Percent"
   android:layout_width="fill_parent"
   android:layout_height="0px"
   android:layout_weight="20"
  />
</LinearLayout>
```

Each of the three widgets will take up a certain percentage of the vertical space for the LinearLayout. Since the LinearLayout is set to fill the screen, this means that the three widgets will divide up the screen based upon their requested percentages.

To request a percentage, each Button:

- Sets its android:layout_height to be 0px (note: we use height here because it is a vertical LinearLayout we are sub-dividing)

- Sets its android:layout_weight to be the desired percentage (e.g., android:layout_weight="50")

So long as the weights sum to 100, as they do in this case, you will get your desired breakdown by percentage:
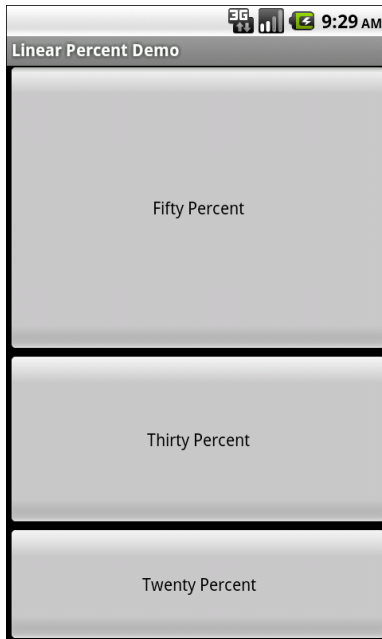
Figure 17. A LinearLayout split among three Buttons by percentage

All Things Are Relative

RelativeLayout, as the name suggests, lays out widgets based upon their relationship to other widgets in the container and the parent container. You can place Widget X below and to the left of Widget Y, or have Widget Z's bottom edge align with the bottom of the container, and so on.

This is reminiscent of James Elliot's RelativeLayout for use with Java/Swing.

Concepts and Properties

To make all this work, we need ways to reference other widgets within an XML layout file, plus ways to indicate the relative positions of those widgets.

Positions Relative to Container

The easiest relations to set up are tying a widget's position to that of its container:

- `android:layout_alignParentTop` says the widget's top should align with the top of the container

- `android:layout_alignParentBottom` says the widget's bottom should align with the bottom of the container

- `android:layout_alignParentLeft` says the widget's left side should align with the left side of the container

- `android:layout_alignParentRight` says the widget's right side should align with the right side of the container

- `android:layout_centerHorizontal` says the widget should be positioned horizontally at the center of the container

- `android:layout_centerVertical` says the widget should be positioned vertically at the center of the container

- `android:layout_centerInParent` says the widget should be positioned both horizontally and vertically at the center of the container

All of these properties take a simple boolean value (`true` or `false`).

Note that the padding of the widget is taken into account when performing these various alignments. The alignments are based on the widget's overall cell (combination of its natural space plus the padding).

Relative Notation in Properties

The remaining properties of relevance to `RelativeLayout` take as a value the identity of a widget in the container. To do this:

1. Put identifiers (`android:id` attributes) on all elements that you will need to address

2. Reference other widgets using the same identifier value

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The first occurrence of an `id` value should have the plus sign (`@+id/widget_a`); the second and subsequent times that `id` value is used in the layout file should drop the plus sign (`@id/widget_a`). This allows the build tools to better help you catch typos in your widget `id` values – if you do not have a plus sign for a widget `id` value that has not been seen before, that will be caught at compile time.

For example, if Widget A is identified as `@+id/widget_a`, Widget B can refer to Widget A in one of its own properties via the identifier `@id/widget_a`.

Positions Relative to Other Widgets

There are four properties that control position of a widget vis a vis other widgets:

- `android:layout_above` indicates that the widget should be placed above the widget referenced in the property
- `android:layout_below` indicates that the widget should be placed below the widget referenced in the property
- `android:layout_toLeftOf` indicates that the widget should be placed to the left of the widget referenced in the property
- `android:layout_toRightOf` indicates that the widget should be placed to the right of the widget referenced in the property

Beyond those four, there are five additional properties that can control one widget's alignment relative to another:

- `android:layout_alignTop` indicates that the widget's top should be aligned with the top of the widget referenced in the property
- `android:layout_alignBottom` indicates that the widget's bottom should be aligned with the bottom of the widget referenced in the property
- `android:layout_alignLeft` indicates that the widget's left should be aligned with the left of the widget referenced in the property

- `android:layout_alignRight` indicates that the widget's right should be aligned with the right of the widget referenced in the property

- `android:layout_alignBaseline` indicates that the baselines of the two widgets should be aligned (where the "baseline" is that invisible line that text appears to sit on)

The last one is useful for aligning labels and fields so that the text appears "natural". Since fields have a box around them and labels do not, `android:layout_alignTop` would align the top of the field's box with the top of the label, which will cause the text of the label to be higher on-screen than the text entered into the field.

So, if we want Widget B to be positioned to the right of Widget A, in the XML element for Widget B, we need to include `android:layout_toRightOf = "@id/widget_a"` (assuming `@id/widget_a` is the identity of Widget A).

Order of Evaluation

It used to be that Android would use a single pass to process `RelativeLayout`-defined rules. That meant you could not reference a widget (e.g., via `android:layout_above`) until it had been declared in the XML. This made defining some layouts a bit complicated. Starting in Android 1.6, Android uses two passes to process the rules, so you can now safely have forward references to as-yet-undefined widgets.

Example

With all that in mind, let's examine a typical "form" with a field, a label, plus a pair of buttons labeled "OK" and "Cancel".

Here is the XML layout, pulled from the `Containers/Relative` sample project:

```
<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
```

```
    android:layout_width="fill_parent"
    android:layout_height="wrap_content">
  <TextView android:id="@+id/label"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:text="URL:"
    android:layout_alignBaseline="@+id/entry"
    android:layout_alignParentLeft="true"/>
  <EditText
    android:id="@id/entry"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:layout_toRightOf="@id/label"
    android:layout_alignParentTop="true"/>
  <Button
    android:id="@+id/ok"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_below="@id/entry"
    android:layout_alignRight="@id/entry"
    android:text="OK" />
  <Button
    android:id="@+id/cancel"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_toLeftOf="@id/ok"
    android:layout_alignTop="@id/ok"
    android:text="Cancel" />
</RelativeLayout>
```

First, we open up the `RelativeLayout`. In this case, we want to use the full width of the screen (`android:layout_width = "fill_parent"`) and only as much height as we need (`android:layout_height = "wrap_content"`).

Next, we define the label as a `TextView`. We indicate that we want its left edge aligned with the left edge of the `RelativeLayout` (`android:layout_alignBaseline="@+id/entry"`) and that we want its baseline aligned with the baseline of the yet-to-be-defined `EditText`. Since the `EditText` has not been declared yet, we use the + sign in the ID (`android:layout_alignParentLeft="true"`).

After that, we add in the field as an `EditText`. We want the field to be to the right of the label, have the field be aligned with the top of the `RelativeLayout`, and for the field to take up the rest of this "row" in the layout. Those are handled by three properties:

- `android:layout_toRightOf = "@id/label"`

- android:layout_alignParentTop = "true"

- android:layout_width = "fill_parent"

Then, the OK button is set to be below the field (android:layout_below = "@id/entry") and have its right side align with the right side of the field (android:layout_alignRight = "@id/entry"). The Cancel button is set to be to the left of the OK button (android:layout_toLeft = "@id/ok") and have its top aligned with the OK button (android:layout_alignTop = "@id/ok").

With no changes to the auto-generated Java code, the emulator gives us:
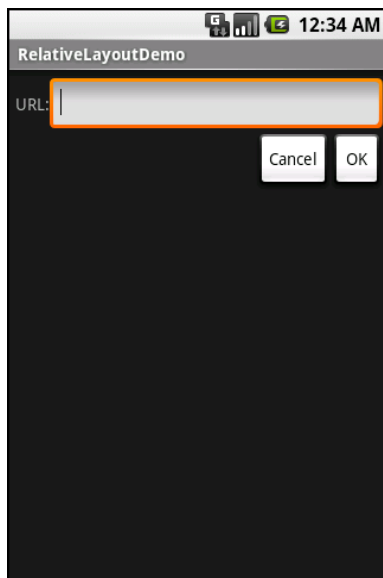
Figure 18. The RelativeLayoutDemo sample application

Overlap

RelativeLayout also has a feature that LinearLayout lacks – the ability to have widgets overlap one another. Later children of a RelativeLayout are "higher in the Z axis" than are earlier children, meaning that later children will overlap earlier children if they are set up to occupy the same space in the layout.

This will be clearer with an example. Here is a layout, from `Containers/RelativeOverlap`, with a `RelativeLayout` holding two `Button` widgets:

```xml
<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <Button
    android:text="I AM BIG"
    android:textSize="120dip"
    android:textStyle="bold"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
  />
  <Button
    android:text="I am small"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_centerInParent="true"
  />
</RelativeLayout>
```

The first `Button` is set to fill the screen. The second `Button` is set to be centered inside the parent, but only take up as much space as is needed for its caption. Hence, the second `Button` will appear to "float" over the first `Button`:

Figure 19. The RelativeOverlap sample application

Both `Button` widgets can still be clicked, though clicking on the smaller `Button` does not also click the bigger `Button`. Your clicks will be handled by the widget on top in the case of an overlap like this.

Tabula Rasa

If you like HTML tables, spreadsheet grids, and the like, you will like Android's `TableLayout` – it allows you to position your widgets in a grid to your specifications. You control the number of rows and columns, which columns might shrink or stretch to accommodate their contents, and so on.

`TableLayout` works in conjunction with `TableRow`. `TableLayout` controls the overall behavior of the container, with the widgets themselves poured into one or more `TableRow` containers, one per row in the grid.

Concepts and Properties

For all this to work, we need to figure out how widgets work with rows and columns, plus how to handle widgets that live outside of rows.

Putting Cells in Rows

Rows are declared by you, the developer, by putting widgets as children of a `TableRow` inside the overall `TableLayout`. You, therefore, control directly how many rows appear in the table.

The number of columns are determined by Android; you control the number of columns in an indirect fashion.

First, there will be at least one column per widget in your longest row. So if you have three rows, one with two widgets, one with three widgets, and one with four widgets, there will be at least four columns.

However, a widget can take up more than one column by including the `android:layout_span` property, indicating the number of columns the widget spans. This is akin to the `colspan` attribute one finds in table cells in HTML:

```
<TableRow>
  <TextView android:text="URL:" />
  <EditText
    android:id="@+id/entry"
    android:layout_span="3"/>
</TableRow>
```

In the above XML layout fragment, the field spans three columns.

Ordinarily, widgets are put into the first available column. In the above fragment, the label would go in the first column (column `0`, as columns are counted starting from `0`), and the field would go into a spanned set of three columns (columns `1` through `3`). However, you can put a widget into a different column via the `android:layout_column` property, specifying the `0`-based column the widget belongs to:

```
<TableRow>
  <Button
    android:id="@+id/cancel"
    android:layout_column="2"
    android:text="Cancel" />
  <Button android:id="@+id/ok" android:text="OK" />
</TableRow>
```

In the preceding XML layout fragment, the Cancel button goes in the third column (column 2). The OK button then goes into the next available column, which is the fourth column.

Non-Row Children of TableLayout

Normally, `TableLayout` contains only `TableRow` elements as immediate children. However, it is possible to put other widgets in between rows. For those widgets, `TableLayout` behaves a bit like `LinearLayout` with vertical orientation. The widgets automatically have their width set to `fill_parent`, so they will fill the same space that the longest row does.

One pattern for this is to use a plain `View` as a divider (e.g., `<View android:layout_height = "2px" android:background = "#0000FF" />` as a two-pixel-high blue bar across the width of the table).

Stretch, Shrink, and Collapse

By default, each column will be sized according to the "natural" size of the widest widget in that column (taking spanned columns into account). Sometimes, though, that does not work out very well, and you need more control over column behavior.

You can place an `android:stretchColumns` property on the `TableLayout`. The value should be a single column number (again, `0`-based) or a comma-delimited list of column numbers. Those columns will be stretched to take up any available space yet on the row. This helps if your content is narrower than the available space.

Conversely, you can place a `android:shrinkColumns` property on the `TableLayout`. Again, this should be a single column number or a comma-delimited list of column numbers. The columns listed in this property will try to word-wrap their contents to reduce the effective width of the column – by default, widgets are not word-wrapped. This helps if you have columns with potentially wordy content that might cause some columns to be pushed off the right side of the screen.

You can also leverage an `android:collapseColumns` property on the `TableLayout`, again with a column number or comma-delimited list of column numbers. These columns will start out "collapsed", meaning they will be part of the table information but will be invisible. Programmatically, you can collapse and un-collapse columns by calling `setColumnCollapsed()` on the `TableLayout`. You might use this to allow users to control which columns are of importance to them and should be shown versus which ones are less important and can be hidden.

You can also control stretching and shrinking at runtime via `setColumnStretchable()` and `setColumnShrinkable()`.

Example

The XML layout fragments shown above, when combined, give us a `TableLayout` rendition of the "form" we created for `RelativeLayout`, with the addition of a divider line between the label/field and the two buttons (found in the `Containers/Table` demo):

```xml
<?xml version="1.0" encoding="utf-8"?>
<TableLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:stretchColumns="1">
  <TableRow>
    <TextView
        android:text="URL:" />
    <EditText android:id="@+id/entry"
      android:layout_span="3"/>
  </TableRow>
  <View
    android:layout_height="2px"
```

```
    android:background="#0000FF" />
  <TableRow>
    <Button android:id="@+id/cancel"
      android:layout_column="2"
      android:text="Cancel" />
    <Button android:id="@+id/ok"
      android:text="OK" />
  </TableRow>
</TableLayout>
```

When compiled against the generated Java code and run on the emulator, we get:
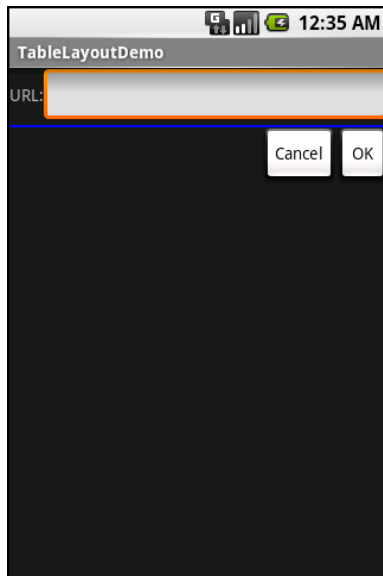
Figure 20. The TableLayoutDemo sample application

Scrollwork

Phone screens tend to be small, which requires developers to use some tricks to present a lot of information in the limited available space. One trick for doing this is to use scrolling, so only part of the information is visible at one time, the rest available via scrolling up or down.

ScrollView is a container that provides scrolling for its contents. You can take a layout that might be too big for some screens, wrap it in a ScrollView,

and still use your existing layout logic. It just so happens that the user can only see part of your layout at one time, the rest available via scrolling.

For example, here is a ScrollView used in an XML layout file (from the Containers/Scroll demo):

```xml
<?xml version="1.0" encoding="utf-8"?>
<ScrollView
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="wrap_content">
  <TableLayout
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:stretchColumns="0">
    <TableRow>
      <View
        android:layout_height="80px"
        android:background="#000000"/>
      <TextView android:text="#000000"
        android:paddingLeft="4px"
        android:layout_gravity="center_vertical" />
    </TableRow>
    <TableRow>
      <View
        android:layout_height="80px"
        android:background="#440000" />
      <TextView android:text="#440000"
        android:paddingLeft="4px"
        android:layout_gravity="center_vertical" />
    </TableRow>
    <TableRow>
      <View
        android:layout_height="80px"
        android:background="#884400" />
      <TextView android:text="#884400"
        android:paddingLeft="4px"
        android:layout_gravity="center_vertical" />
    </TableRow>
    <TableRow>
      <View
        android:layout_height="80px"
        android:background="#aa8844" />
      <TextView android:text="#aa8844"
        android:paddingLeft="4px"
        android:layout_gravity="center_vertical" />
    </TableRow>
    <TableRow>
      <View
        android:layout_height="80px"
        android:background="#ffaa88" />
```

```
      <TextView android:text="#ffaa88"
        android:paddingLeft="4px"
        android:layout_gravity="center_vertical" />
    </TableRow>
    <TableRow>
      <View
        android:layout_height="80px"
        android:background="#ffffaa" />
      <TextView android:text="#ffffaa"
        android:paddingLeft="4px"
        android:layout_gravity="center_vertical" />
    </TableRow>
    <TableRow>
      <View
        android:layout_height="80px"
        android:background="#ffffff" />
      <TextView android:text="#ffffff"
        android:paddingLeft="4px"
        android:layout_gravity="center_vertical" />
    </TableRow>
  </TableLayout>
</ScrollView>
```

Without the ScrollView, the table would take up at least 560 pixels (7 rows at 80 pixels each, based on the View declarations). There may be some devices with screens capable of showing that much information, but many will be smaller. The ScrollView lets us keep the table as-is, but only present part of it at a time.

On the stock Android emulator, when the activity is first viewed, you see:

Figure 21. The ScrollViewDemo sample application

Notice how only five rows and part of the sixth are visible. By pressing the up/down buttons on the directional pad, you can scroll up and down to see the remaining rows. Also note how the right side of the content gets clipped by the scrollbar – be sure to put some padding on that side or otherwise ensure your own content does not get clipped in that fashion.

Android 1.5 introduced HorizontalScrollView, which works like ScrollView...just horizontally. This would be good for forms that might be too wide rather than too tall. Note that neither ScrollView nor HorizontalScrollView will give you bi-directional scrolling – you have to choose vertical or horizontal.

Also, note that you cannot put scrollable items into a ScrollView. For example, a ListView widget – which we will see in the next chapter – already knows how to scroll. You do not need to put a ListView in a ScrollView, and if you were to try, it would not work very well.

Using Selection Widgets

Back in the chapter on basic widgets, you saw how fields could have constraints placed upon them to limit possible input, such as numeric-only or phone-number-only. These sorts of constraints help users "get it right" when entering information, particularly on a mobile device with cramped keyboards.

Of course, the ultimate in constrained input is to select a choice from a set of items, such as the radio buttons seen earlier. Classic UI toolkits have listboxes, comboboxes, drop-down lists, and the like for that very purpose. Android has many of the same sorts of widgets, plus others of particular interest for mobile devices (e.g., the Gallery for examining saved photos).

Moreover, Android offers a flexible framework for determining what choices are available in these widgets. Specifically, Android offers a framework of data adapters that provide a common interface to selection lists ranging from static arrays to database contents. Selection views – widgets for presenting lists of choices – are handed an adapter to supply the actual choices.

Adapting to the Circumstances

In the abstract, adapters provide a common interface to multiple disparate APIs. More specifically, in Android's case, adapters provide a common interface to the data model behind a selection-style widget, such as a

listbox. This use of Java interfaces is fairly common (e.g., Java/Swing's model adapters for `JTable`), and Java is far from the only environment offering this sort of abstraction (e.g., Flex's XML data-binding framework accepts XML inlined as static data or retrieved from the Internet).

Android's adapters are responsible for providing the roster of data for a selection widget plus converting individual elements of data into specific views to be displayed inside the selection widget. The latter facet of the adapter system may sound a little odd, but in reality it is not that different from other GUI toolkits' ways of overriding default display behavior. For example, in Java/Swing, if you want a `JList`-backed listbox to actually be a checklist (where individual rows are a checkbox plus label, and clicks adjust the state of the checkbox), you inevitably wind up calling `setCellRenderer()` to supply your own `ListCellRenderer`, which in turn converts strings for the list into `JCheckBox`-plus-`JLabel` composite widgets.

Using ArrayAdapter

The easiest adapter to use is `ArrayAdapter` – all you need to do is wrap one of these around a Java array or `java.util.List` instance, and you have a fully-functioning adapter:

```java
String[] items={"this", "is", "a",
                "really", "silly", "list"};
new ArrayAdapter<String>(this,
  android.R.layout.simple_list_item_1, items);
```

One flavor of the `ArrayAdapter` constructor takes three parameters:

- The `Context` to use (typically this will be your activity instance)
- The resource ID of a view to use (such as a built-in system resource ID, as shown above)
- The actual array or list of items to show

By default, the `ArrayAdapter` will invoke `toString()` on the objects in the list and wrap each of those strings in the view designated by the supplied resource. `android.R.layout.simple_list_item_1` simply turns those strings

into TextView objects. Those TextView widgets, in turn, will be shown in the list or spinner or whatever widget uses this ArrayAdapter. If you want to see what android.R.layout.simple_list_item_1 looks like, you can find a copy of it in your SDK installation – just search for simple_list_item_1.xml.

We will see in a later chapter how to subclass an Adapter and override row creation, to give you greater control over how rows appear.

Lists of Naughty and Nice

The classic listbox widget in Android is known as ListView. Include one of these in your layout, invoke setAdapter() to supply your data and child views, and attach a listener via setOnItemSelectedListener() to find out when the selection has changed. With that, you have a fully-functioning listbox.

However, if your activity is dominated by a single list, you might well consider creating your activity as a subclass of ListActivity, rather than the regular Activity base class. If your main view is just the list, you do not even need to supply a layout – ListActivity will construct a full-screen list for you. If you do want to customize the layout, you can, so long as you identify your ListView as @android:id/list, so ListActivity knows which widget is the main list for the activity.

For example, here is a layout pulled from the Selection/List sample project:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent" >
  <TextView
    android:id="@+id/selection"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"/>
  <ListView
    android:id="@android:id/list"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:drawSelectorOnTop="false"
```

```
    />
</LinearLayout>
```

It is just a list with a label on top to show the current selection.

The Java code to configure the list and connect the list with the label is:

```java
public class ListViewDemo extends ListActivity {
  private TextView selection;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    setListAdapter(new ArrayAdapter<String>(this,
                       android.R.layout.simple_list_item_1,
                       items));
    selection=(TextView)findViewById(R.id.selection);
  }

  public void onListItemClick(ListView parent, View v, int position,
                                 long id) {
   selection.setText(items[position]);
  }
}
```

With `ListActivity`, you can set the list adapter via `setListAdapter()` – in this case, providing an `ArrayAdapter` wrapping an array of nonsense strings. To find out when the list selection changes, override `onListItemClick()` and take appropriate steps based on the supplied child view and position (in this case, updating the label with the text for that position).

The results?
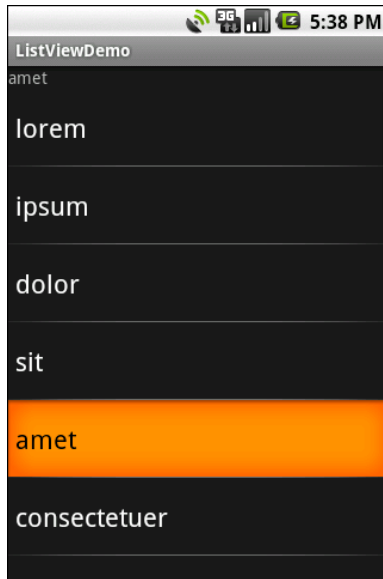
Figure 22. The ListViewDemo sample application

The second parameter to our `ArrayAdapter` – `android.R.layout.simple_list_item_1` – controls what the rows look like. The value used in the preceding example provides the standard Android list row: big font, lots of padding, white text.

Selection Modes

By default, `ListView` is set up simply to collect clicks on list entries. Sometimes, though, you want a list that tracks a user's selection, or possibly multiple selections. `ListView` can handle that as well, but it requires a few changes.

First, you will need to call `setChoiceMode()` on the `ListView` in Java code to set the choice mode, supplying either `CHOICE_MODE_SINGLE` or `CHOICE_MODE_MULTIPLE` as the value. You can get your `ListView` from a `ListActivity` via `getListView()`. You can also declare this via the `android:choiceMode` attribute in your layout XML.

Then, rather than use `android.R.layout.simple_list_item_1` as the layout for the list rows in your `ArrayAdapter` constructor, you will need to use either `android.R.layout.simple_list_item_single_choice` or `android.R.layout.simple_list_item_multiple_choice` for single-choice or multiple-choice lists, respectively.

For example, here is an activity layout from the `Selection/Checklist` sample project:

```xml
<?xml version="1.0" encoding="utf-8"?>
<ListView
xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@android:id/list"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:drawSelectorOnTop="false"
  android:choiceMode="multipleChoice"
/>
```

It is a full-screen `ListView`, with the `android:choiceMode="multipleChoice"` attribute to indicate that we want multiple choice support.

Our activity just uses a standard `ArrayAdapter` on our list of nonsense words, but uses `android.R.layout.simple_list_item_multiple_choice` as the row layout:

```java
        "ligula", "vitae", "arcu", "aliquet", "mollis",
         "etiam", "vel", "erat", "placerat", "ante",
         "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    setListAdapter(new ArrayAdapter<String>(this,
                      android.R.layout.simple_list_item_multiple_choice,
                      items));
  }
}
```

What the user sees is the list of words with checkboxes down the right edge:

Figure 23. Multiple-select mode

If we wanted, we could call methods like `getCheckedItemPositions()` on our `ListView` to find out which items the user checked, or `setItemChecked()` if we wanted to check (or un-check) a specific entry ourselves.

Spin Control

In Android, the `Spinner` is the equivalent of the drop-down selector you might find in other toolkits (e.g., `JComboBox` in Java/Swing). Pressing the center button on the D-pad pops up a selection dialog for the user to choose an item from. You basically get the ability to select from a list without taking up all the screen space of a `ListView`, at the cost of an extra click or screen tap to make a change.

As with `ListView`, you provide the adapter for data and child views via `setAdapter()` and hook in a listener object for selections via `setOnItemSelectedListener()`.

If you want to tailor the view used when displaying the drop-down perspective, you need to configure the adapter, not the `Spinner` widget. Use the `setDropDownViewResource()` method to supply the resource ID of the view to use.

For example, culled from the `Selection/Spinner` sample project, here is an XML layout for a simple view with a `Spinner`:

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <TextView
    android:id="@+id/selection"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    />
  <Spinner android:id="@+id/spinner"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:drawSelectorOnTop="true"
  />
</LinearLayout>
```

This is the same view as shown in the previous section, just with a `Spinner` instead of a `ListView`. The `Spinner` property `android:drawSelectorOnTop` controls whether the arrows are drawn on the selector button on the right side of the `Spinner` UI.

To populate and use the `Spinner`, we need some Java code:

```
public class SpinnerDemo extends Activity
  implements AdapterView.OnItemSelectedListener {
  private TextView selection;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
```

```
      super.onCreate(icicle);
      setContentView(R.layout.main);
      selection=(TextView)findViewById(R.id.selection);

      Spinner spin=(Spinner)findViewById(R.id.spinner);
      spin.setOnItemSelectedListener(this);

      ArrayAdapter<String> aa=new ArrayAdapter<String>(this,
                              android.R.layout.simple_spinner_item,
                              items);

      aa.setDropDownViewResource(
        android.R.layout.simple_spinner_dropdown_item);
      spin.setAdapter(aa);
    }

    public void onItemSelected(AdapterView<?> parent,
                               View v, int position, long id) {
      selection.setText(items[position]);
    }

    public void onNothingSelected(AdapterView<?> parent) {
      selection.setText("");
    }
}
```

Here, we attach the activity itself as the selection listener
(spin.setOnItemSelectedListener(this)). This works because the activity
implements the OnItemSelectedListener interface. We configure the adapter
not only with the list of fake words, but also with a specific resource to use
for the drop-down view (via aa.setDropDownViewResource()). Also note the
use of android.R.layout.simple_spinner_item as the built-in View for showing
items in the spinner itself. Finally, we implement the callbacks required by
OnItemSelectedListener to adjust the selection label based on user input.

What we get is:
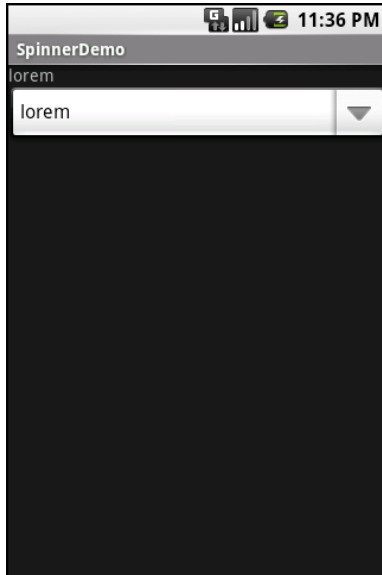
Figure 24. The SpinnerDemo sample application, as initially launched

Figure 25. The same application, with the spinner drop-down list displayed

Grid Your Lions (Or Something Like That...)

As the name suggests, `GridView` gives you a two-dimensional grid of items to choose from. You have moderate control over the number and size of the columns; the number of rows is dynamically determined based on the number of items the supplied adapter says are available for viewing.

There are a few properties which, when combined, determine the number of columns and their sizes:

- `android:numColumns` spells out how many columns there are, or, if you supply a value of `auto_fit`, Android will compute the number of columns based on available space and the properties listed below.

- `android:verticalSpacing` and `android:horizontalSpacing` indicate how much whitespace there should be between items in the grid.

- `android:columnWidth` indicates how many pixels wide each column should be.

- `android:stretchMode` indicates, for grids with `auto_fit` for `android:numColumns`, what should happen for any available space not taken up by columns or spacing – this should be `columnWidth` to have the columns take up available space or `spacingWidth` to have the whitespace between columns absorb extra space. For example, suppose the screen is 320 pixels wide, and we have `android:columnWidth` set to `100px` and `android:horizontalSpacing` set to `5px`. Three columns would use 310 pixels (three columns of 100 pixels and two whitespaces of 5 pixels). With `android:stretchMode` set to `columnWidth`, the three columns will each expand by 3-4 pixels to use up the remaining 10 pixels. With `android:stretchMode` set to `spacingWidth`, the two whitespaces will each grow by 5 pixels to consume the remaining 10 pixels.

Otherwise, the `GridView` works much like any other selection widget – use `setAdapter()` to provide the data and child views, invoke `setOnItemSelectedListener()` to register a selection listener, etc.

For example, here is an XML layout from the `Selection/Grid` sample project, showing a `GridView` configuration:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <TextView
    android:id="@+id/selection"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    />
  <GridView
    android:id="@+id/grid"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:verticalSpacing="40dip"
    android:horizontalSpacing="5dip"
    android:numColumns="auto_fit"
    android:columnWidth="100dip"
    android:stretchMode="columnWidth"
    android:gravity="center"
    />
</LinearLayout>
```

For this grid, we take up the entire screen except for what our selection label requires. The number of columns is computed by Android (`android:numColumns = "auto_fit"`) based on our horizontal spacing (`android:horizontalSpacing = "5dip"`) and columns width (`android:columnWidth = "100dip"`), with the columns absorbing any "slop" width left over (`android:stretchMode = "columnWidth"`).

The Java code to configure the `GridView` is:

```java
package com.commonsware.android.grid;

import android.app.Activity;
import android.content.Context;
import android.os.Bundle;
import android.view.View;
import android.widget.AdapterView;
import android.widget.ArrayAdapter;
import android.widget.GridView;
import android.widget.TextView;
```

```
public class GridDemo extends Activity
  implements AdapterView.OnItemSelectedListener {
  private TextView selection;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    selection=(TextView)findViewById(R.id.selection);

    GridView g=(GridView) findViewById(R.id.grid);
    g.setAdapter(new ArrayAdapter<String>(this,
                      R.layout.cell,
                      items));
    g.setOnItemSelectedListener(this);
  }

  public void onItemSelected(AdapterView<?> parent, View v,
                             int position, long id) {
    selection.setText(items[position]);
  }

  public void onNothingSelected(AdapterView<?> parent) {
    selection.setText("");
  }
}
```

The grid cells are defined by a separate res/layout/cell.xml file, referenced in our ArrayAdapter as R.layout.cell:

```
<?xml version="1.0" encoding="utf-8"?>
<TextView
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="wrap_content"
  android:layout_height="wrap_content"
  android:textSize="14dip"
/>
```

With the vertical spacing from the XML layout (android:verticalSpacing = "40dip"), the grid overflows the boundaries of the emulator's screen:

Figure 26. The GridDemo sample application, as initially launched

Figure 27. The same application, scrolled to the bottom of the grid

Fields: Now With 35% Less Typing!

The `AutoCompleteTextView` is sort of a hybrid between the `EditText` (field) and the `Spinner`. With auto-completion, as the user types, the text is treated as a prefix filter, comparing the entered text as a prefix against a list of candidates. Matches are shown in a selection list that folds down from the field. The user can either type out an entry (e.g., something not in the list) or choose an entry from the list to be the value of the field.

`AutoCompleteTextView` subclasses `EditText`, so you can configure all the standard look-and-feel aspects, such as font face and color.

In addition, `AutoCompleteTextView` has a `android:completionThreshold` property, to indicate the minimum number of characters a user must enter before the list filtering begins.

You can give `AutoCompleteTextView` an adapter containing the list of candidate values via `setAdapter()`. However, since the user could type something not in the list, `AutoCompleteTextView` does not support selection listeners. Instead, you can register a `TextWatcher`, like you can with any `EditText`, to be notified when the text changes. These events will occur either because of manual typing or from a selection from the drop-down list.

Below we have a familiar-looking XML layout, this time containing an `AutoCompleteTextView` (pulled from the `Selection/AutoComplete` sample application):

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <TextView
    android:id="@+id/selection"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    />
```

```
  <AutoCompleteTextView android:id="@+id/edit"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:completionThreshold="3"/>
</LinearLayout>
```

The corresponding Java code is:

```
package com.commonsware.android.auto;

import android.app.Activity;
import android.os.Bundle;
import android.text.Editable;
import android.text.TextWatcher;
import android.view.View;
import android.widget.AdapterView;
import android.widget.ArrayAdapter;
import android.widget.AutoCompleteTextView;
import android.widget.TextView;

public class AutoCompleteDemo extends Activity
  implements TextWatcher {
  private TextView selection;
  private AutoCompleteTextView edit;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    selection=(TextView)findViewById(R.id.selection);
    edit=(AutoCompleteTextView)findViewById(R.id.edit);
    edit.addTextChangedListener(this);

    edit.setAdapter(new ArrayAdapter<String>(this,
                        android.R.layout.simple_dropdown_item_1line,
                        items));
  }

  public void onTextChanged(CharSequence s, int start, int before,
                              int count) {
    selection.setText(edit.getText());
  }

  public void beforeTextChanged(CharSequence s, int start,
                                  int count, int after) {
    // needed for interface, but not used
  }
```

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```
  public void afterTextChanged(Editable s) {
    // needed for interface, but not used
  }
}
```

This time, our activity implements `TextWatcher`, which means our callbacks are `onTextChanged()`, `beforeTextChanged()`, and `afterTextChanged()`. In this case, we are only interested in the former, and we update the selection label to match the `AutoCompleteTextView`'s current contents.

Here we have the results:
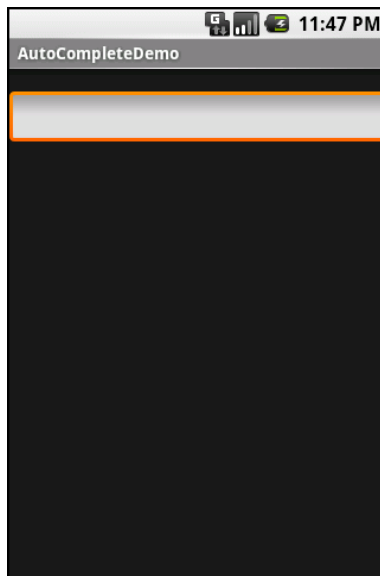
Figure 28. The AutoCompleteDemo sample application, as initially launched
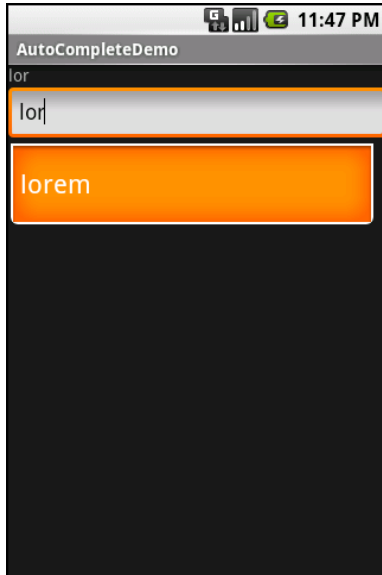
Figure 29. The same application, after a few matching letters were entered, showing the auto-complete drop-down
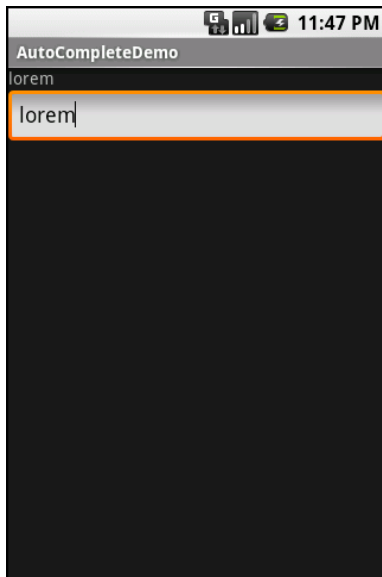
Figure 30. The same application, after the auto-complete value was selected

Galleries, Give Or Take The Art

The Gallery widget is not one ordinarily found in GUI toolkits. It is, in effect, a horizontally-laid-out listbox. One choice follows the next across the horizontal plane, with the currently-selected item highlighted. On an Android device, one rotates through the options through the left and right D-pad buttons.

Compared to the ListView, the Gallery takes up less screen space while still showing multiple choices at one time (assuming they are short enough). Compared to the Spinner, the Gallery always shows more than one choice at a time.

The quintessential example use for the Gallery is image preview – given a collection of photos or icons, the Gallery lets people preview the pictures in the process of choosing one.

Code-wise, the Gallery works much like a Spinner or GridView. In your XML layout, you have a few properties at your disposal:

- android:spacing controls the number of pixels between entries in the list

- android:spinnerSelector controls what is used to indicate a selection – this can either be a reference to a Drawable (see the resources chapter) or an RGB value in #AARRGGBB or similar notation

- android:drawSelectorOnTop indicates if the selection bar (or Drawable) should be drawn before (false) or after (true) drawing the selected child – if you choose true, be sure that your selector has sufficient transparency to show the child through the selector, otherwise users will not be able to read the selection

Getting Fancy With Lists

The humble `ListView` is one of the most important widgets in all of Android, simply because it is used so frequently. Whether choosing a contact to call or an email message to forward or an ebook to read, `ListView` widgets are employed in a wide range of activities.

Of course, it would be nice if they were more than just plain text.

The good news is that they can be as fancy as you want, within the limitations of a mobile device's screen, of course. However, making them fancy takes some work and some features of Android that we will cover in this chapter.

Getting To First Base

The classic Android `ListView` is a plain list of text — solid but uninspiring. This is because all we have handed to the `ListView` is a bunch of words in an array, and told Android to use a simple built-in layout for pouring those words into a list.

However, you can have a list whose rows are made up of icons, or icons and text, or checkboxes and text, or whatever you want. It is merely a matter of supplying enough data to the adapter and helping the adapter to create a richer set of `View` objects for each row.

For example, suppose you want a `ListView` whose entries are made up of an icon, followed by some text. You could construct a layout for the row that looks like this, found in `res/layout/row.xml` in the `FancyLists/Static` sample project:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="wrap_content"
  android:orientation="horizontal"
>
  <ImageView
    android:id="@+id/icon"
    android:padding="2dip"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:src="@drawable/ok"
  />
  <TextView
    android:id="@+id/label"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:textSize="40sp"
  />
</LinearLayout>
```

This layout uses a `LinearLayout` to set up a row, with the icon on the left and the text (in a nice big font) on the right.

By default, though, Android has no idea that you want to use this layout with your `ListView`. To make the connection, you need to supply your `Adapter` with the resource ID of the custom layout shown above:

```java
public class StaticDemo extends ListActivity {
  private TextView selection;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    setListAdapter(new ArrayAdapter<String>(this,
                    R.layout.row, R.id.label,
```

```
                        items));
    selection=(TextView)findViewById(R.id.selection);
  }

  public void onListItemClick(ListView parent, View v,
                              int position,  long id) {
   selection.setText(items[position]);
  }
}
```

This follows the general structure for the previous ListView sample.

The key in this example is that you have told ArrayAdapter that you want to use your custom layout (R.layout.row) and that the TextView where the word should go is known as R.id.label within that custom layout. Remember: to reference a layout (row.xml), use R.layout as a prefix on the base name of the layout XML file (R.layout.row).

The result is a ListView with icons down the left side. In particular, all the icons are the same:

Figure 31. The StaticDemo application

A Dynamic Presentation

This technique – supplying an alternate layout to use for rows – handles simple cases very nicely.

However, what happens when we want the icon to change based on the row data? For example, perhaps we want to use one icon for small words and a different icon for large words.

In the case of `ArrayAdapter`, you will need to extend it, creating your own custom subclass (e.g., `IconicAdapter`) that incorporates your business logic. In particular, it will need to override `getView()`.

The `getView()` method of an `Adapter` is what an `AdapterView` (like `ListView` or `Spinner`) calls when it needs the `View` associated with a given piece of data the `Adapter` is managing. In the case of an `ArrayAdapter`, `getView()` is called as needed for each position in the array – "get me the `View` for the first row", "get me the `View` for the second row", etc.

For example, let us rework the above code to use `getView()`, so we can have different icons for different rows – in this case, one icon for short words and one for long words (from the `FancyLists/Dynamic` sample project):

```
public class DynamicDemo extends ListActivity {
  TextView selection;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    setListAdapter(new IconicAdapter());
    selection=(TextView)findViewById(R.id.selection);
  }

  public void onListItemClick(ListView parent, View v,
                              int position, long id) {
```

```
  selection.setText(items[position]);
}

class IconicAdapter extends ArrayAdapter<String> {
  IconicAdapter() {
    super(DynamicDemo.this, R.layout.row, R.id.label, items);
  }

  public View getView(int position, View convertView,
                      ViewGroup parent) {
    View row=super.getView(position, convertView, parent);
    ImageView icon=(ImageView)row.findViewById(R.id.icon);

    if (items[position].length()>4) {
      icon.setImageResource(R.drawable.delete);
    }
    else {
      icon.setImageResource(R.drawable.ok);
    }

    return(row);
  }
}
}
```

Our `IconicAdapter` – an inner class of the activity – has two methods. First, it has the constructor, which just passes to `ArrayAdapter` the same data we used in the `ArrayAdapter` constructor in `StaticDemo`. Second, it has our `getView()` implementation, which does two things:

1. It chains to the superclass' implementation of `getView()`, which returns to us an instance of our row `View`, as prepared by `ArrayAdapter`. In particular, our word has already been put into the `TextView`, since `ArrayAdapter` does that normally.

2. It finds our `ImageView` and applies a business rule to set which icon should be used, referencing one of two drawable resources (`R.drawable.ok` and `R.drawable.delete`).

This gives us:

Figure 32. The DynamicDemo application

Inflating Rows Ourselves

The solution shown in this version of the DynamicDemo works fine. However, there will be times when ArrayAdapter cannot even be used for setting up the basics of our row. For example, it is possible to have a ListView where the rows are materially different, such as category headers interspersed among "regular" rows. In that case, we may need to do all of the work ourselves, starting with inflating our rows.

A Sidebar About Inflation

In this case, "inflation" means the act of converting an XML layout specification into the actual tree of View objects the XML represents. This is undoubtedly a tedious bit of code: take an element, create an instance of the specified View class, walk the attributes, convert those into property setter calls, iterate over all child elements, lather, rinse, repeat.

The good news is that the fine folk on the Android team wrapped all that up into a class called LayoutInflater that we can use ourselves. When it comes to fancy lists, for example, we will want to inflate Views for each row shown in the list, so we can use the convenient shorthand of the XML layout to describe what the rows are supposed to look like.

For example, let us look at a slightly different implementation of the DynamicDemo class, from the FancyLists/DynamicEx project:

```java
public class DynamicDemo extends ListActivity {
  TextView selection;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    setListAdapter(new IconicAdapter());
    selection=(TextView)findViewById(R.id.selection);
  }

  public void onListItemClick(ListView parent, View v,
                              int position, long id) {
   selection.setText(items[position]);
  }

  class IconicAdapter extends ArrayAdapter<String> {
    IconicAdapter() {
      super(DynamicDemo.this, R.layout.row, items);
    }

    public View getView(int position, View convertView,
                        ViewGroup parent) {
      LayoutInflater inflater=getLayoutInflater();
      View row=inflater.inflate(R.layout.row, parent, false);
      TextView label=(TextView)row.findViewById(R.id.label);

      label.setText(items[position]);

      ImageView icon=(ImageView)row.findViewById(R.id.icon);

      if (items[position].length()>4) {
        icon.setImageResource(R.drawable.delete);
      }
      else {
```

```
        icon.setImageResource(R.drawable.ok);
    }

    return(row);
    }
  }
}
```

Here we inflate our `R.layout.row` layout by use of a `LayoutInflater` object, obtained from our `Activity` via `getLayoutInflater()`. This gives us a `View` object back which, in reality, is our `LinearLayout` with an `ImageView` and a `TextView`, just as `R.layout.row` specifies. However, rather than having to create all those objects ourselves and wire them together, the XML and `LayoutInflater` handle the "heavy lifting" for us.

And Now, Back To Our Story

So we have used `LayoutInflater` to give us a `View` representing the row. This row is "empty", since the static layout file has no idea what actual data goes into the row. It is our job to customize and populate the row as we see fit before returning it. So, we:

- Fill in the text label into our label widget, using the word at the supplied position

- See if the word is longer than four characters and, if so, we find our `ImageView` icon widget and replace the stock resource with a different one

The user sees nothing different – we have simply changed how those rows are being created.

Obviously, this was a fairly contrived example, but you can see where this technique could be used to customize rows based on any sort of criteria.

Better. Stronger. Faster.

The `getView()` implementation shown in the `FancyLists/DynamicEx` project works, but is inefficient. Every time the user scrolls, we have to create a bunch of new `View` objects to accommodate the newly-shown rows.

This is bad.

It might be bad for the immediate user experience, if the list appears to be sluggish. More likely, though, it will be bad due to battery usage – every bit of CPU that is used eats up the battery. This is compounded by the extra work the garbage collector needs to do to get rid of all those extra objects you create. So the less efficient your code, the more quickly the phone's battery will be drained, and the less happy the user will be.

And you want happy users, right?

So, let us take a look at a few tricks to make your fancy `ListView` widgets more efficient.

Using convertView

The `getView()` method receives, as one of its parameters, a `View` named, by convention, `convertView`. Sometimes, `convertView` will be `null`. In those cases, you have to create a new row `View` from scratch (e.g., via inflation), just as we did before.

However, if `convertView` is not `null`, then it is actually one of your previously-created `View` objects! This will happen primarily when the user scrolls the `ListView` – as new rows appear, Android will attempt to recycle the views of the rows that scrolled off the other end of the list, to save you having to rebuild them from scratch.

Assuming that each of your rows has the same basic structure, you can use `findViewById()` to get at the individual widgets that make up your row and

change their contents, then return `convertView` from `getView()`, rather than create a whole new row.

For example, here is the `getView()` implementation from last time, now optimized via `convertView` (from the `FancyLists/Recycling` project):

```java
public class RecyclingDemo extends ListActivity {
  private TextView selection;
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    setListAdapter(new IconicAdapter());
    selection=(TextView)findViewById(R.id.selection);
  }

  public void onListItemClick(ListView parent, View v,
                              int position, long id) {
   selection.setText(items[position]);
  }

  class IconicAdapter extends ArrayAdapter<String> {
    IconicAdapter() {
      super(RecyclingDemo.this, R.layout.row, items);
    }

    public View getView(int position, View convertView,
                        ViewGroup parent) {
      View row=convertView;

      if (row==null) {
        LayoutInflater inflater=getLayoutInflater();

        row=inflater.inflate(R.layout.row, parent, false);
      }

      TextView label=(TextView)row.findViewById(R.id.label);

      label.setText(items[position]);

      ImageView icon=(ImageView)row.findViewById(R.id.icon);

      if (items[position].length()>4) {
        icon.setImageResource(R.drawable.delete);
```

```
    }
    else {
      icon.setImageResource(R.drawable.ok);
    }

    return(row);
  }
 }
}
```

Here, we check to see if the `convertView` is null and, if so, we then inflate our row – but if it is not-null, we just reuse it. The work to fill in the contents (icon image, text) is the same in either case. The advantage is that we avoid the potentially-expensive inflation step. In fact, according to statistics cited by Google at the 2010 Google I|O conference, a `ListView` that uses a recycling `ListAdapter` will perform 150% faster than one that does not. In fact, for complex rows, that might understate the benefit.

Not only is this faster, but it uses much less memory. Each widget or container – in other words, each subclass of `View` – holds onto up to 2KB of data, not counting things like images in `ImageView` widgets. Each of our rows, therefore, might be as big as 6KB. For our list of 25 nonsense words, consuming as much as 150KB for a non-recycling list (25 rows at 6KB each) would be inefficient but not a huge problem. A list of 1,000 nonsense words, though, consuming as much as 6MB of RAM, would be a much bigger issue. Bear in mind that your application may only have 16MB of Java heap memory to work with. Recycling allows us to handle arbitrary list lengths with only as much `View` memory consumed as is needed for the rows visible on screen.

Note that row recycling is only an issue if we are creating the rows ourself. If we let `ArrayAdapter` create the rows, by leveraging its implementation of `getView()` as shown in the `FancyLists/Dynamic` project, then it deals with the recycling.

Using the Holder Pattern

Another somewhat expensive operation we do a lot with fancy views is call `findViewById()`. This dives into our inflated row and pulls out widgets by

their assigned identifiers, so we can customize the widget contents (e.g., change the text of a `TextView`, change the icon in an `ImageView`). Since `findViewById()` can find widgets anywhere in the tree of children of the row's root `View`, this could take a fair number of instructions to execute, particularly if we keep having to re-find widgets we had found once before.

In some GUI toolkits, this problem is avoided by having the composite `View` objects, like our rows, be declared totally in program code (in this case, Java). Then, accessing individual widgets is merely the matter of calling a getter or accessing a field. And you can certainly do that with Android, but the code gets rather verbose. What would be nice is a way where we can still use the layout XML yet cache our row's key child widgets so we only have to find them once.

That's where the holder pattern comes into play, in a class we'll call `ViewHolder`.

All `View` objects have `getTag()` and `setTag()` methods. These allow you to associate an arbitrary object with the widget. What the holder pattern does is use that "tag" to hold an object that, in turn, holds each of the child widgets of interest. By attaching that holder to the row `View`, every time we use the row, we already have access to the child widgets we care about, without having to call `findViewById()` again.

So, let's take a look at one of these holder classes (taken from the `FancyLists/ViewHolder` sample project):

```java
package com.commonsware.android.fancylists.five;

import android.view.View;
import android.widget.ImageView;

class ViewHolder {
  ImageView icon=null;

  ViewHolder(View base) {
    this.icon=(ImageView)base.findViewById(R.id.icon);
  }
}
```

`ViewHolder` holds onto the child widgets, initialized via `findViewById()` in its constructor. The widgets are simply package-protected data members, accessible from other classes in this project...such as a `ViewHolderDemo` activity. In this case, we are only holding onto one widget – the icon – since we will let ArrayAdapter handle our label for us.

Using `ViewHolder` is a matter of creating an instance whenever we inflate a row and attaching said instance to the row `View` via `setTag()`, as shown in this rewrite of `getView()`, found in `ViewHolderDemo`:

```
public View getView(int position, View convertView,
                    ViewGroup parent) {
  View row=super.getView(position, convertView, parent);
  ViewHolder holder=(ViewHolder)row.getTag();

  if (holder==null) {
    holder=new ViewHolder(row);
    row.setTag(holder);
  }

  if (getModel(position).length()>4) {
    holder.icon.setImageResource(R.drawable.delete);
  }
  else {
    holder.icon.setImageResource(R.drawable.ok);
  }

  return(row);
}
```

Here, we go back to allowing `ArrayAdapter` to handle our row inflation and recycling for us. If the call to `getTag()` on the row returns null, we know we need to create a new `ViewHolder`, which we then attach to the row via `setTag()` for later reuse. Then, accessing the child widgets is merely a matter of accessing the data members on the holder. The first time the `ListView` is displayed, all new rows need to be inflated, and we wind up creating a `ViewHolder` for each. As the user scrolls, rows get recycled, and we can reuse their corresponding `ViewHolder` widget caches.

Using a holder helps performance, but the effect is not as dramatic. Whereas recycling can give you a 150% performance improvement, adding in a holder increases the improvement to 175%. Hence, while you may wish to implement recycling up front when you create your adapter, adding in a

holder might be something you deal with later, when you are working specifically on performance tuning.

In this particular case, we certainly could simplify all of this, by skipping `ViewHolder` and using `getTag()` and `setTag()` with the `ImageView` directly. This example is written as it is to demonstrate how to handle a more complex scenario, where you might have several widgets that would need to be cached via the holder pattern.

Interactive Rows

Lists with pretty icons next to them are all fine and well. But, can we create `ListView` widgets whose rows contain interactive child widgets instead of just passive widgets like `TextView` and `ImageView`? For example, there is a `RatingBar` widget that allows users to assign a rating by clicking on a set of star icons. Could we combine the `RatingBar` with text in order to allow people to scroll a list of, say, songs and rate them right inside the list?

There is good news and bad news.

The good news is that interactive widgets in rows work just fine. The bad news is that it is a little tricky, specifically when it comes to taking action when the interactive widget's state changes (e.g., a value is typed into a field). We need to store that state somewhere, since our `RatingBar` widget will be recycled when the `ListView` is scrolled. We need to be able to set the `RatingBar` state based upon the actual word we are viewing as the `RatingBar` is recycled, and we need to save the state when it changes so it can be restored when this particular row is scrolled back into view.

What makes this interesting is that, by default, the `RatingBar` has absolutely no idea what item in the `ArrayAdapter` it represents. After all, the `RatingBar` is just a widget, used in a row of a `ListView`. We need to teach the rows which item in the `ArrayAdapter` they are currently displaying, so when their `RatingBar` is checked, they know which item's state to modify.

So, let's see how this is done, using the activity in the FancyLists/RateList sample project. We will use the same basic classes as our previous demo – we are showing a list of nonsense words, which you can then rate. In addition, words given a top rating are put in all caps:

```
package com.commonsware.android.fancylists.six;

import android.app.Activity;
import android.os.Bundle;
import android.app.ListActivity;
import android.view.View;
import android.view.ViewGroup;
import android.view.LayoutInflater;
import android.widget.AdapterView;
import android.widget.ArrayAdapter;
import android.widget.RatingBar;
import android.widget.LinearLayout;
import android.widget.ListView;
import android.widget.TextView;
import java.util.ArrayList;

public class RateListDemo extends ListActivity {
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet",
          "consectetuer", "adipiscing", "elit", "morbi", "vel",
          "ligula", "vitae", "arcu", "aliquet", "mollis",
          "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);

    ArrayList<RowModel> list=new ArrayList<RowModel>();

    for (String s : items) {
      list.add(new RowModel(s));
    }

    setListAdapter(new RatingAdapter(list));
  }

  private RowModel getModel(int position) {
    return(((RatingAdapter)getListAdapter()).getItem(position));
  }

  class RatingAdapter extends ArrayAdapter<RowModel> {
    RatingAdapter(ArrayList<RowModel> list) {
      super(RateListDemo.this, R.layout.row, R.id.label, list);
    }

    public View getView(int position, View convertView,
```

```
                        ViewGroup parent) {
    View row=super.getView(position, convertView, parent);
    ViewHolder holder=(ViewHolder)row.getTag();

    if (holder==null) {
      holder=new ViewHolder(row);
      row.setTag(holder);

      RatingBar.OnRatingBarChangeListener l=
                  new RatingBar.OnRatingBarChangeListener() {
        public void onRatingChanged(RatingBar ratingBar,
                                    float rating,
                                    boolean fromTouch)  {
          Integer myPosition=(Integer)ratingBar.getTag();
          RowModel model=getModel(myPosition);

          model.rating=rating;

          LinearLayout parent=(LinearLayout)ratingBar.getParent();
          TextView label=(TextView)parent.findViewById(R.id.label);

          label.setText(model.toString());
        }
      };

      holder.rate.setOnRatingBarChangeListener(l);
    }

    RowModel model=getModel(position);

    holder.rate.setTag(new Integer(position));
    holder.rate.setRating(model.rating);

    return(row);
  }
}

class RowModel {
  String label;
  float rating=2.0f;

  RowModel(String label) {
    this.label=label;
  }

  public String toString() {
    if (rating>=3.0) {
      return(label.toUpperCase());
    }

    return(label);
  }
}
}
```

Here is what is different in this activity and `getView()` implementation than before:

1. While we are still using `String[]` items as the list of nonsense words, rather than pour that `String` array straight into an `ArrayAdapter`, we turn it into a list of `RowModel` objects. `RowModel` is the mutable model: it holds the nonsense word plus the current checked state. In a real system, these might be objects populated from a database, and the properties would have more business meaning.

2. Utility methods like `onListItemClick()` had to be updated to reflect the change from a pure-`String` model to use a `RowModel`.

3. The `ArrayAdapter` subclass (`CheckAdapter`), in `getView()`, lets `ArrayAdapter` inflate and recycle the row, then checks to see if we have a `ViewHolder` in the row's tag. If not, we create a new `ViewHolder` and associate it with the row. For the row's `RatingBar`, we add an anonymous `onRatingChanged()` listener that looks at the row's tag (`getTag()`) and converts that into an `Integer`, representing the position within the `ArrayAdapter` that this row is displaying. Using that, the rating bar can get the actual `RowModel` for the row and update the model based upon the new state of the rating bar. It also updates the text adjacent to the `RatingBar` when checked to match the rating bar state.

4. We always make sure that the `RatingBar` has the proper contents and has a tag (via `setTag()`) pointing to the position in the adapter the row is displaying.

The row layout is very simple: just a `RatingBar` and a `TextView` inside a `LinearLayout`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="wrap_content"
  android:orientation="horizontal"
>
  <RatingBar
    android:id="@+id/rate"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:numStars="3"
```

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```
      android:stepSize="1"
      android:rating="2" />
   <TextView
      android:id="@+id/label"
      android:padding="2dip"
      android:textSize="18sp"
      android:layout_gravity="left|center_vertical"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"/>
</LinearLayout>
```

The ViewHolder is similarly simple, just extracting the RatingBar out of the row View for caching purposes:

```
package com.commonsware.android.fancylists.six;

import android.view.View;
import android.widget.RatingBar;

class ViewHolder {
  RatingBar rate=null;

  ViewHolder(View base) {
    this.rate=(RatingBar)base.findViewById(R.id.rate);
  }
}
```

And the result is what you would expect, visually:
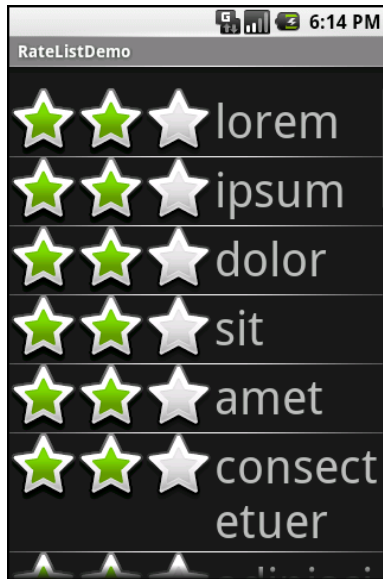
Figure 33. The RateListDemo application, as initially launched

This includes the toggled rating bars turning their words into all caps:
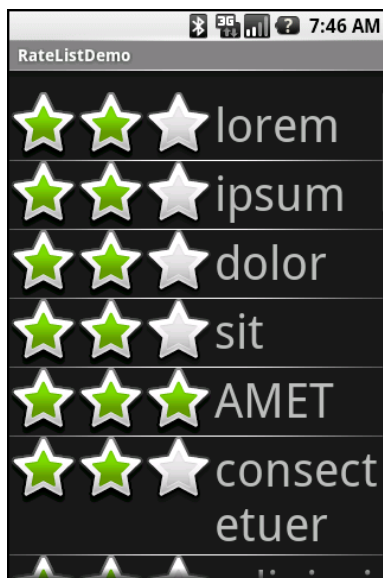
Figure 34. The same application, showing a top-rated word

Still More Widgets and Containers

This book has covered a number of widgets and containers so far. This chapter is the last that focuses exclusively on widgets and containers, covering a number of popular options, from date and time widgets to tabs. After this chapter, we will still introduce the occasional new widget, but in the context of some other topic, such as introducing the `ProgressBar` in the chapter on threads.

Pick and Choose

With limited-input devices like phones, having widgets and dialogs that are aware of the type of stuff somebody is supposed to be entering is very helpful. It minimizes keystrokes and screen taps, plus reduces the chance of making some sort of error (e.g., entering a letter someplace where only numbers are expected).

As shown previously, `EditText` has content-aware flavors for entering in numbers, phone numbers, etc. Android also supports widgets (`DatePicker`, `TimePicker`) and dialogs (`DatePickerDialog`, `TimePickerDialog`) for helping users enter dates and times.

The `DatePicker` and `DatePickerDialog` allow you to set the starting date for the selection, in the form of a year, month, and day of month value. Note

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that the month runs from 0 for January through 11 for December. Most importantly, each let you provide a callback object (`OnDateChangedListener` or `OnDateSetListener`) where you are informed of a new date selected by the user. It is up to you to store that date someplace, particularly if you are using the dialog, since there is no other way for you to get at the chosen date later on.

Similarly, `TimePicker` and `TimePickerDialog` let you:

- set the initial time the user can adjust, in the form of an hour (0 through 23) and a minute (0 through 59)

- indicate if the selection should be in 12-hour mode with an AM/PM toggle, or in 24-hour mode (what in the US is thought of as "military time" and much of the rest of the world is thought of as "the way times are supposed to be")

- provide a callback object (`OnTimeChangedListener` or `OnTimeSetListener`) to be notified of when the user has chosen a new time, which is supplied to you in the form of an hour and minute

For example, from the `Fancy/Chrono` sample project, here's a trivial layout containing a label and two buttons – the buttons will pop up the dialog flavors of the date and time pickers:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <TextView android:id="@+id/dateAndTime"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    />
  <Button android:id="@+id/dateBtn"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:text="Set the Date"
    android:onClick="chooseDate"
    />
  <Button android:id="@+id/timeBtn"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
```

```
    android:text="Set the Time"
    android:onClick="chooseTime"
    />
</LinearLayout>
```

The more interesting stuff comes in the Java source:

```java
package com.commonsware.android.chrono;

import android.app.Activity;
import android.os.Bundle;
import android.app.DatePickerDialog;
import android.app.TimePickerDialog;
import android.view.View;
import android.widget.DatePicker;
import android.widget.TimePicker;
import android.widget.TextView;
import java.text.DateFormat;
import java.util.Calendar;

public class ChronoDemo extends Activity {
  DateFormat fmtDateAndTime=DateFormat.getDateTimeInstance();
  TextView dateAndTimeLabel;
  Calendar dateAndTime=Calendar.getInstance();

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    dateAndTimeLabel=(TextView)findViewById(R.id.dateAndTime);

    updateLabel();
  }

  public void chooseDate(View v) {
    new DatePickerDialog(ChronoDemo.this, d,
                         dateAndTime.get(Calendar.YEAR),
                         dateAndTime.get(Calendar.MONTH),
                         dateAndTime.get(Calendar.DAY_OF_MONTH))
      .show();
  }

  public void chooseTime(View v) {
    new TimePickerDialog(ChronoDemo.this, t,
                         dateAndTime.get(Calendar.HOUR_OF_DAY),
                         dateAndTime.get(Calendar.MINUTE),
                         true)
      .show();
  }

  private void updateLabel() {
    dateAndTimeLabel.setText(fmtDateAndTime
```

```
                           .format(dateAndTime.getTime()));
  }

  DatePickerDialog.OnDateSetListener d=new DatePickerDialog.OnDateSetListener()
{
    public void onDateSet(DatePicker view, int year, int monthOfYear,
                          int dayOfMonth) {
      dateAndTime.set(Calendar.YEAR, year);
      dateAndTime.set(Calendar.MONTH, monthOfYear);
      dateAndTime.set(Calendar.DAY_OF_MONTH, dayOfMonth);
      updateLabel();
    }
  };

  TimePickerDialog.OnTimeSetListener t=new TimePickerDialog.OnTimeSetListener()
{
    public void onTimeSet(TimePicker view, int hourOfDay,
                          int minute) {
      dateAndTime.set(Calendar.HOUR_OF_DAY, hourOfDay);
      dateAndTime.set(Calendar.MINUTE, minute);
      updateLabel();
    }
  };
}
```

The "model" for this activity is just a Calendar instance, initially set to be the current date and time. We pour it into the view via a DateFormat formatter. In the updateLabel() method, we take the current Calendar, format it, and put it in the TextView.

Each button has a corresponding method that will get control when the user clicks it (chooseDate() and chooseTime()). When the button is clicked, either a DatePickerDialog or a TimePickerDialog is shown. In the case of the DatePickerDialog, we give it a OnDateSetListener callback that updates the Calendar with the new date (year, month, day of month). We also give the dialog the last-selected date, getting the values out of the Calendar. In the case of the TimePickerDialog, it gets a OnTimeSetListener callback to update the time portion of the Calendar, the last-selected time, and a true indicating we want 24-hour mode on the time selector.

With all this wired together, the resulting activity looks like this:
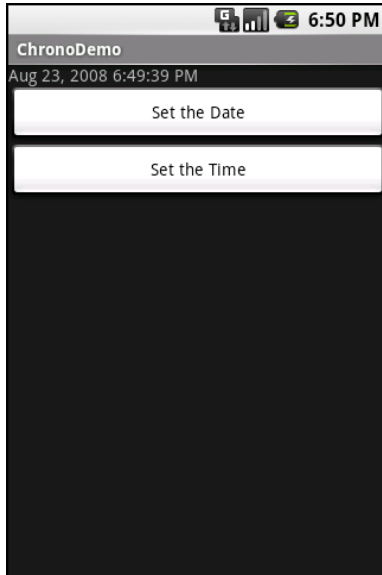
Figure 35. The ChronoDemo sample application, as initially launched

Figure 36. The same application, showing the date picker dialog
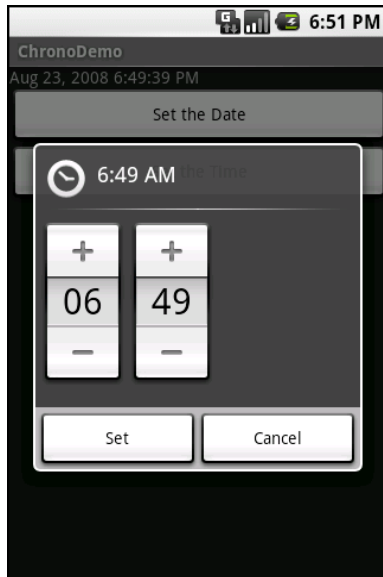
Figure 37. The same application, showing the time picker dialog

Time Keeps Flowing Like a River

If you want to display the time, rather than have users enter the time, you may wish to use the `DigitalClock` or `AnalogClock` widgets. These are extremely easy to use, as they automatically update with the passage of time. All you need to do is put them in your layout and let them do their thing.

For example, from the `Fancy/Clocks` sample application, here is an XML layout containing both `DigitalClock` and `AnalogClock`:

```
<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <AnalogClock android:id="@+id/analog"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:layout_centerHorizontal="true"
    android:layout_alignParentTop="true"
    />
```

```
  <DigitalClock android:id="@+id/digital"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_centerHorizontal="true"
    android:layout_below="@id/analog"
    />
</RelativeLayout>
```

Without any Java code other than the generated stub, we can build this project and get the following activity:
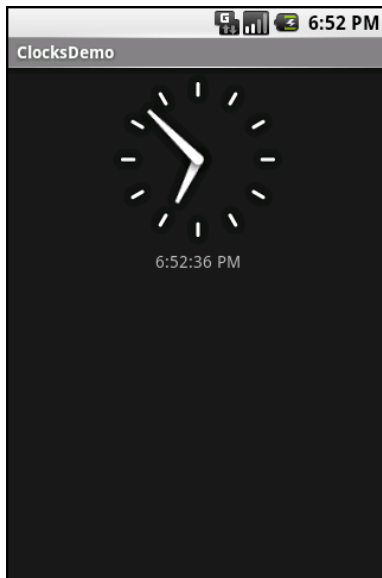
Figure 38. The ClocksDemo sample application

If you are looking for more of a timer, `Chronometer` may be of interest. With a `Chronometer`, you can track elapsed time from a starting point. You simply tell it when to `start()` and `stop()`, and possibly override the format string that displays the text:
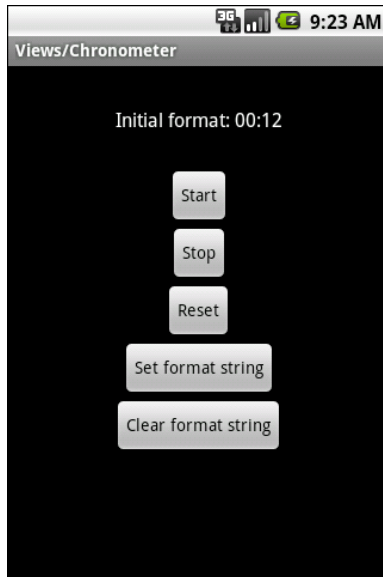
Figure 39. The Views/Chronometer API Demo from the Android 2.0 SDK

Seeking Resolution

The SeekBar in an input widget, allowing the user to select a value along a range of possible values:
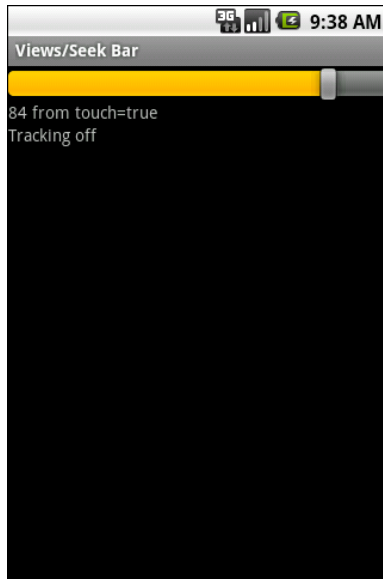
Figure 40. The Views/SeekBar API Demo from the Android 2.0 SDK

The user can either drag the "thumb" or click on either side of it to reposition the thumb. The thumb then points to a particular value along a range. That range will be 0 to some maximum value, 100 by default, that you control via a call to setMax(). You can find out what the current position is via getProgress(), or find out when the user makes a change to the thumb's position by registering a listener via setOnSeekBarChangeListener().

We saw another variation on this theme with the RatingBar in the previous chapter.

Putting It On My Tab

The general Android philosophy is to keep activities short and sweet. If there is more information than can reasonably fit on one screen, albeit perhaps with scrolling, then it perhaps belongs in another activity kicked off via an Intent, as will be described later in this book. However, that can be complicated to set up. Moreover, sometimes there legitimately is a lot of information that needs to be collected to be processed as an atomic operation.

In a traditional UI, you might use tabs to accomplish this end, such as a `JTabbedPane` in Java/Swing. In Android, you now have an option of using a `TabHost` container in much the same way – a portion of your activity's screen is taken up with tabs which, when clicked, swap out part of the view and replace it with something else. For example, you might have an activity with a tab for entering a location and a second tab for showing a map of that location.

Some GUI toolkits refer to "tabs" as being just the things a user clicks on to toggle from one view to another. Some toolkits refer to "tabs" as being the combination of the clickable button-ish element and the content that appears when that tab is chosen. Android treats the tab buttons and contents as discrete entities, so we will call them "tab buttons" and "tab contents" in this section.

The Pieces

There are a few widgets and containers you need to use in order to set up a tabbed portion of a view:

- `TabHost` is the overarching container for the tab buttons and tab contents

- `TabWidget` implements the row of tab buttons, which contain text labels and optionally contain icons

- `FrameLayout` is the container for the tab contents; each tab content is a child of the `FrameLayout`

This is similar to the approach that Mozilla's XUL takes. In XUL's case, the `tabbox` element corresponds to Android's `TabHost`, the `tabs` element corresponds to `TabWidget`, and `tabpanels` corresponds to the `FrameLayout`.

For example, here is a layout definition for a tabbed activity, from `Fancy/Tab`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<TabHost xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/tabhost"
```

```
  android:layout_width="fill_parent"
  android:layout_height="fill_parent">
  <LinearLayout
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent">
    <TabWidget android:id="@android:id/tabs"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
    />
    <FrameLayout android:id="@android:id/tabcontent"
      android:layout_width="fill_parent"
      android:layout_height="fill_parent">
      <AnalogClock android:id="@+id/tab1"
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:layout_centerHorizontal="true"
      />
      <Button android:id="@+id/tab2"
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:text="A semi-random button"
      />
    </FrameLayout>
  </LinearLayout>
</TabHost>
```

Note that the `TabWidget` and `FrameLayout` are indirect children of the `TabHost`, and the `FrameLayout` itself has children representing the various tabs. In this case, there are two tabs: a clock and a button. In a more complicated scenario, the tabs are probably some form of container (e.g., `LinearLayout`) with their own contents.

Wiring It Together

You can put these widgets in a regular `Activity` or a `TabActivity`. `TabActivity`, like `ListActivity`, wraps a common UI pattern (activity made up entirely of tabs) into a pattern-aware activity subclass. If you wish to use the `TabActivity`, you must give the `TabHost` an `android:id` of `@android:id/tabhost`. Conversely, if you do not wish to use `TabActivity`, you need to get your `TabHost` via `findViewById()`, then call `setup()` on the `TabHost`, before you do anything else.

The rest of the Java code needs to tell the `TabHost` what views represent the tab contents and what the tab buttons should look like. This is all wrapped

up in `TabSpec` objects. You get a `TabSpec` instance from the host via `newTabSpec()`, fill it out, then add it to the host in the proper sequence.

The two key methods on `TabSpec` are:

- `setContent()`, where you indicate what goes in the tab content for this tab, typically the `android:id` of the view you want shown when this tab is selected

- `setIndicator()`, where you provide the caption for the tab button and, in some flavors of this method, supply a `Drawable` to represent the icon for the tab

Note that tab "indicators" can actually be views in their own right, if you need more control than a simple label and optional icon.

Also note that you must call `setup()` on the `TabHost` before configuring any of these `TabSpec` objects. The call to `setup()` is not needed if you are using the `TabActivity` base class for your activity.

For example, here is the Java code to wire together the tabs from the preceding layout example:

```
package com.commonsware.android.fancy;

import android.app.Activity;
import android.os.Bundle;
import android.widget.TabHost;

public class TabDemo extends Activity {
  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    TabHost tabs=(TabHost)findViewById(R.id.tabhost);

    tabs.setup();

    TabHost.TabSpec spec=tabs.newTabSpec("tag1");

    spec.setContent(R.id.tab1);
    spec.setIndicator("Clock");
    tabs.addTab(spec);
```

```
    spec=tabs.newTabSpec("tag2");
    spec.setContent(R.id.tab2);
    spec.setIndicator("Button");
    tabs.addTab(spec);
  }
}
```

We find our `TabHost` via the familiar `findViewById()` method, then have it setup(). After that, we get a `TabSpec` via `newTabSpec()`, supplying a tag whose purpose is unknown at this time. Given the spec, you call `setContent()` and `setIndicator()`, then call `addTab()` back on the `TabHost` to register the tab as available for use. Finally, you can choose which tab is the one to show via `setCurrentTab()`, providing the 0-based index of the tab.

The result?
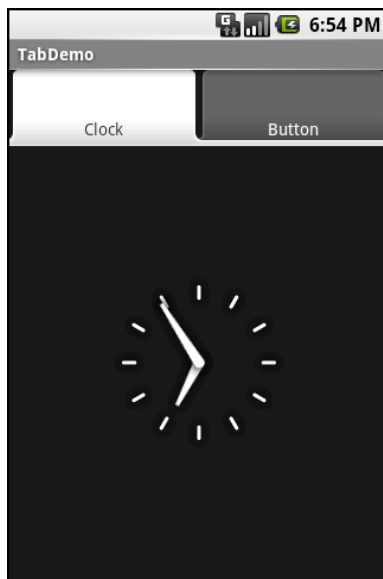
Figure 41. The TabDemo sample application, showing the first tab
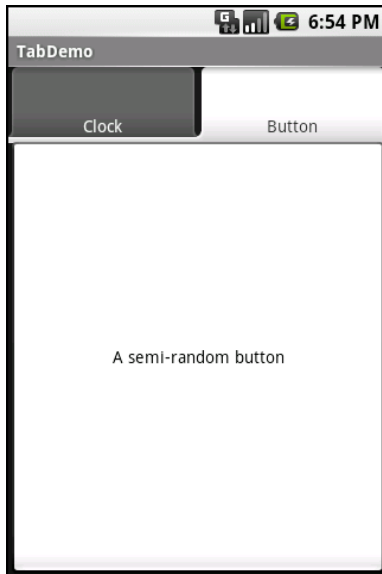
Figure 42. The same application, showing the second tab

Adding Them Up

TabWidget is set up to allow you to easily define tabs at compile time. However, sometimes, you want to add tabs to your activity during runtime. For example, imagine an email client where individual email messages get opened in their own tab, for easy toggling between messages. In this case, you do not know how many tabs or what their contents will be until runtime, when the user chooses to open a message.

Fortunately, Android also supports adding tabs dynamically at runtime.

Adding tabs dynamically at runtime works much like the compile-time tabs shown above, except you use a different flavor of setContent(), one that takes a TabHost.TabContentFactory instance. This is just a callback that will be invoked – you provide an implementation of createTabContent() and use it to build and return the View that becomes the content of the tab.

Let us take a look at an example (Fancy/DynamicTab).

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First, here is some layout XML for an activity that sets up the tabs and defines one tab, containing a single button:

```xml
<?xml version="1.0" encoding="utf-8"?>
<TabHost xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/tabhost"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent">
  <LinearLayout
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent">
    <TabWidget android:id="@android:id/tabs"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
    />
    <FrameLayout android:id="@android:id/tabcontent"
      android:layout_width="fill_parent"
      android:layout_height="fill_parent">
      <Button android:id="@+id/buttontab"
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:text="A semi-random button"
        android:onClick="addTab"
      />
    </FrameLayout>
  </LinearLayout>
</TabHost>
```

What we want to do is add new tabs whenever the button is clicked. That can be accomplished in just a few lines of code:

```java
package com.commonsware.android.dynamictab;

import android.app.Activity;
import android.os.Bundle;
import android.view.View;
import android.widget.AnalogClock;
import android.widget.TabHost;

public class DynamicTabDemo extends Activity {
  private TabHost tabs=null;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    tabs=(TabHost)findViewById(R.id.tabhost);
    tabs.setup();
```

```
    TabHost.TabSpec spec=tabs.newTabSpec("buttontab");

    spec.setContent(R.id.buttontab);
    spec.setIndicator("Button");
    tabs.addTab(spec);
  }

  public void addTab(View v) {
    TabHost.TabSpec spec=tabs.newTabSpec("tag1");

    spec.setContent(new TabHost.TabContentFactory() {
      public View createTabContent(String tag) {
        return(new AnalogClock(DynamicTabDemo.this));
      }
    });

    spec.setIndicator("Clock");
    tabs.addTab(spec);
  }
}
```

In our button's `addTab()` callback, we create a `TabHost.TabSpec` object and give it an anonymous `TabHost.TabContentFactory`. The factory, in turn, returns the `View` to be used for the tab – in this case, just an `AnalogClock`. The logic for constructing the tab's `View` could be much more elaborate, such as using `LayoutInflater` to construct a view from layout XML.

Initially, when the activity is launched, we just have the one tab:
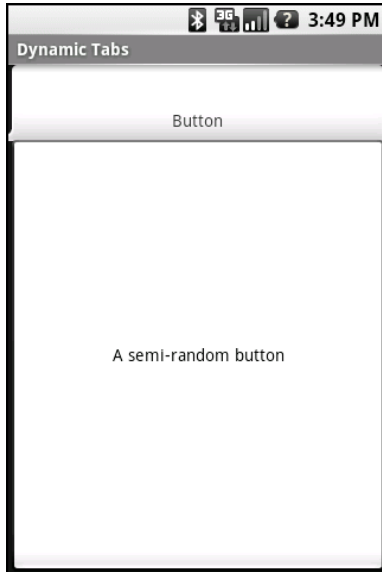
Figure 43. The DynamicTab application, with the single initial tab
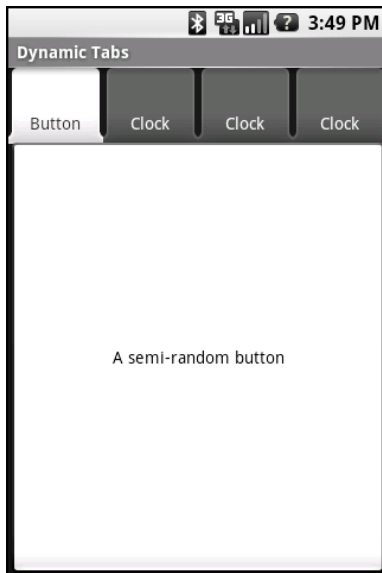
Figure 44. The DynamicTab application, with three dynamically-created tabs

Flipping Them Off

Sometimes, you want the overall effect of tabs (only some Views visible at a time), but you do not want the actual UI implementation of tabs. Maybe the tabs take up too much screen space. Maybe you want to switch between perspectives based on a gesture or a device shake. Or maybe you just like being different.

The good news is that the guts of the view-flipping logic from tabs can be found in the ViewFlipper container, which can be used in other ways than the traditional tab.

ViewFlipper inherits from FrameLayout, just like we used to describe the innards of a TabWidget. However, initially, it just shows the first child view. It is up to you to arrange for the views to flip, either manually by user interaction, or automatically via a timer.

For example, here is a layout for a simple activity (Fancy/Flipper1) using a Button and a ViewFlipper:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
  <Button android:id="@+id/flip_me"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:text="Flip Me!"
      android:onClick="flip"
      />
  <ViewFlipper android:id="@+id/details"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
    <TextView
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:textStyle="bold"
      android:textColor="#FF00FF00"
      android:text="This is the first panel"
    />
    <TextView
```

```
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:textStyle="bold"
      android:textColor="#FFFF0000"
      android:text="This is the second panel"
    />
    <TextView
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:textStyle="bold"
      android:textColor="#FFFFFF00"
      android:text="This is the third panel"
    />
  </ViewFlipper>
</LinearLayout>
```

Notice that the layout defines three child views for the ViewFlipper, each a TextView with a simple message. Of course, you could have very complicated child views, if you so chose.

To manually flip the views, we need to hook into the Button and flip them ourselves when the button is clicked:

```java
package com.commonsware.android.flipper1;

import android.app.Activity;
import android.os.Bundle;
import android.view.View;
import android.widget.ViewFlipper;

public class FlipperDemo extends Activity {
  ViewFlipper flipper;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    flipper=(ViewFlipper)findViewById(R.id.details);
  }

  public void flip(View v) {
    flipper.showNext();
  }
}
```

This is just a matter of calling showNext() on the ViewFlipper, like you can on any ViewAnimator class.

The result is a trivial activity: click the button, and the next `TextView` in sequence is displayed, wrapping around to the first after viewing the last:
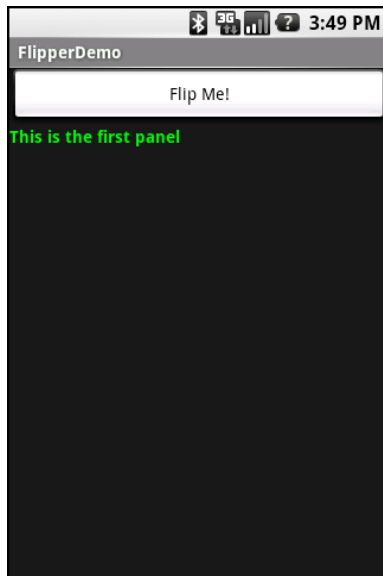
Figure 45. The Flipper1 application, showing the first panel
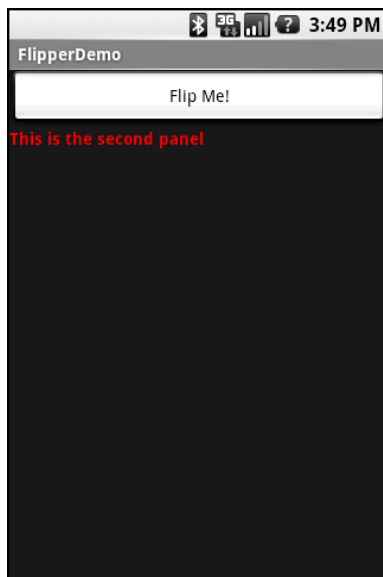
Figure 46. The same application, after switching to the second panel

This, of course, could be handled more simply by having a single `TextView` and changing the text and color on each click. However, you can imagine that the `ViewFlipper` contents could be much more complicated, like the contents you might put into a `TabView`.

As with the `TabWidget`, sometimes, your `ViewFlipper` contents may not be known at compile time. As with `TabWidget`, though, you can add new contents on the fly with ease.

For example, let us look at another sample activity (`Fancy/Flipper2`), using this layout:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
  <ViewFlipper android:id="@+id/details"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
  </ViewFlipper>
</LinearLayout>
```

Notice that the `ViewFlipper` has no contents at compile time. Also note that there is no `Button` for flipping between the contents – more on this in a moment.

For the `ViewFlipper` contents, we will create large `Button` widgets, each containing one of the random words used in many chapters in this book. And, we will set up the `ViewFlipper` to automatically rotate between the `Button` widgets:

```java
package com.commonsware.android.flipper2;

import android.app.Activity;
import android.os.Bundle;
import android.view.View;
import android.view.ViewGroup;
import android.widget.Button;
import android.widget.ViewFlipper;
```

```
public class FlipperDemo2 extends Activity {
  static String[] items={"lorem", "ipsum", "dolor", "sit", "amet",
                         "consectetuer", "adipiscing", "elit",
                         "morbi", "vel", "ligula", "vitae",
                         "arcu", "aliquet", "mollis", "etiam",
                         "vel", "erat", "placerat", "ante",
                         "porttitor", "sodales", "pellentesque",
                         "augue", "purus"};
  ViewFlipper flipper;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    flipper=(ViewFlipper)findViewById(R.id.details);

    for (String item : items) {
      Button btn=new Button(this);

      btn.setText(item);

      flipper.addView(btn,
                      new ViewGroup.LayoutParams(
                              ViewGroup.LayoutParams.FILL_PARENT,
                              ViewGroup.LayoutParams.FILL_PARENT));
    }

    flipper.setFlipInterval(2000);
    flipper.startFlipping();
  }
}
```

After iterating over the funky words, turning each into a Button, and adding the Button as a child of the ViewFlipper, we set up the flipper to automatically flip between children (flipper.setFlipInterval(2000);) and to start flipping (flipper.startFlipping();).

The result is an endless series of buttons, each appearing, then being replaced by the next button in sequence after 2 seconds, wrapping around to the first after the last has been shown:
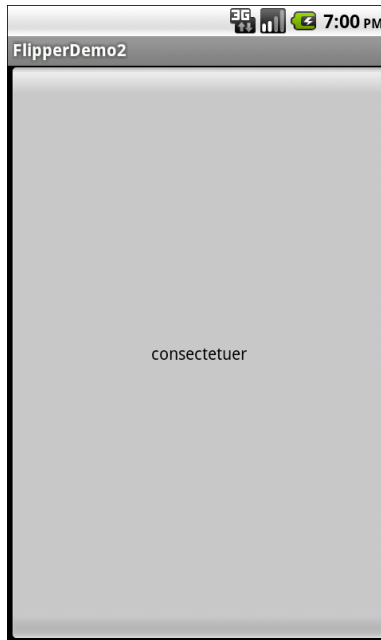
Figure 47. The Flipper2 application

The auto-flipping `ViewFlipper` is useful for status panels or other situations where you have a lot of information to display, but not much room. The key is that, since it automatically flips between views, expecting users to interact with individual views is dicey – the view might switch away part-way through their interaction.

Getting In Somebody's Drawer

For a long time, Android developers yearned for a sliding drawer container that worked like the one on the home screen, containing the icons for launching applications. The official implementation was in the open source code but was not part of the SDK...until Android 1.5, when they released `SlidingDrawer` for others to use.

Unlike most other Android containers, `SlidingDrawer` moves, switching from a closed to an open position. This puts some restrictions on what container the `SlidingDrawer` itself can be in. It needs to be a container that

allows multiple widgets to sit atop each other. `RelativeLayout` and `FrameLayout` satisfy this requirement, where `FrameLayout` is a container purely for stacking widgets atop one another. On the flip side, `LinearLayout` does not allow widgets to stack (they fall one after another in a row or column), and so you should not have a `SlidingDrawer` as an immediate child of a `LinearLayout`.

Here is a layout, showing a `SlidingDrawer` in a `FrameLayout`, from the `Fancy/DrawerDemo` project:

```xml
<?xml version="1.0" encoding="utf-8"?>
<FrameLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:background="#FF4444CC"
    >
  <SlidingDrawer
    android:id="@+id/drawer"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:handle="@+id/handle"
    android:content="@+id/content">
    <ImageView
      android:id="@id/handle"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:src="@drawable/tray_handle_normal"
    />
    <Button
      android:id="@id/content"
      android:layout_width="fill_parent"
      android:layout_height="fill_parent"
      android:text="I'm in here!"
    />
  </SlidingDrawer>
</FrameLayout>
```

The `SlidingDrawer` should contain two things:

1. A handle, frequently an `ImageView` or something along those lines, such as the one used here, pulled from the Android open source project

2. The contents of the drawer itself, usually some sort of container, though in this case we are using a `Button`

Moreover, SlidingDrawer needs to know the android:id values of the handle and contents, via the android:handle and android:content attributes, respectively. This tells the drawer how to animate itself as it slides open and closed.

Here is what the SlidingDrawer looks like closed, using the supplied handle:

Figure 48. A SlidingDrawer, closed

And here it is open, showing its contents:
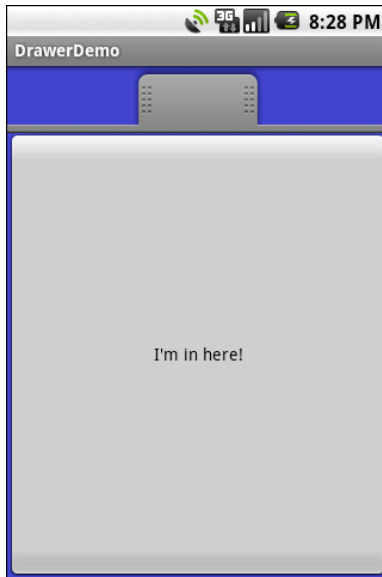
Figure 49. A SlidingDrawer, open

As one might expect, you can open and close the drawer from Java code as well as via user touch events. However, you have two sets of these methods, ones that take place instantaneously (`open()`, `close()`, and `toggle()`) and ones that use the animation (`animateOpen()`, `animateClose()`, `animateToggle()`). You can also `lock()` and `unlock()` the drawer; while locked, the drawer will not respond to touch events.

You can also register three types of callbacks if you wish:

1. A listener to be invoked when the drawer is opened
2. A listener to be invoked when the drawer is closed
3. A listener to be invoked when the drawer is "scrolled" (i.e., the user drags or flings the handle)

For example, the Launcher's `SlidingDrawer` toggles the icon on the handle from open to closed to "delete" (if you long-tap something on the desktop). It accomplishes this, in part, through callbacks like these.

SlidingDrawer can be vertical or horizontal. Note, though, that it keeps its orientation despite the screen orientation. In other words, if you rotate the Android device or emulator running DrawerDemo, the drawer always opens from the bottom – it does not always "stick" to the original side it opened from. This means that if you want the drawer to always open from the same side, like the Launcher does, you will need separate layouts for portrait versus landscape, a topic we discuss in the chapter on resources.

Other Good Stuff

Android offers AbsoluteLayout, where the contents are laid out based on specific coordinate positions. You tell AbsoluteLayout where to place a child in precise X,Y coordinates, and Android puts it there, no questions asked. On the plus side, this gives you precise positioning. On the minus side, it means your views will only look "right" on screens of a certain dimension, or it requires you to write a bunch of code to adjust the coordinates based on screen size. Since Android screens might run the gamut of sizes, plus have new sizes crop up periodically, using AbsoluteLayout could get quite annoying. Also, note that AbsoluteLayout is officially deprecated, meaning that while it is available to you, its use is discouraged.

Android also has the ExpandableListView. This provides a simplified tree representation, supporting two levels of depth: groups and children. Groups contain children; children are "leaves" of the tree. This requires a new set of adapters, since the ListAdapter family does not provide any sort of group information for the items in the list.

Here are some other widgets available in Android beyond those covered so far in this book:

- CheckedTextView: a TextView that can either have a checkbox or a radio button next to it, used with single-choice and multi-choice lists

- Chronometer: a stopwatch-style countdown timer

- Gallery: a horizontal scrolling selection widget, designed for thumbnail previews of images (e.g., camera photos, album covers)

- `MultiAutoCompleteTextView`: like an `AutoCompleteTextView`, except that the user can make multiple choices from the drop-down list, rather than just one

- `QuickContactBadge`: given the identity of a contact from the user's contacts database, displays a roster of icons representing actions to be performed on that contact (place a call, send a text message, send an email, etc.)

- `SeekBar`: a "slider" widget that allows the user to choose a value from a range

- `ToggleButton`: a two-state button where the states are indicated by a "light" and prose ("ON", "OFF") instead of a checkmark

- `ViewSwitcher` (and the `ImageSwitcher` and `TextSwitcher` subclasses): like a simplified `ViewFlipper` for toggling between two views

CHAPTER 10

The Input Method Framework

Android 1.5 introduced the input method framework (IMF), which is commonly referred to as "soft keyboards". However, the "soft keyboard" term is not necessarily accurate, as IMF could be used for handwriting recognition or other means of accepting text input via the screen.

Keyboards, Hard and Soft

Some Android devices have a hardware keyboard that is visible some of the time (when it is slid out). A few Android devices have a hardware keyboard that is always visible (so-called "bar" or "slab" phones). Most Android devices, though, have no hardware keyboard at all.

The IMF handles all of these scenarios. In short, if there is no hardware keyboard, an input method editor (IME) will be available to the user when they tap on an enabled `EditText`.

This requires no code changes to your application...if the default functionality of the IME is what you want. Fortunately, Android is fairly smart about guessing what you want, so it may be you can just test with the IME but otherwise make no specific code changes.

Of course, the keyboard may not quite behave how you would like. For example, in the `Basic/Field` sample project, the `FieldDemo` activity has the IME overlaying the multiple-line `EditText`:
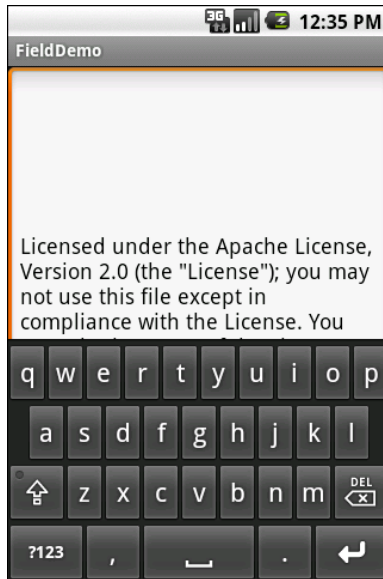
Figure 50. The input method editor, as seen in the FieldDemo sample application

It would be nice to have more control over how this appears, and for other behavior of the IME. Fortunately, the framework as a whole gives you many options for this, as is described over the bulk of this chapter.

Tailored To Your Needs

Android 1.1 and earlier offered many attributes on `EditText` widgets to control their style of input, such as `android:password` to indicate a field should be for password entry (shrouding the password keystrokes from prying eyes). Starting in Android 1.5, with the IMF, many of these have been combined into a single `android:inputType` attribute.

The `android:inputType` attribute takes a class plus modifiers, in a pipe-delimited (where | is the pipe character). The class generally describes what the user is allowed to input, and this determines the basic set of keys available on the soft keyboard. The available classes are:

- `text` (the default)
- `number`

- phone

- datetime

- date

- time

Many of these classes offer one or more modifiers, to further refine what the user will be entering. To help explain those, take a look at the `res/layout/main.xml` file from the `InputMethod/IMEDemo1` project:

```xml
<?xml version="1.0" encoding="utf-8"?>
<TableLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:stretchColumns="1"
  >
  <TableRow>
    <TextView
      android:text="No special rules:"
    />
    <EditText
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="Email address:"
    />
    <EditText
      android:inputType="text|textEmailAddress"
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="Signed decimal number:"
    />
    <EditText
      android:inputType="number|numberSigned|numberDecimal"
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="Date:"
    />
    <EditText
      android:inputType="date"
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="Multi-line text:"
    />
```

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```
    <EditText
      android:inputType="text|textMultiLine|textAutoCorrect"
      android:minLines="3"
      android:gravity="top"
    />
  </TableRow>
</TableLayout>
```

Here, you will see a `TableLayout` containing five rows, each demonstrating a slightly different flavor of `EditText`:

1. One has no attributes at all on the `EditText`, meaning you get a plain text entry field

2. One has `android:inputType = "text|textEmailAddress"`, meaning it is text entry, but specifically seeks an email address

3. One allows for signed decimal numeric input, via `android:inputType = "number|numberSigned|numberDecimal"`

4. One is set up to allow for data entry of a date (`android:inputType = "date"`)

5. The last allows for multi-line input with auto-correction of probable spelling errors (`android:inputType = "text|textMultiLine| textAutoCorrect"`)

The class and modifiers tailor the keyboard. So, a plain text entry field results in a plain soft keyboard:
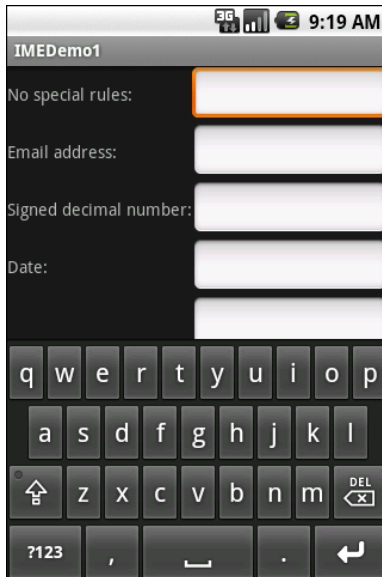
Figure 51. A standard input method editor (a.k.a., soft keyboard)

An email address field puts the @ symbol on the soft keyboard, at the cost of a smaller spacebar:
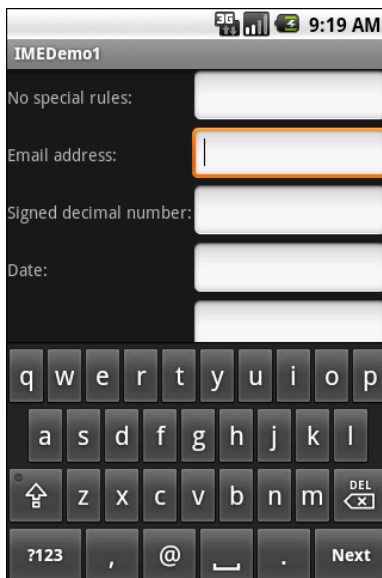
Figure 52. The input method editor for email addresses

Numbers and dates restrict the keys to numeric keys, plus a set of symbols that may or may not be valid on a given field:
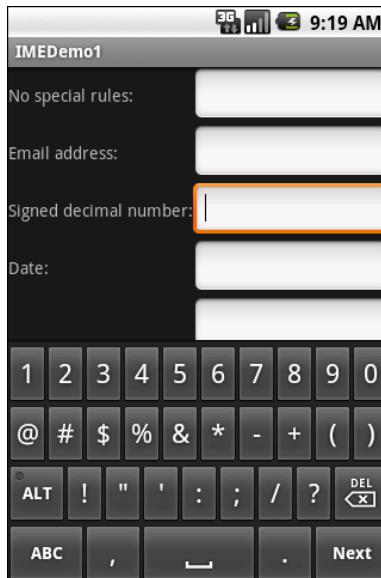
Figure 53. The input method editor for signed decimal numbers

And so on.

By choosing the appropriate `android:inputType`, you can give the user a soft keyboard that best suits what it is they should be entering.

Tell Android Where It Can Go

You may have noticed a subtle difference between the first and second input method editors, beyond the addition of the @ key. If you look in the lower-right corner of the soft keyboard, the second field's editor has a "Next" button, while the first field's editor has a newline button.

This points out two things:

1. `EditText` widgets are multi-line by default if you do not specify `android:inputType`

2. You can control what goes on with that lower-right-hand button, called the accessory button

By default, on an `EditText` where you have specified `android:inputType`, the accessory button will be "Next", moving you to the next `EditText` in sequence, or "Done", if you are on the last `EditText` on the screen. You can manually stipulate what the accessory button will be labeled via the `android:imeOptions` attribute. For example, in the `res/layout/main.xml` from `InputMethod/IMEDemo2`, you will see an augmented version of the previous example, where two input fields specify what their accessory button should look like:

```xml
<?xml version="1.0" encoding="utf-8"?>
<ScrollView xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
>
  <TableLayout
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:stretchColumns="1"
    >
    <TableRow>
      <TextView
        android:text="No special rules:"
      />
      <EditText
      />
    </TableRow>
    <TableRow>
      <TextView
        android:text="Email address:"
      />
      <EditText
        android:inputType="text|textEmailAddress"
        android:imeOptions="actionSend"
      />
    </TableRow>
    <TableRow>
      <TextView
        android:text="Signed decimal number:"
      />
      <EditText
        android:inputType="number|numberSigned|numberDecimal"
        android:imeOptions="actionDone"
      />
    </TableRow>
    <TableRow>
      <TextView
```

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```
      android:text="Date:"
    />
    <EditText
      android:inputType="date"
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="Multi-line text:"
    />
    <EditText
      android:inputType="text|textMultiLine|textAutoCorrect"
      android:minLines="3"
      android:gravity="top"
    />
  </TableRow>
  </TableLayout>
</ScrollView>
```

Here, we attach a "Send" action to the accessory button for the email address (`android:imeOptions = "actionSend"`), and the "Done" action on the middle field (`android:imeOptions = "actionDone"`).

By default, "Next" will move the focus to the next `EditText` and "Done" will close up the input method editor. However, for those, or for any other ones like "Send", you can use `setOnEditorActionListener()` on `EditText` (technically, on the `TextView` superclass) to get control when the accessory button is clicked or the user presses the `<Enter>` key. You are provided with a flag indicating the desired action (e.g., `IME_ACTION_SEND`), and you can then do something to handle that request (e.g., send an email to the supplied email address).

Fitting In

You will notice that the `IMEDemo2` layout shown above has another difference from its `IMEDemo1` predecessor: the use of a `ScrollView` container wrapping the `TableLayout`. This ties into another level of control you have over the input method editors: what happens to your activity's own layout when the input method editor appears?

There are three possibilities, depending on circumstances:

- Android can "pan" your activity, effectively sliding the whole layout up to accommodate the input method editor, or overlaying your layout, depending on whether the `EditText` being edited is at the top or bottom. This has the effect of hiding some portion of your UI.

- Android can resize your activity, effectively causing it to shrink to a smaller screen dimension, allowing the input method editor to sit below the activity itself. This is great when the layout can readily be shrunk (e.g., it is dominated by a list or multi-line input field that does not need the whole screen to be functional).

- In landscape mode, Android may display the input method editor full-screen, obscuring your entire activity. This allows for a bigger keyboard and generally easier data entry.

Android controls the full-screen option purely on its own. And, by default, Android will choose between pan and resize modes depending on what your layout looks like. If you want to specifically choose between pan and resize, you can do so via an `android:windowSoftInputMode` attribute on the `<activity>` element in your `AndroidManifest.xml` file. For example, here is the manifest from `IMEDemo2`:

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
      package="com.commonsware.android.imf.two"
      android:versionCode="1"
      android:versionName="1.0">
    <application android:label="@string/app_name"
        android:icon="@drawable/cw">
        <activity android:name=".IMEDemo2"
                  android:label="@string/app_name"
                  android:windowSoftInputMode="adjustResize">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
    </application>
</manifest>
```

Because we specified resize, Android will shrink our layout to accommodate the input method editor. With the `ScrollView` in place, this means the scroll bar will appear as needed:
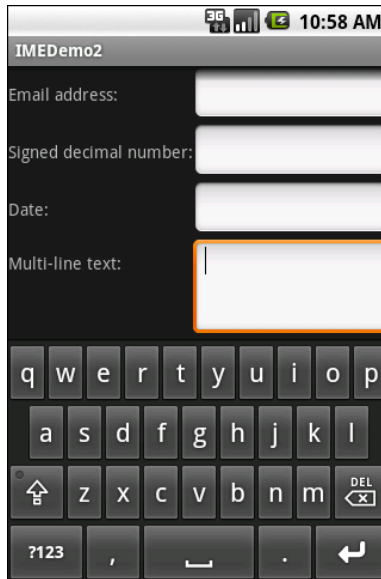
Figure 54. The shrunken, scrollable layout

Jane, Stop This Crazy Thing!

Sometimes, you need the input method editor to just go away. For example, if you make the action button be "Search", the user tapping that button will not automatically hide the editor.

To hide the editor, you will need to make a call to the `InputMethodManager`, a system service that controls these input method editors:

```
InputMethodManager
mgr=(InputMethodManager)getSystemService(INPUT_METHOD_SERVICE);

mgr.hideSoftInputFromWindow(fld.getWindowToken(), 0);
```

(where `fld` is the `EditText` whose input method editor you want to hide)

This will always close the input method editor. However, bear in mind that there are two ways for a user to have opened that input method editor in the first place:

1. If their device does not have a hardware keyboard exposed, and they tap on the `EditText`, the input method editor should appear

2. If they previously dismissed the editor, or if they are using the editor for a widget that does not normally pop one up (e.g., `ListView`), and they long-tap on the MENU button, the input method editor should appear

If you only want to close the input method editor for the first scenario, but not the second, use `InputMethodManager.HIDE_IMPLICIT_ONLY` as a flag for the second parameter to your call to `hideSoftInputFromWindow()`, instead of the `0` shown in the previous example.

Applying Menus

Like applications for the desktop and some mobile operating systems, Android supports activities with "application" menus. Most Android phones will have a dedicated menu key for popping up the menu; other devices will offer alternate means for triggering the menu to appear, such as the on-screen button used by the ARCHOS 5 Android tablet.

Also, as with many GUI toolkits, you can create "context menus". On a traditional GUI, this might be triggered by the right-mouse button. On mobile devices, context menus typically appear when the user "taps-and-holds" over a particular widget. For example, if a `TextView` had a context menu, and the device was designed for finger-based touch input, you could push the `TextView` with your finger, hold it for a second or two, and a pop-up menu will appear for the user to choose from.

Flavors of Menu

Android considers the two types of menu described above as being the "options menu" and "context menu". The options menu is triggered by pressing the hardware "Menu" button on the device, while the context menu is raised by a tap-and-hold on the widget sporting the menu.

In addition, the options menu operates in one of two modes: icon and expanded. When the user first presses the "Menu" button, the icon mode will appear, showing up to the first six menu choices as large, finger-

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friendly buttons in a grid at the bottom of the screen. If the menu has more than six choices, the sixth button will become "More" – clicking that option will bring up the expanded mode, showing the remaining choices not visible in the regular menu. The menu is scrollable, so the user can get to any of the menu choices.

Menus of Options

Rather than building your activity's options menu during `onCreate()`, the way you wire up the rest of your UI, you instead need to implement `onCreateOptionsMenu()`. This callback receives an instance of `Menu`.

The first thing you should do is chain upward to the superclass (`super.onCreateOptionsMenu(menu)`), so the Android framework can add in any menu choices it feels are necessary. Then, you can go about adding your own options, described below.

If you will need to adjust the menu during your activity's use (e.g., disable a now-invalid menu choice), just hold onto the `Menu` instance you receive in `onCreateOptionsMenu()`. Or, implement `onPrepareOptionsMenu()`, which is called just before displaying the menu each time it is requested.

Given that you have received a `Menu` object via `onCreateOptionsMenu()`, you add menu choices by calling `add()`. There are many flavors of this method, which require some combination of the following parameters:

- A group identifier (`int`), which should be `NONE` unless you are creating a specific grouped set of menu choices for use with `setGroupCheckable()` (see below)

- A choice identifier (also an `int`), for use in identifying this choice in the `onOptionsItemSelected()` callback when a menu choice is chosen

- An order identifier (yet another `int`), for indicating where this menu choice should be slotted if the menu has Android-supplied choices alongside your own – for now, just use `NONE`

- The text of the menu choice, as a String or a resource ID

The add() family of methods all return an instance of MenuItem, where you can adjust any of the menu item settings you have already set (e.g., the text of the menu choice). You can also set the shortcuts for the menu choice – single-character mnemonics that choose that menu choice when the menu is visible. Android supports both an alphabetic (or "qwerty") set of shortcuts and a numeric set of shortcuts. These are set individually by calling setAlphabeticShortcut() and setNumericShortcut() respectively. The menu is placed into alphabetic shortcut mode by calling setQwertyMode() on the menu with a true parameter.

The choice and group identifiers are keys used to unlock additional menu features, such as:

- Calling MenuItem#setCheckable() with a choice identifier, to control if the menu choice has a two-state checkbox alongside the title, where the checkbox value gets toggled when the user chooses that menu choice

- Calling Menu#setGroupCheckable() with a group identifier, to turn a set of menu choices into ones with a mutual-exclusion radio button between them, so one out of the group can be in the "checked" state at any time

Finally, you can create fly-out sub-menus by calling addSubMenu(), supplying the same parameters as addMenu(). Android will eventually call onCreatePanelMenu(), passing it the choice identifier of your sub-menu, along with another Menu instance representing the sub-menu itself. As with onCreateOptionsMenu(), you should chain upward to the superclass, then add menu choices to the sub-menu. One limitation is that you cannot indefinitely nest sub-menus – a menu can have a sub-menu, but a sub-menu cannot have a sub-sub-menu.

If the user makes a menu choice, your activity will be notified via the onOptionsItemSelected() callback that a menu choice was selected. You are given the MenuItem object corresponding to the selected menu choice. A typical pattern is to switch() on the menu ID (item.getItemId()) and take appropriate behavior. Note that onOptionsItemSelected() is used regardless of whether the chosen menu item was in the base menu or in a submenu.

Menus in Context

By and large, context menus use the same guts as option menus. The two main differences are how you populate the menu and how you are informed of menu choices.

First, you need to indicate which widget(s) on your activity have context menus. To do this, call `registerForContextMenu()` from your activity, supplying the `View` that is the widget needing a context menu.

Next, you need to implement `onCreateContextMenu()`, which, among other things, is passed the `View` you supplied in `registerForContextMenu()`. You can use that to determine which menu to build, assuming your activity has more than one.

The `onCreateContextMenu()` method gets the `ContextMenu` itself, the `View` the context menu is associated with, and a `ContextMenu.ContextMenuInfo`, which tells you which item in the list the user did the tap-and-hold over, in case you want to customize the context menu based on that information. For example, you could toggle a checkable menu choice based upon the current state of the item.

It is also important to note that `onCreateContextMenu()` gets called for each time the context menu is requested. Unlike the options menu (which is only built once per activity), context menus are discarded once they are used or dismissed. Hence, you do not want to hold onto the supplied `ContextMenu` object; just rely on getting the chance to rebuild the menu to suit your activity's needs on an on-demand basis based on user actions.

To find out when a context menu choice was chosen, implement `onContextItemSelected()` on the activity. Note that you only get the `MenuItem` instance that was chosen in this callback. As a result, if your activity has two or more context menus, you may want to ensure they have unique menu item identifiers for all their choices, so you can tell them apart in this callback. Also, you can call `getMenuInfo()` on the `MenuItem` to get the `ContextMenu.ContextMenuInfo` you received in `onCreateContextMenu()`.

Otherwise, this callback behaves the same as onOptionsItemSelected() as is described above.

Taking a Peek

In the sample project Menus/Menus, you will find an amended version of the ListView sample (List) with associated menus. Since the menus do not affect the layout, the XML layout file needs not change and is not reprinted here.

However, the Java code has a few new behaviors:

```java
package com.commonsware.android.menus;

import android.app.AlertDialog;
import android.app.ListActivity;
import android.content.DialogInterface;
import android.os.Bundle;
import android.view.ContextMenu;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.widget.AdapterView;
import android.widget.ArrayAdapter;
import android.widget.EditText;
import android.widget.ListView;
import android.widget.TextView;
import java.util.ArrayList;

public class MenuDemo extends ListActivity {
  private static final String[] items={"lorem", "ipsum", "dolor",
          "sit", "amet", "consectetuer", "adipiscing", "elit",
          "morbi", "vel", "ligula", "vitae", "arcu", "aliquet",
          "mollis", "etiam", "vel", "erat", "placerat", "ante",
          "porttitor", "sodales", "pellentesque", "augue", "purus"};
  public static final int MENU_ADD = Menu.FIRST+1;
  public static final int MENU_RESET = Menu.FIRST+2;
  public static final int MENU_CAP = Menu.FIRST+3;
  public static final int MENU_REMOVE = Menu.FIRST+4;
  private ArrayList<String> words=null;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);

    initAdapter();
    registerForContextMenu(getListView());
  }
```

```
@Override
public boolean onCreateOptionsMenu(Menu menu) {
  menu
    .add(Menu.NONE, MENU_ADD, Menu.NONE, "Add")
    .setIcon(R.drawable.ic_menu_add);
  menu
    .add(Menu.NONE, MENU_RESET, Menu.NONE, "Reset")
    .setIcon(R.drawable.ic_menu_refresh);

  return(super.onCreateOptionsMenu(menu));
}

@Override
public void onCreateContextMenu(ContextMenu menu, View v,
                                ContextMenu.ContextMenuInfo menuInfo) {
  menu.add(Menu.NONE, MENU_CAP, Menu.NONE, "Capitalize");
  menu.add(Menu.NONE, MENU_REMOVE, Menu.NONE, "Remove");
}

@Override
public boolean onOptionsItemSelected(MenuItem item) {
  switch (item.getItemId()) {
    case MENU_ADD:
      add();
      return(true);

    case MENU_RESET:
      initAdapter();
      return(true);
  }

  return(super.onOptionsItemSelected(item));
}

@Override
public boolean onContextItemSelected(MenuItem item) {
  AdapterView.AdapterContextMenuInfo info=
    (AdapterView.AdapterContextMenuInfo)item.getMenuInfo();
  ArrayAdapter<String> adapter=(ArrayAdapter<String>)getListAdapter();

  switch (item.getItemId()) {
    case MENU_CAP:
      String word=words.get(info.position);

      word=word.toUpperCase();

      adapter.remove(words.get(info.position));
      adapter.insert(word, info.position);

      return(true);

    case MENU_REMOVE:
      adapter.remove(words.get(info.position));
```

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```
        return(true);
    }

    return(super.onOptionsItemSelected(item));
  }

  private void initAdapter() {
    words=new ArrayList<String>();

    for (String s : items) {
      words.add(s);
    }

    setListAdapter(new ArrayAdapter<String>(this,
                   android.R.layout.simple_list_item_1, words));
  }

  private void add() {
    final View addView=getLayoutInflater().inflate(R.layout.add, null);

    new AlertDialog.Builder(this)
      .setTitle("Add a Word")
      .setView(addView)
      .setPositiveButton("OK",
                          new DialogInterface.OnClickListener() {
        public void onClick(DialogInterface dialog,
                            int whichButton) {
          ArrayAdapter<String> adapter=(ArrayAdapter<String>)getListAdapter();
          EditText title=(EditText)addView.findViewById(R.id.title);

          adapter.add(title.getText().toString());
        }
      })
      .setNegativeButton("Cancel", null)
      .show();
  }
}
```

In onCreate(), we register our ListView widget as having a context menu. We also delegate loading the adapter to an initAdapter() private method, one that copies the data out of our static String array and pours it into an ArrayList, using the ArrayList for the ArrayAdapter. The reason: we want to be able to change the contents of the list on the fly, and that is much easier if you use an ArrayList rather than a ordinary String array.

For the options menu, we override onCreateOptionsMenu() and add two menu items, one to add a new word to the list and one to reset the words to their initial state. These menu items have IDs defined locally as static data

members (`MENU_ADD` and `MENU_RESET`), and they also sport icons copied out of the Android open source project. If the user displays the menu, it looks like this:

Figure 55. The MenuDemo sample application and its options menu

We also override `onOptionsItemSelected()`, which will be called if the user makes a choice from the menu. The supplied `MenuItem` has a `getItemId()` method that should map to either `MENU_ADD` or `MENU_RESET`. In the case of `MENU_ADD`, we call a private `add()` method that displays an `AlertDialog` with a custom View as its contents, inflated from `res/layout/add.xml`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="horizontal"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    >
  <TextView
      android:text="Word:"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      />
  <EditText
```

```
      android:id="@+id/title"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:layout_marginLeft="4dip"
      />
</LinearLayout>
```

That gives us a dialog like this one:
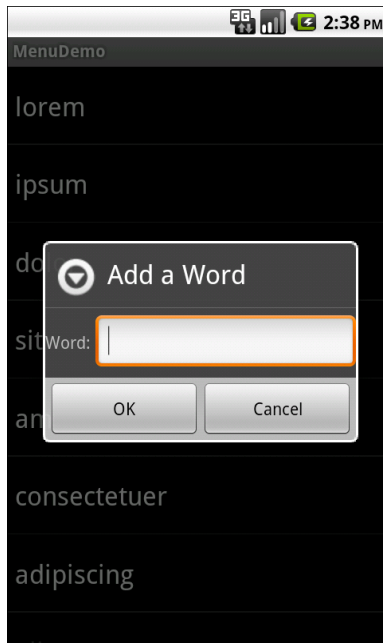
Figure 56. The same application, showing the add-word dialog

If the user clicks the OK button, we get our ArrayAdapter and call add() on it, adding the entered word to the end of the list.

If the user chooses MENU_RESET, we call initAdapter() again, setting up a new ArrayAdapter and attaching the new one to our ListActivity.

For the context menu, we override onCreateContextMenu(). Once again, we define a pair of menu items with local IDs, MENU_CAP (to capitalize the long-tapped-upon word) and MENU_REMOVE (to remove the word). Since context

menus have no icons, we can skip that part. That gives the user a context menu if they long tap on a word:
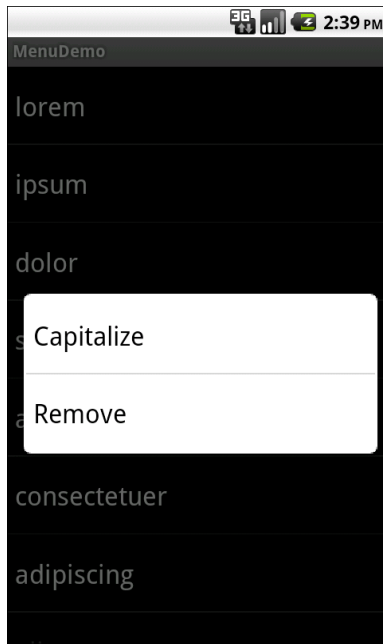
Figure 57. The same application, showing the context menu

We also override onContextMenuSelected(). Since this is a context menu for a ListView, our MenuItem has some extra information for us – specifically, which item was long-tapped-upon in the list. To do that, we call getMenuInfo() on the MenuItem and cast the result to be an AdapterView.AdapterContextMenuInfo. That object, in turn, has a position data member, which is the index into our array of the word the user chose. From there, we work with our ArrayAdapter to capitalize or remove the word, as requested.

Yet More Inflation

We saw earlier in this book that you can describe Views via XML files and "inflate" them into actual View objects at runtime. Android also allows you to describe menus via XML files and "inflate" them when a menu is called for. This helps you keep your menu structure separate from the

implementation of menu-handling logic, and it provides easier ways to develop menu-authoring tools.

Menu XML Structure

Menu XML goes in `res/menu/` in your project tree, alongside the other types of resources that your project might employ. As with layouts, you can have several menu XML files in your project, each with their own filename and the `.xml` extension.

For example, from the `Menus/Inflation` sample project, here is a menu called `option.xml`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<menu xmlns:android="http://schemas.android.com/apk/res/android">
  <item android:id="@+id/add"
    android:title="Add"
    android:icon="@drawable/ic_menu_add" />
  <item android:id="@+id/reset"
    android:title="Reset"
    android:icon="@drawable/ic_menu_refresh" />
</menu>
```

- You must start with a `menu` root element

- Inside a `menu` are `item` elements and `group` elements, the latter representing a collection of menu items that can be operated upon as a group

- Submenus are specified by adding a `menu` element as a child of an `item` element, using this new `menu` element to describe the contents of the submenu

- If you want to detect when an item is chosen, or to reference an item or group from your Java code, be sure to apply an `android:id`, just as you do with `View` layout XML

Menu Options and XML

Inside the item and group elements you can specify various options, matching up with corresponding methods on `Menu` or `MenuItem`.

Title

The title of a menu item is provided via the `android:title` attribute on an `item` element. This can be either a literal string or a reference to a string resource (e.g., `@string/foo`).

Icon

Menu items optionally have icons. To provide an icon – in the form of a reference to a drawable resource (e.g., `@drawable/eject`), use the `android:icon` attribute on the `item` element.

Order

By default, the order of the items in the menu is determined by the order they appear in the menu XML. If you want, you can change that, by specifying the `android:orderInCategory` attribute on `item` element. This is a 0-based index of the order for the items associated with the current category. There is an implicit default category; groups can provide an `android:menuCategory` attribute to specify a different category to use for items in that group.

Generally, though, it is simplest just to put the items in the XML in the order you want them to appear.

Enabled

Items and groups can be enabled or disabled, controlled in the XML via the `android:enabled` attribute on the item or group element. By default, items and groups are enabled. Disabled items and groups appear in the menu but cannot be selected. You can change an item's status at runtime via the `setEnabled()` method on `MenuItem`, or change a group's status via `setGroupEnabled()` on `Menu`.

Visible

Similarly, items and groups can be visible or invisible, controlled in the XML via the `android:visible` attribute on the item or group element. By default, items and groups are visible. Invisible items and groups do not appear in the menu at all. You can change an item's status at runtime via the `setVisible()` method on `MenuItem`, or change a group's status via `setGroupVisible()` on `Menu`.

In the layout XML shown above, the `other_stuff` group is initially invisible. If we make it visible in our Java code, the two menu items in the group will "magically" appear.

Shortcut

Items can have shortcuts – single letters (`android:alphabeticShortcut`) or numbers (`android:numericShortcut`) that can be pressed to choose the item without having to use the touchscreen, D-pad, or trackball to navigate the full menu.

Inflating the Menu

Actually using the menu, once defined in XML, is easy. Just create a `MenuInflater` and tell it to inflate your menu.

The `Menus/Inflation` project is a clone of the `Menus/Menus` project, with the menu creation converted to use menu XML resources and `MenuInflater`. The option menu was converted to the XML shown previously in this section; here is the context menu:

```xml
<?xml version="1.0" encoding="utf-8"?>
<menu xmlns:android="http://schemas.android.com/apk/res/android">
  <item android:id="@+id/cap"
    android:title="Capitalize" />
  <item android:id="@+id/remove"
    android:title="Remove" />
</menu>
```

The Java code is nearly identical, changing mostly in the implementation of onCreateOptionsMenu() and onCreateContextMenu():

```
@Override
public boolean onCreateOptionsMenu(Menu menu) {
  new MenuInflater(this).inflate(R.menu.option, menu);

  return(super.onCreateOptionsMenu(menu));
}

@Override
public void onCreateContextMenu(ContextMenu menu, View v,
                               ContextMenu.ContextMenuInfo menuInfo) {
  new MenuInflater(this).inflate(R.menu.context, menu);
}
```

Here, we see how MenuInflater "pours in" the menu items specified in the menu resource (e.g., R.menu.option) into the supplied Menu or ContextMenu object.

We also need to change onOptionsItemSelected() and onContextItemSelected() to use the android:id values specified in the XML:

```
@Override
public boolean onOptionsItemSelected(MenuItem item) {
  switch (item.getItemId()) {
    case R.id.add:
      add();
      return(true);

    case R.id.reset:
      initAdapter();
      return(true);
  }

  return(super.onOptionsItemSelected(item));
}

@Override
public boolean onContextItemSelected(MenuItem item) {
  AdapterView.AdapterContextMenuInfo info=
    (AdapterView.AdapterContextMenuInfo)item.getMenuInfo();
  ArrayAdapter<String> adapter=(ArrayAdapter<String>)getListAdapter();

  switch (item.getItemId()) {
    case R.id.cap:
      String word=words.get(info.position);

      word=word.toUpperCase();
```

```
    adapter.remove(words.get(info.position));
    adapter.insert(word, info.position);

    return(true);

  case R.id.remove:
    adapter.remove(words.get(info.position));

    return(true);
}

return(super.onOptionsItemSelected(item));
}
```

Fonts

Inevitably, you'll get the question "hey, can we change this font?" when doing application development. The answer depends on what fonts come with the platform, whether you can add other fonts, and how to apply them to the widget or whatever needs the font change.

Android is no different. It comes with some fonts plus a means for adding new fonts. Though, as with any new environment, there are a few idiosyncrasies to deal with.

Love The One You're With

Android natively knows three fonts, by the shorthand names of "sans", "serif", and "monospace". These fonts are actually the Droid series of fonts, created for the Open Handset Alliance by Ascender.

For those fonts, you can just reference them in your layout XML, if you choose, such as the following layout from the `Fonts/FontSampler` sample project:

```xml
<?xml version="1.0" encoding="utf-8"?>
<TableLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:stretchColumns="1">
  <TableRow>
```

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```
    <TextView
      android:text="sans:"
      android:layout_marginRight="4px"
      android:textSize="20sp"
    />
    <TextView
      android:id="@+id/sans"
      android:text="Hello, world!"
      android:typeface="sans"
      android:textSize="20sp"
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="serif:"
      android:layout_marginRight="4px"
      android:textSize="20sp"
    />
    <TextView
      android:id="@+id/serif"
      android:text="Hello, world!"
      android:typeface="serif"
      android:textSize="20sp"
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="monospace:"
      android:layout_marginRight="4px"
      android:textSize="20sp"
    />
    <TextView
      android:id="@+id/monospace"
      android:text="Hello, world!"
      android:typeface="monospace"
      android:textSize="20sp"
    />
  </TableRow>
  <TableRow>
    <TextView
      android:text="Custom:"
      android:layout_marginRight="4px"
      android:textSize="20sp"
    />
    <TextView
      android:id="@+id/custom"
      android:text="Hello, world!"
      android:textSize="20sp"
    />
  </TableRow>
  <TableRow android:id="@+id/filerow">
    <TextView
      android:text="Custom from File:"
      android:layout_marginRight="4px"
```

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```
      android:textSize="20sp"
    />
    <TextView
      android:id="@+id/file"
      android:text="Hello, world!"
      android:textSize="20sp"
    />
  </TableRow>
</TableLayout>
```

This layout builds a table showing short samples of five fonts. Notice how the first three have the android:typeface attribute, whose value is one of the three built-in font faces (e.g., "sans").

The three built-in fonts are very nice. However, it may be that a designer, or a manager, or a customer wants a different font than one of those three. Or perhaps you want to use a font for specialized purposes, such as a "dingbats" font instead of a series of PNG graphics.

The easiest way to accomplish this is to package the desired font(s) with your application. To do this, simply create an assets/ folder in the project root, and put your TrueType (TTF) fonts in the assets. You might, for example, create assets/fonts/ and put your TTF files in there.

Then, you need to tell your widgets to use that font. Unfortunately, you can no longer use layout XML for this, since the XML does not know about any fonts you may have tucked away as an application asset. Instead, you need to make the change in Java code:

```java
import android.widget.TextView;
import java.io.File;

public class FontSampler extends Activity {
  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    TextView tv=(TextView)findViewById(R.id.custom);
    Typeface face=Typeface.createFromAsset(getAssets(),
                                    "fonts/HandmadeTypewriter.ttf");

    tv.setTypeface(face);
```

```
    File font=new File(Environment.getExternalStorageDirectory(),
                       "MgOpenCosmeticaBold.ttf");

    if (font.exists()) {
      tv=(TextView)findViewById(R.id.file);
      face=Typeface.createFromFile(font);

      tv.setTypeface(face);
    }
    else {
      findViewById(R.id.filerow).setVisibility(View.GONE);
    }
  }
}
```

Here we grab the TextView for our "custom" sample, then create a Typeface object via the static createFromAsset() builder method. This takes the application's AssetManager (from getAssets()) and a path within your assets/ directory to the font you want.

Then, it is just a matter of telling the TextView to setTypeface(), providing the Typeface you just created. In this case, we are using the Handmade Typewriter font.

You can also load a font out of a local file and use it. The benefit is that you can customize your fonts after your application has been distributed. On the other hand, you have to somehow arrange to get the font onto the device. But just as you can get a Typeface via createFromAsset(), you can get a Typeface via createFromFile(). In our FontSampler, we look in the root of "external storage" (typically the SD card) for the MgOpenCosmeticaBold TrueType font file, and if it is found, we use it for the fifth row of the table. Otherwise, we hide that row.

The results?
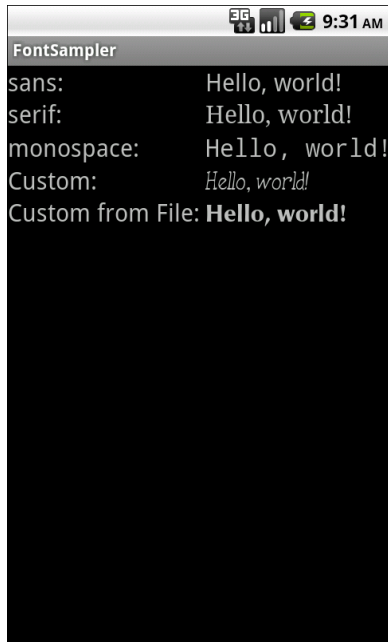
Figure 58. The FontSampler application

We will go into more details regarding assets and local files in an upcoming chapter.

Note that Android does not seem to like all TrueType fonts. When Android dislikes a custom font, rather than raise an Exception, it seems to substitute Droid Sans ("sans") quietly. So, if you try to use a different font and it does not seem to be working, it may be that the font in question is incompatible with Android, for whatever reason.

Here a Glyph, There a Glyph

TrueType fonts can be rather pudgy, particularly if they support an extensive subset of the available Unicode characters. The Handmade Typewriter font used above runs over 70KB; the DejaVu free fonts can run upwards of 500KB apiece. Even compressed, these add bulk to your application, so be careful not to go overboard with custom fonts, lest your application take up too much room on your users' phones.

Conversely, bear in mind that fonts may not have all of the glyphs that you need. As an example, let us talk about the ellipsis.

Android's `TextView` class has the built-in ability to "ellipsize" text, truncating it and adding an ellipsis if the text is longer than the available space. You can use this via the `android:ellipsize` attribute, for example. This works fairly well, at least for single-line text.

The ellipsis that Android uses is not three periods. Rather it uses an actual ellipsis character, where the three dots are contained in a single glyph. Hence, any font that you use that you also use the "ellipsizing" feature will need the ellipsis glyph.

Beyond that, though, Android pads out the string that gets rendered on-screen, such that the length (in characters) is the same before and after "ellipsizing". To make this work, Android replaces one character with the ellipsis, and replaces all other removed characters with the Unicode character 'ZERO WIDTH NO-BREAK SPACE' (`U+FEFF`). This means the "extra" characters after the ellipsis do not take up any visible space on screen, yet they can be part of the string.

However, this means any custom fonts you use for `TextView` widgets that you use with `android:ellipsize` must also support this special Unicode character. Not all fonts do, and you will get artifacts in the on-screen representation of your shortened strings if your font lacks this character (e.g., rogue X's appear at the end of the line).

And, of course, Android's international deployment means your font must handle any language your users might be looking to enter, perhaps through a language-specific input method editor.

Hence, while using custom fonts in Android is very possible, there are many potential problems, and so you must weigh carefully the benefits of the custom fonts versus their potential costs.

Embedding the WebKit Browser

Other GUI toolkits let you use HTML for presenting information, from limited HTML renderers (e.g., Java/Swing, wxWidgets) to embedding Internet Explorer into .NET applications. Android is much the same, in that you can embed the built-in Web browser as a widget in your own activities, for displaying HTML or full-fledged browsing. The Android browser is based on WebKit, the same engine that powers Apple's Safari Web browser.

The Android browser is sufficiently complex that it gets its own Java package (`android.webkit`), though using the `WebView` widget itself can be simple or powerful, based upon your requirements.

A Browser, Writ Small

For simple stuff, `WebView` is not significantly different than any other widget in Android – pop it into a layout, tell it what URL to navigate to via Java code, and you are done.

For example (`WebKit/Browser1`), here is a simple layout with a `WebView`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<WebView xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/webkit"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
/>
```

As with any other widget, you need to tell it how it should fill up the space in the layout (in this case, it fills all remaining space).

The Java code is equally simple:

```java
package com.commonsware.android.browser1;

import android.app.Activity;
import android.os.Bundle;
import android.webkit.WebView;

public class BrowserDemo1 extends Activity {
  WebView browser;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    browser=(WebView)findViewById(R.id.webkit);

    browser.loadUrl("http://commonsware.com");
  }
}
```

The only thing unusual with this edition of `onCreate()` is that we invoke `loadUrl()` on the `WebView` widget, to tell it to load a Web page (in this case, the home page of some random firm).

However, we also have to make one change to `AndroidManifest.xml`, requesting permission to access the Internet:

```xml
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.commonsware.android.browser1">
  <uses-permission android:name="android.permission.INTERNET" />
  <application android:icon="@drawable/cw">
    <activity android:name=".BrowserDemo1" android:label="BrowserDemo1">
      <intent-filter>
        <action android:name="android.intent.action.MAIN" />
        <category android:name="android.intent.category.LAUNCHER" />
      </intent-filter>
    </activity>
  </application>
</manifest>
```

If we fail to add this permission, the browser will refuse to load pages. Permissions will be covered in greater detail in a later chapter.

The resulting activity looks like a Web browser, just with hidden scrollbars:

Figure 59. The Browser1 sample application

As with the regular Android browser, you can pan around the page by dragging it, while the directional pad moves you around all the focusable elements on the page.

What is missing is all the extra stuff that make up a Web browser, such as a navigational toolbar.

Now, you may be tempted to replace the URL in that source code with something else, such as Google's home page or something else that relies upon Javascript. By default Javascript is turned off in `WebView` widgets. If you want to enable Javascript, call `getSettings().setJavaScriptEnabled(true);` on the `WebView` instance. This notion will be covered in a bit more detail later in this chapter.

Loading It Up

There are two main ways to get content into the WebView. One, shown above, is to provide the browser with a URL and have the browser display that page via loadUrl(). The browser will access the Internet through whatever means are available to that specific device at the present time (WiFi, 2G, 3G, WiMax, well-trained tiny carrier pigeons, etc.).

The alternative is to use loadData(). Here, you supply the HTML for the browser to view. You might use this to:

- display a manual that was installed as a file with your application package

- display snippets of HTML you retrieved as part of other processing, such as the description of an entry in an Atom feed

- generate a whole user interface using HTML, instead of using the Android widget set

There are two flavors of loadData(). The simpler one allows you to provide the content, the MIME type, and the encoding, all as strings. Typically, your MIME type will be text/html and your encoding will be UTF-8 for ordinary HTML.

For example, if you replace the loadUrl() invocation in the previous example with the following:

```
browser.loadData("<html><body>Hello, world!</body></html>",
                 "text/html", "UTF-8");
```

You get:
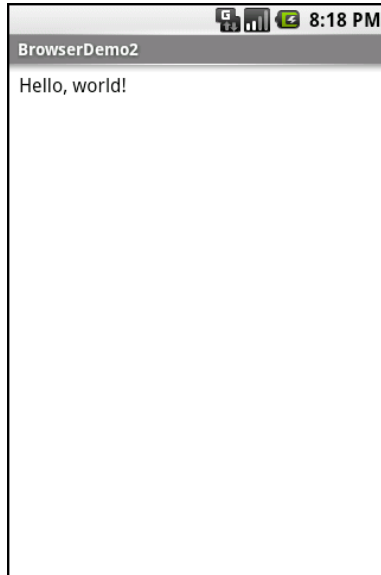
Figure 60. The Browser2 sample application

This is also available as a fully-buildable sample, as `WebKit/Browser2`.

Navigating the Waters

As was mentioned above, there is no navigation toolbar with the `WebView` widget. This allows you to use it in places where such a toolbar would be pointless and a waste of screen real estate. That being said, if you want to offer navigational capabilities, you can, but you have to supply the UI.

`WebView` offers ways to perform garden-variety browser navigation, including:

- `reload()` to refresh the currently-viewed Web page

- `goBack()` to go back one step in the browser history, and `canGoBack()` to determine if there is any history to go back to

- `goForward()` to go forward one step in the browser history, and `canGoForward()` to determine if there is any history to go forward to

- `goBackOrForward()` to go backwards or forwards in the browser history, where negative numbers represent a count of steps to go backwards, and positive numbers represent how many steps to go forwards

- `canGoBackOrForward()` to see if the browser can go backwards or forwards the stated number of steps (following the same positive/negative convention as `goBackOrForward()`)

- `clearCache()` to clear the browser resource cache and `clearHistory()` to clear the browsing history

Entertaining the Client

Particularly if you are going to use the `WebView` as a local user interface (vs. browsing the Web), you will want to be able to get control at key times, particularly when users click on links. You will want to make sure those links are handled properly, either by loading your own content back into the `WebView`, by submitting an `Intent` to Android to open the URL in a full browser, or by some other means (see the chapter on launching activities).

Your hook into the `WebView` activity is via `setWebViewClient()`, which takes an instance of a `WebViewClient` implementation as a parameter. The supplied callback object will be notified of a wide range of events, ranging from when parts of a page have been retrieved (`onPageStarted()`, etc.) to when you, as the host application, need to handle certain user- or circumstance-initiated events, such as:

- `onTooManyRedirects()`

- `onReceivedHttpAuthRequest()`

- etc.

A common hook will be `shouldOverrideUrlLoading()`, where your callback is passed a URL (plus the `WebView` itself) and you return `true` if you will handle the request or `false` if you want default handling (e.g., actually fetch the Web page referenced by the URL). In the case of a feed reader application, for example, you will probably not have a full browser with navigation built into your reader, so if the user clicks a URL, you probably want to use an

Intent to ask Android to load that page in a full browser. But, if you have inserted a "fake" URL into the HTML, representing a link to some activity-provided content, you can update the WebView yourself.

For example, let's amend the first browser example to be a browser-based equivalent of our original example: an application that, upon a click, shows the current time.

From WebKit/Browser3, here is the revised Java:

```java
public class BrowserDemo3 extends Activity {
  WebView browser;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    browser=(WebView)findViewById(R.id.webkit);
    browser.setWebViewClient(new Callback());

    loadTime();
  }

  void loadTime() {
    String page="<html><body><a href=\"clock\">"
            +new Date().toString()
            +"</a></body></html>";

    browser.loadData(page, "text/html", "UTF-8");
  }

  private class Callback extends WebViewClient {
    public boolean shouldOverrideUrlLoading(WebView view, String url) {
      loadTime();

      return(true);
    }
  }
}
```

Here, we load a simple Web page into the browser (loadTime()) that consists of the current time, made into a hyperlink to the /clock URL. We also attach an instance of a WebViewClient subclass, providing our implementation of shouldOverrideUrlLoading(). In this case, no matter what the URL, we want to just reload the WebView via loadTime().

Running this activity gives us:
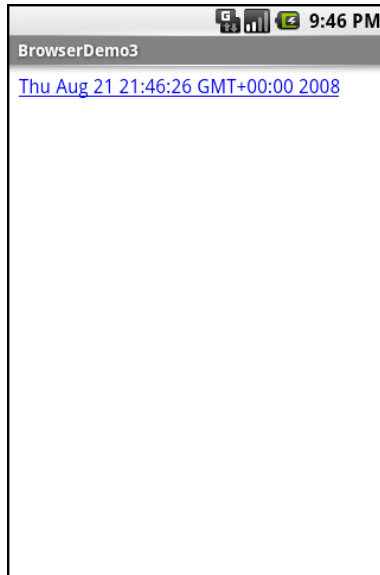
Figure 61. The Browser3 sample application

Selecting the link and clicking the D-pad center button will "click" the link, causing us to rebuild the page with the new time.

Settings, Preferences, and Options (Oh, My!)

With your favorite desktop Web browser, you have some sort of "settings" or "preferences" or "options" window. Between that and the toolbar controls, you can tweak and twiddle the behavior of your browser, from preferred fonts to the behavior of Javascript.

Similarly, you can adjust the settings of your `WebView` widget as you see fit, via the `WebSettings` instance returned from calling the widget's `getSettings()` method.

There are lots of options on `WebSettings` to play with. Most appear fairly esoteric (e.g., `setFantasyFontFamily()`). However, here are some that you may find more useful:

- Control the font sizing via `setDefaultFontSize()` (to use a point size) or `setTextSize()` (to use constants indicating relative sizes like `LARGER` and `SMALLEST`)

- Control Javascript via `setJavaScriptEnabled()` (to disable it outright) and `setJavaScriptCanOpenWindowsAutomatically()` (to merely stop it from opening pop-up windows)

- Control Web site rendering via `setUserAgent()`, so you can supply your own user agent string to make the Web server think you are a desktop browser, another mobile device (e.g., iPhone), or whatever

The settings you change are not persistent, so you should store them somewhere (such as via the Android preferences engine) if you are allowing your users to determine the settings, versus hard-wiring the settings in your application.

Showing Pop-Up Messages

Sometimes, your activity (or other piece of Android code) will need to speak up.

Not every interaction with Android users will be neat, tidy, and containable in activities composed of views. Errors will crop up. Background tasks may take way longer than expected. Something asynchronous may occur, such as an incoming message. In these and other cases, you may need to communicate with the user outside the bounds of the traditional user interface.

Of course, this is nothing new. Error messages in the form of dialog boxes have been around for a very long time. More subtle indicators also exist, from task tray icons to bouncing dock icons to a vibrating cell phone.

Android has quite a few systems for letting you alert your users outside the bounds of an `Activity`-based UI. One, notifications, is tied heavily into intents and services and, as such, is covered in a later chapter. In this chapter, you will see two means of raising pop-up messages: toasts and alerts.

Raising Toasts

A `Toast` is a transient message, meaning that it displays and disappears on its own without user interaction. Moreover, it does not take focus away

from the currently-active `Activity`, so if the user is busy writing the next Great Programming Guide, they will not have keystrokes be "eaten" by the message.

Since a `Toast` is transient, you have no way of knowing if the user even notices it. You get no acknowledgment from them, nor does the message stick around for a long time to pester the user. Hence, the `Toast` is mostly for advisory messages, such as indicating a long-running background task is completed, the battery has dropped to a low-but-not-too-low level, etc.

Making a `Toast` is fairly easy. The `Toast` class offers a static `makeText()` that accepts a `String` (or string resource ID) and returns a `Toast` instance. The `makeText()` method also needs the `Activity` (or other `Context`) plus a duration. The duration is expressed in the form of the `LENGTH_SHORT` or `LENGTH_LONG` constants to indicate, on a relative basis, how long the message should remain visible.

If you would prefer your `Toast` be made out of some other `View`, rather than be a boring old piece of text, simply create a new `Toast` instance via the constructor (which takes a `Context`), then call `setView()` to supply it with the view to use and `setDuration()` to set the duration.

Once your `Toast` is configured, call its `show()` method, and the message will be displayed. We will see an example of this in action later in this chapter.

Alert! Alert!

If you would prefer something in the more classic dialog box style, what you want is an `AlertDialog`. As with any other modal dialog box, an `AlertDialog` pops up, grabs the focus, and stays there until closed by the user. You might use this for a critical error, a validation message that cannot be effectively displayed in the base activity UI, or something else where you are sure that the user needs to see the message and needs to see it now.

The simplest way to construct an `AlertDialog` is to use the `Builder` class. Following in true builder style, `Builder` offers a series of methods to

configure an `AlertDialog`, each method returning the `Builder` for easy chaining. At the end, you call `show()` on the builder to display the dialog box.

Commonly-used configuration methods on `Builder` include:

- `setMessage()` if you want the "body" of the dialog to be a simple textual message, from either a supplied `String` or a supplied string resource ID.

- `setTitle()` and `setIcon()`, to configure the text and/or icon to appear in the title bar of the dialog box.

- `setPositiveButton()`, `setNeutralButton()`, and `setNegativeButton()`, to indicate which button(s) should appear across the bottom of the dialog, where they should be positioned (left, center, or right, respectively), what their captions should be, and what logic should be invoked when the button is clicked (besides dismissing the dialog).

If you need to configure the `AlertDialog` beyond what the builder allows, instead of calling `show()`, call `create()` to get the partially-built `AlertDialog` instance, configure it the rest of the way, then call one of the flavors of `show()` on the `AlertDialog` itself.

Once `show()` is called, the dialog box will appear and await user input.

Note that pressing any of the buttons will close the dialog, even if you have registered a listener for the button in question. Hence, if all you need a button to do is close the dialog, give it a caption and a `null` listener. There is no option, with `AlertDialog`, to have a button at the bottom invoke a listener yet not close the dialog.

Checking Them Out

To see how these work in practice, take a peek at `Messages/Message`, containing the following layout...:

```
<?xml version="1.0" encoding="utf-8"?>
<Button xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/alert"
  android:text="Raise an alert"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:onClick="showAlert"
/>
```

...and Java code:

```java
public void onCreate(Bundle icicle) {
   super.onCreate(icicle);

   setContentView(R.layout.main);
}

public void showAlert(View view) {
   new AlertDialog.Builder(this)
     .setTitle("MessageDemo")
     .setMessage("Let's raise a toast!")
     .setNeutralButton("Here, here!", new DialogInterface.OnClickListener() {
       public void onClick(DialogInterface dlg, int sumthin) {
         Toast
           .makeText(MessageDemo.this, "<clink, clink>",
                 Toast.LENGTH_SHORT)
           .show();
       }
     })
     .show();
}
}
```

The layout is unremarkable – just a really large `Button` to show the `AlertDialog`.

When you click the `Button`, we use a builder (`new Builder(this)`) to set the title (`setTitle("MessageDemo")`), message (`setMessage("Let's raise a toast!")`), and "neutral button" (`setNeutralButton("Here, here!", new OnClickListener() ...`) before showing the dialog. When the button is clicked, the `OnClickListener` callback triggers the `Toast` class to make us a text-based toast (`makeText(this, "<clink, clink>", LENGTH_SHORT)`), which we then `show()`. The result is a typical dialog box:
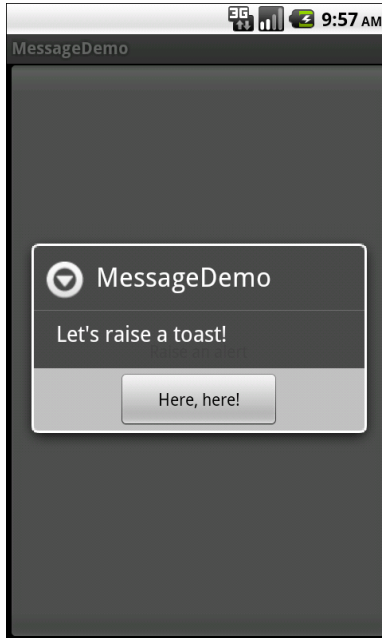
Figure 62. The MessageDemo sample application, after clicking the "Raise an alert" button

When you close the dialog via the button, it raises the toast:
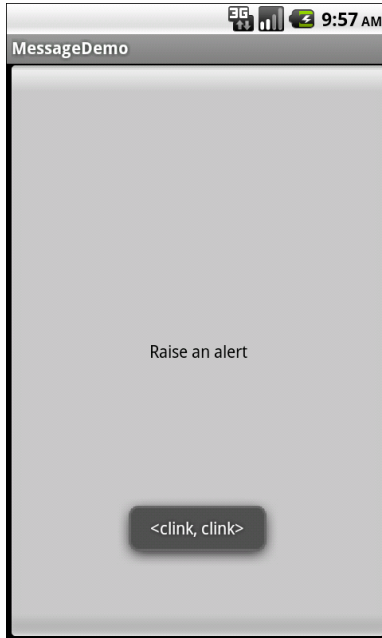
Figure 63. The same application, after clicking the "Make a toast" button

Handling Activity Lifecycle Events

While this may sound like a broken record...please remember that Android devices, by and large, are phones. As such, some activities are more important than others – taking a call is probably more important to users than is playing Sudoku. And, since it is a phone, it probably has less RAM than does your current desktop or notebook.

As a result, your activity may find itself being killed off because other activities are going on and the system needs your activity's memory. Think of it as the Android equivalent of the "circle of life" – your activity dies so others may live, and so on. You cannot assume that your activity will run until you think it is complete, or even until the user thinks it is complete.

This is one example – perhaps the most important example – of how an activity's lifecycle will affect your own application logic. This chapter covers the various states and callbacks that make up an activity's lifecycle and how you can hook into them appropriately.

Schroedinger's Activity

An activity, generally speaking, is in one of four states at any point in time:

- **Active**: the activity was started by the user, is running, and is in the foreground. This is what you are used to thinking of in terms of your activity's operation.

- **Paused**: the activity was started by the user, is running, and is visible, but a notification or something is overlaying part of the screen. During this time, the user can see your activity but may not be able to interact with it. For example, if a call comes in, the user will get the opportunity to take the call or ignore it.

- **Stopped**: the activity was started by the user, is running, but it is hidden by other activities that have been launched or switched to. Your application will not be able to present anything meaningful to the user directly, only by way of a Notification.

- **Dead**: either the activity was never started (e.g., just after a phone reset) or the activity was terminated, perhaps due to lack of available memory.

Life, Death, and Your Activity

Android will call into your activity as the activity transitions between the four states listed above. Some transitions may result in multiple calls to your activity, and sometimes Android will kill your application without calling it. This whole area is rather murky and probably subject to change, so pay close attention to the official Android documentation as well as this section when deciding which events to pay attention to and which you can safely ignore.

Note that for all of these, you should chain upward and invoke the superclass' edition of the method, or Android may raise an exception.

onCreate() and onDestroy()

We have been implementing onCreate() in all of our Activity subclasses in all the examples. This will get called in three situations:

1. When the activity is first started (e.g., since a system restart), `onCreate()` will be invoked with a null parameter.

2. If the activity had been running, then sometime later was killed off, `onCreate()` will be invoked with the `Bundle` from `onSaveInstanceState()` as a parameter (see below).

3. If the activity had been running and you have set up your activity to have different resources based on different device states (e.g., landscape versus portrait), your activity will be re-created and `onCreate()` will be called.

Here is where you initialize your user interface and set up anything that needs to be done once, regardless of how the activity gets used.

On the other end of the lifecycle, `onDestroy()` may be called when the activity is shutting down, either because the activity called `finish()` (which "finishes" the activity) or because Android needs RAM and is closing the activity prematurely. Note that `onDestroy()` may not get called if the need for RAM is urgent (e.g., incoming phone call) and that the activity will just get shut down regardless. Hence, `onDestroy()` is mostly for cleanly releasing resources you obtained in `onCreate()` (if any).

onStart(), onRestart(), and onStop()

An activity can come to the foreground either because it is first being launched, or because it is being brought back to the foreground after having been hidden (e.g., by another activity, by an incoming phone call).

The `onStart()` method is called in either of those cases. The `onRestart()` method is called in the case where the activity had been stopped and is now restarting.

Conversely, `onStop()` is called when the activity is about to be stopped.

onPause() and onResume()

The `onResume()` method is called just before your activity comes to the foreground, either after being initially launched, being restarted from a stopped state, or after a pop-up dialog (e.g., incoming call) is cleared. This is a great place to refresh the UI based on things that may have occurred since the user last was looking at your activity. For example, if you are polling a service for changes to some information (e.g., new entries for a feed), `onResume()` is a fine time to both refresh the current view and, if applicable, kick off a background thread to update the view (e.g., via a `Handler`).

Conversely, anything that steals your user away from your activity – mostly, the activation of another activity – will result in your `onPause()` being called. Here, you should undo anything you did in `onResume()`, such as stopping background threads, releasing any exclusive-access resources you may have acquired (e.g., camera), and the like.

Once `onPause()` is called, Android reserves the right to kill off your activity's process at any point. Hence, you should not be relying upon receiving any further events.

The Grace of State

Mostly, the aforementioned methods are for dealing with things at the application-general level (e.g., wiring together the last pieces of your UI in `onCreate()`, closing down background threads in `onPause()`).

However, a large part of the goal of Android is to have a patina of seamlessness. Activities may come and go as dictated by memory requirements, but users are, ideally, unaware that this is going on. If, for example, they were using a calculator, and come back to that calculator after an absence, they should see whatever number(s) they were working on originally – unless they themselves took some action to close down the calculator (e.g., pressed the BACK button to exit it).

To make all this work, activities need to be able to save their application-instance state, and to do so quickly and cheaply. Since activities could get killed off at any time, activities may need to save their state more frequently than one might expect. Then, when the activity restarts, the activity should get its former state back, so it can restore the activity to the way it appeared previously. Think of it as establishing a bookmark, such that when the user returns to that bookmark, you can return the application to the same state as when they left it.

Saving instance state is handled by `onSaveInstanceState()`. This supplies a `Bundle`, into which activities can pour whatever data they need (e.g., the number showing on the calculator's display). This method implementation needs to be speedy, so do not try to do too much fancy – just put your data in the `Bundle` and exit the method.

That instance state is provided to you again in two places:

1. In `onCreate()`
2. In `onRestoreInstanceState()`

It is your choice when you wish to re-apply the state data to your activity – either callback is a reasonable option.

The built-in implementation of `onSaveInstanceState()` will save likely mutable state from a subset of widgets. For example, it will save the text in an `EditText`, but it will not save whether or not a `Button` is enabled or disabled. This works so long as the widgets are uniquely identified via their `android:id` attributes.

Hence, if you implement `onSaveInstanceState()`, you can elect to either chain upward and leverage the inherited implementation or not and override the inherited implementation. Similarly, some activities may not need `onSaveInstanceState()` to be implemented at all, as the built-in one handles everything that is needed.

Handling Rotation

Some Android handsets offer a slide-out keyboard that triggers rotating the screen from portrait to landscape. Other handsets use accelerometers to determine when the screen rotates. As a result, it is reasonable to assume that switching from portrait to landscape and back again may be something your users will look to do.

Android has a number of ways for you to handle screen rotation, so your application can properly handle either orientation. All these facilities do is help you detect and manage the rotation process – you are still required to make sure you have layouts that look decent on each orientation.

A Philosophy of Destruction

By default, when there is a change in the phone configuration that might affect resource selection, Android will destroy and re-create any running or paused activities the next time they are to be viewed. While this could happen for a variety of different configuration changes (e.g., change of language selection), it will most likely trip you up mostly for rotations, since a change in orientation can cause you to load a different set of resources (e.g., layouts).

The types of configuration changes that trigger this destroy-and-recreate behavior include:

- Orientation changes (i.e., rotating the screen)

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- Extending or hiding a physical keyboard, for devices that have such sliding keyboards

- Putting the device in a car or desk dock, or removing it from a dock

- Changing the locale, and thereby changing the preferred language

The key here is that this is the default behavior. It is probably the behavior that is best for most of your activities. You do have some control over the matter, though, and can tailor how your activities respond to orientation changes or similar configuration switches.

It's All The Same, Just Different

Since, by default, Android destroys and re-creates your activity on a rotation, you may only need to hook into the same `onSaveInstanceState()` that you would if your activity were destroyed for any other reason (e.g., low memory). Implement that method in your activity and fill in the supplied `Bundle` with enough information to get you back to your current state. Then, in `onCreate()` (or `onRestoreInstanceState()`, if you prefer), pick the data out of the `Bundle` and use it to bring your activity back to the way it was.

To demonstrate this, let's take a look at the `Rotation/RotationOne` project. It, and the other sample projects used in this chapter, use a pair of `main.xml` layouts, one in `res/layout/` and one in `res/layout-land/` for use in landscape mode. Here is the portrait layout:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <Button android:id="@+id/pick"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_weight="1"
    android:text="Pick"
    android:enabled="true"
    android:onClick="pickContact"
  />
```

```
  <Button android:id="@+id/view"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_weight="1"
    android:text="View"
    android:enabled="false"
    android:onClick="viewContact"
  />
</LinearLayout>

<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="horizontal"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <Button android:id="@+id/pick"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_weight="1"
    android:text="Pick"
    android:enabled="true"
    android:onClick="pickContact"
  />
  <Button android:id="@+id/view"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_weight="1"
    android:text="View"
    android:enabled="false"
    android:onClick="viewContact"
  />
</LinearLayout>
```

Basically, it is a pair of buttons, each taking up half the screen. In portrait mode, the buttons are stacked; in landscape mode, they are side-by-side.

If you were to simply create a project, put in those two layouts, and compile it, the application would appear to work just fine – a rotation (`<Ctrl>-<F12>` in the emulator) will cause the layout to change. And while buttons lack state, if you were using other widgets (e.g., `EditText`), you would even find that Android hangs onto some of the widget state for you (e.g., the text entered in the `EditText`).

What Android cannot automatically help you with is anything held outside the widgets.

Picking and Viewing a Contact

This application lets you pick a contact, then view the contact, via separate buttons, with the "View" button only enabled when we actually have a contact. Let us take a closer look at how this feat is accomplished.

When the user clicks the Pick button, we call `startActivityForResult()`. This is a variation on `startActivity()`, designed for activities that are set up to return some sort of result – a user's choice of file, or contact, or whatever. Relatively few activities are set up this way, so you cannot expect to call `startActivityForResult()` and get answers from any activity you choose.

In this case, we want to pick a contact. There is an `ACTION_PICK Intent` action available in Android, designed for this sort of scenario. An `ACTION_PICK Intent` indicates to Android that we want to pick...something. The "something" is determined by the `Uri` we put in the Intent.

In our case, it turns out that we can use an `ACTION_PICK Intent` for certain system-defined `Uri` values to let the user pick a contact out of the device's contacts. In particular, on Android 2.0 and higher, we can use `android.provider.ContactsContract.Contacts.CONTENT_URI` for this purpose:

```
public void pickContact(View v) {
  Intent i=new Intent(Intent.ACTION_PICK,
                      Contacts.CONTENT_URI);

  startActivityForResult(i, PICK_REQUEST);
}
```

For Android 1.6 and older, there is a separate `android.provider.Contacts.CONTENT_URI` that we could use.

The second parameter to `startActivityForResult()` is an identifying number, to help us distinguish this call to `startActivityForResult()` from any others we might make.

Calling startActivityForResult() with an ACTION_PICK Intent for the Contacts.CONTENT_URI will bring up a contact-picker activity, supplied by Android.

When the user taps a contact, the picker activity ends (e.g., via finish()), and control returns to our activity. At that point, our activity is called with onActivityResult(). Android supplies us with three pieces of information:

1. The identifying number we supplied to startActivityForResult(), so we can match this result to its original request

2. A result status, either RESULT_OK or RESULT_CANCELED, to indicate if the user made a positive selection or if the user abandoned the picker (e.g., by clicking the BACK button)

3. An Intent that represents the result data itself, for a RESULT_OK response

The details of what is in the Intent will need to be documented by the activity that you called. In the case of an ACTION_PICK Intent for the Contacts.CONTENT_URI, the returned Intent has its own Uri (via getData()) that represents the chosen contact. In the RotationOne example, we stick that in a data member of the activity and enable the View button:

```
@Override
protected void onActivityResult(int requestCode, int resultCode,
                                Intent data) {
  if (requestCode==PICK_REQUEST) {
    if (resultCode==RESULT_OK) {
      contact=data.getData();
      viewButton.setEnabled(true);
    }
  }
}
```

If the user clicks the now-enabled View button, we create an ACTION_VIEW Intent on the contact's Uri, and call startActivity() on that Intent:

```
public void viewContact(View v) {
  startActivity(new Intent(Intent.ACTION_VIEW, contact));
}
```

This will bring up an Android-supplied activity to view details of that contact.

Saving Your State

Given that we have used `startActivityForResult()` to pick a contact, now we need to hang onto that contact when the screen orientation changes. In the `RotationOne` example, we do this via `onSaveInstanceState()`:

```
package com.commonsware.android.rotation.one;

import android.app.Activity;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.provider.ContactsContract.Contacts;
import android.view.View;
import android.widget.Button;
import android.util.Log;

public class RotationOneDemo extends Activity {
  static final int PICK_REQUEST=1337;
  Button viewButton=null;
  Uri contact=null;

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    viewButton=(Button)findViewById(R.id.view);
    restoreMe(savedInstanceState);

    viewButton.setEnabled(contact!=null);
  }

  @Override
  protected void onActivityResult(int requestCode, int resultCode,
                                  Intent data) {
    if (requestCode==PICK_REQUEST) {
      if (resultCode==RESULT_OK) {
        contact=data.getData();
        viewButton.setEnabled(true);
      }
    }
  }

  public void pickContact(View v) {
    Intent i=new Intent(Intent.ACTION_PICK,
                        Contacts.CONTENT_URI);
```

```
    startActivityForResult(i, PICK_REQUEST);
  }

  public void viewContact(View v) {
    startActivity(new Intent(Intent.ACTION_VIEW, contact));
  }

  @Override
  protected void onSaveInstanceState(Bundle outState) {
    super.onSaveInstanceState(outState);

    if (contact!=null) {
      outState.putString("contact", contact.toString());
    }
  }

  private void restoreMe(Bundle state) {
    contact=null;

    if (state!=null) {
      String contactUri=state.getString("contact");

      if (contactUri!=null) {
        contact=Uri.parse(contactUri);
      }
    }
  }
}
```

By and large, it looks like a normal activity…because it is. Initially, the "model" – a `Uri` named `contact` – is `null`. It is set as the result of spawning the `ACTION_PICK` sub-activity. Its string representation is saved in `onSaveInstanceState()` and restored in `restoreMe()` (called from `onCreate()`). If the contact is not `null`, the "View" button is enabled and can be used to view the chosen contact.

Visually, it looks pretty much as one would expect:
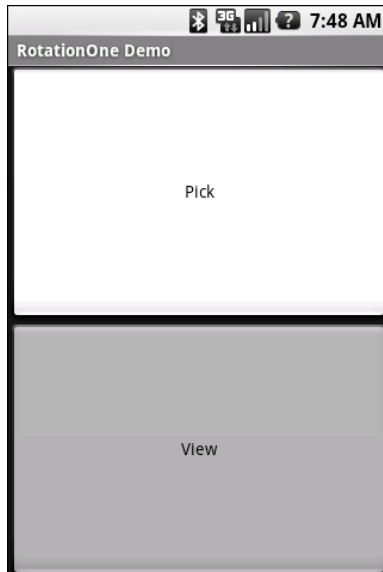
Figure 64. The RotationOne application, in portrait mode
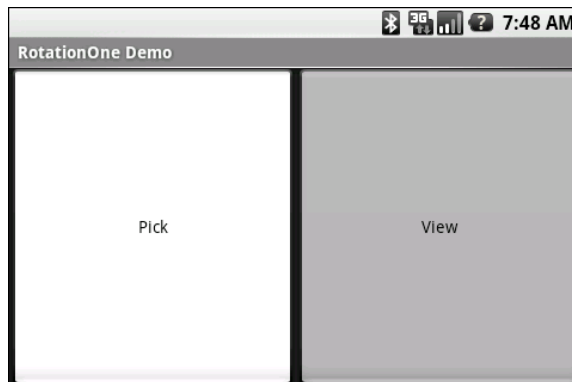
Figure 65. The RotationOne application, in landscape mode

The benefit to this implementation is that it handles a number of system events beyond mere rotation, such as being closed by Android due to low memory.

For fun, comment out the restoreMe() call in onCreate() and try running the application. You will see that the application "forgets" a contact selected in one orientation when you rotate the emulator or device.

Now With More Savings!

The problem with onSaveInstanceState() is that you are limited to a Bundle. That's because this callback is also used in cases where your whole process might be terminated (e.g., low memory), so the data to be saved has to be something that can be serialized and has no dependencies upon your running process.

For some activities, that limitation is not a problem. For others, though, it is more annoying. Take an online chat, for example. You have no means of storing a socket in a Bundle, so by default, you will have to drop your connection to the chat server and re-establish it. That not only may be a performance hit, but it might also affect the chat itself, such as you appearing in the chat logs as disconnecting and reconnecting.

One way to get past this is to use onRetainNonConfigurationInstance() instead of onSaveInstanceState() for "light" changes like a rotation. Your activity's onRetainNonConfigurationInstance() callback can return an Object, which you can retrieve later via getLastNonConfigurationInstance(). The Object can be just about anything you want – typically, it will be some kind of "context" object holding activity state, such as running threads, open sockets, and the like. Your activity's onCreate() can call getLastNonConfigurationInstance() – if you get a non-null response, you now have your sockets and threads and whatnot. The biggest limitation is that you do not want to put in the saved context anything that might reference a resource that will get swapped out, such as a Drawable loaded from a resource.

Let's take a look at the Rotation/RotationTwo sample project, which uses this approach to handling rotations. The layouts, and hence the visual appearance, is the same as with Rotation/RotationOne. Where things differ slightly is in the Java code:

```
package com.commonsware.android.rotation.two;
```

```java
import android.app.Activity;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.provider.ContactsContract.Contacts;
import android.view.View;
import android.widget.Button;
import android.util.Log;

public class RotationTwoDemo extends Activity {
  static final int PICK_REQUEST=1337;
  Button viewButton=null;
  Uri contact=null;

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    viewButton=(Button)findViewById(R.id.view);
    restoreMe();

    viewButton.setEnabled(contact!=null);
  }

  @Override
  protected void onActivityResult(int requestCode, int resultCode,
                                   Intent data) {
    if (requestCode==PICK_REQUEST) {
      if (resultCode==RESULT_OK) {
        contact=data.getData();
        viewButton.setEnabled(true);
      }
    }
  }

  public void pickContact(View v) {
    Intent i=new Intent(Intent.ACTION_PICK,
                        Contacts.CONTENT_URI);

    startActivityForResult(i, PICK_REQUEST);
  }

  public void viewContact(View v) {
    startActivity(new Intent(Intent.ACTION_VIEW, contact));
  }

  @Override
  public Object onRetainNonConfigurationInstance() {
    return(contact);
  }

  private void restoreMe() {
    contact=null;
```

```
    if (getLastNonConfigurationInstance()!=null) {
      contact=(Uri)getLastNonConfigurationInstance();
    }
  }
}
```

In this case, we override `onRetainNonConfigurationInstance()`, returning the actual `Uri` for our contact, rather than a string representation of it. In turn, `restoreMe()` calls `getLastNonConfigurationInstance()`, and if it is not `null`, we hold onto it as our contact and enable the "View" button.

The advantage here is that we are passing around the `Uri` rather than a string representation. In this case, that is not a big savings. But our state could be much more complicated, including threads and sockets and other things we cannot pack into a `Bundle`.

DIY Rotation

Even this, though, may still be too intrusive to your application. Suppose, for example, you are creating a real-time game, such as a first-person shooter. The "hiccup" your users experience as your activity is destroyed and re-created might be enough to get them shot, which they may not appreciate. While this would be less of an issue on the T-Mobile G1, since a rotation requires sliding open the keyboard and therefore is unlikely to be done mid-game, other devices might rotate based solely upon the device's position as determined by accelerometers.

The third possibility for handling rotations, therefore, is to tell Android that you will handle them completely yourself and that you do not want assistance from the framework. To do this:

1. Put an `android:configChanges` entry in your `AndroidManifest.xml` file, listing the configuration changes you want to handle yourself versus allowing Android to handle for you

2. Implement `onConfigurationChanged()` in your `Activity`, which will be called when one of the configuration changes you listed in `android:configChanges` occurs

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Now, for any configuration change you want, you can bypass the whole activity-destruction process and simply get a callback letting you know of the change.

To see this in action, turn to the `Rotation/RotationThree` sample application. Once again, our layouts are the same, so the application looks the same as the preceding two samples. However, the Java code is significantly different, because we are no longer concerned with saving our state, but rather with updating our UI to deal with the layout.

But first, we need to make a small change to our manifest:

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
      package="com.commonsware.android.rotation.three"
      android:versionCode="1"
      android:versionName="1.0.0">
  <uses-sdk
        android:minSdkVersion="5"
        android:targetSdkVersion="6"
   />
   <application android:label="@string/app_name"
        android:icon="@drawable/cw">
        <activity android:name=".RotationThreeDemo"
                  android:label="@string/app_name"
                  android:configChanges="keyboardHidden|orientation">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
    </application>
</manifest>
```

Here, we state that we will handle `keyboardHidden` and `orientation` configuration changes ourselves. This covers us for any cause of the "rotation" – whether it is a sliding keyboard or a physical rotation. Note that this is set on the activity, not the application – if you have several activities, you will need to decide for each which of the tactics outlined in this chapter you wish to use.

The Java code for this project is shown below:

```
package com.commonsware.android.rotation.three;

import android.app.Activity;
import android.content.Intent;
import android.content.res.Configuration;
import android.net.Uri;
import android.os.Bundle;
import android.provider.ContactsContract.Contacts;
import android.view.View;
import android.widget.Button;
import android.util.Log;

public class RotationThreeDemo extends Activity {
  static final int PICK_REQUEST=1337;
  Button viewButton=null;
  Uri contact=null;

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);

    setupViews();
  }

  @Override
  protected void onActivityResult(int requestCode, int resultCode,
                                  Intent data) {
    if (requestCode==PICK_REQUEST) {
      if (resultCode==RESULT_OK) {
        contact=data.getData();
        viewButton.setEnabled(true);
      }
    }
  }

  public void pickContact(View v) {
    Intent i=new Intent(Intent.ACTION_PICK,
                        Contacts.CONTENT_URI);

    startActivityForResult(i, PICK_REQUEST);
  }

  public void viewContact(View v) {
    startActivity(new Intent(Intent.ACTION_VIEW, contact));
  }

  public void onConfigurationChanged(Configuration newConfig) {
    super.onConfigurationChanged(newConfig);

    setupViews();
  }

  private void setupViews() {
    setContentView(R.layout.main);
```

```
    viewButton=(Button)findViewById(R.id.view);
    viewButton.setEnabled(contact!=null);
  }
}
```

The onCreate() implementation delegates most of its logic to a setupViews() method, which loads the layout and sets up the buttons. The reason this logic was broken out into its own method is because it is also called from onConfigurationChanged().

…But Google Does Not Recommend This

You might think that onConfigurationChanged() and android:configChanges would be the ultimate solution. After all, we no longer have to worry about all that messy passing of data to the new activity as the old one is being destroyed. The onConfigurationChanged() approach is very sexy.

However, Google does not recommend it.

The primary concern is forgetting about resources. With the onConfigurationChanged() approach, you must take steps to ensure that each and every resource that might possibly have changed as a result of this configuration change gets updated. That includes strings, layouts, drawables, menus, animations, preferences, dimensions, colors, and all the others. If you are incomplete, your app will have a whole series of little (or not so little) bugs as a result.

Allowing Android to destroy and recreate your activity guarantees you will get the proper resources. All you need to do is arrange to pass the proper data from the old to the new activity.

The onConfigurationChanged() approach is there where the user would be directly affected by a destroy-and-create cycle. For example, imagine a video player application, playing a streaming video. Destroying and recreating the activity would necessarily cause us to have to reconnect to the stream, losing our buffered data. Users will get frustrated if an accidental movement causes the device to change orientation and interrupt

their video playback. In this case, since the user will perceive problems with a destroy-and-create cycle, `onConfigurationChanged()` is an appropriate choice.

Forcing the Issue

In the previous three sections, we covered ways to deal with rotational events. There is, of course, a radical alternative: tell Android not to rotate your activity at all. If the activity does not rotate, you do not have to worry about writing code to deal with rotations.

To block Android from rotating your activity, all you need to do is add `android:screenOrientation = "portrait"` (or `"landscape"`, as you prefer) to your `AndroidManifest.xml` file, as shown below (from the `Rotation/RotationFour` sample project):

```xml
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
      package="com.commonsware.android.rotation.four"
      android:versionCode="1"
      android:versionName="1.0.0">
  <uses-sdk
      android:minSdkVersion="5"
      android:targetSdkVersion="6"
   />
   <application android:label="@string/app_name"
      android:icon="@drawable/cw">
      <activity android:name=".RotationFourDemo"
              android:screenOrientation="portrait"
              android:label="@string/app_name">
          <intent-filter>
              <action android:name="android.intent.action.MAIN" />
              <category android:name="android.intent.category.LAUNCHER" />
          </intent-filter>
      </activity>
   </application>
</manifest>
```

Since this is applied on a per-activity basis, you will need to decide which of your activities may need this turned on.

At this point, your activity is locked into whatever orientation you specified, regardless of what you do. The following screen shots show the

same activity as in the previous three sections, but using the above manifest and with the emulator set for both portrait and landscape orientation. Note that the UI does not move a bit, but remains in portrait mode.
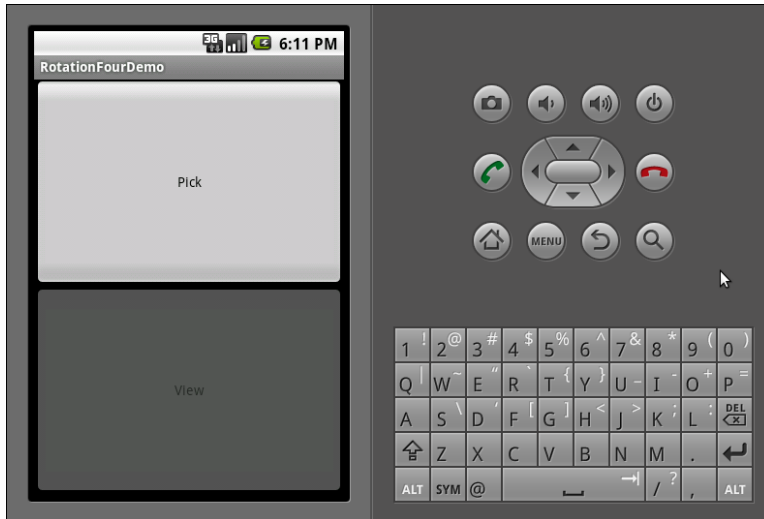
Figure 66. The RotationFour application, in portrait mode

Figure 67. The RotationFour application, in landscape mode

Note that Android will *still* destroy and recreate your activity, even if you have the orientation set to a specific value as shown here. If you wish to avoid that, you will also need to set `android:configChanges` in the manifest, as described earlier in this chapter. Or, you can still use `onSaveInstanceState()` or `onRetainNonConfigurationInstance()` to save your activity's mutable state.

Making Sense of it All

As noted at the top of this chapter, devices with side-slider keyboards (T-Mobile G1, Motorola DROID/Milestone, etc.) change screen orientation when the keyboard is exposed or hidden, whereas other devices change screen orientation based upon the accelerometer.

If you have an activity that should change orientation based on the accelerometer, even if the device has a side-slider keyboard, just add `android:screenOrientation = "sensor"` to your `AndroidManifest.xml` file (as seen in the `Rotation/RotationFive` sample project):

```xml
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
      package="com.commonsware.android.rotation.five"
      android:versionCode="1"
      android:versionName="1.0.0">
  <uses-sdk
        android:minSdkVersion="5"
        android:targetSdkVersion="6"
    />
    <application android:label="@string/app_name"
        android:icon="@drawable/cw">
        <activity android:name=".RotationFiveDemo"
                  android:screenOrientation="sensor"
                  android:label="@string/app_name">
          <intent-filter>
              <action android:name="android.intent.action.MAIN" />
              <category android:name="android.intent.category.LAUNCHER" />
          </intent-filter>
        </activity>
    </application>
</manifest>
```

The "sensor", in this case, tells Android you want the accelerometers to control the screen orientation, so the physical shift in the device orientation controls the screen orientation.

Dealing with Threads

Users like snappy applications. Users do not like applications that feel sluggish.

The way to help your application feel snappy is to use the standard threading capabilities built into Android. This chapter will go through the issues involved with thread management in Android and will walk you through some of the options for keeping the user interface crisp and responsive.

The Main Application Thread

When you call `setText()` on a `TextView`, you probably think that the screen is updated with the text you supply, right then and there.

You would be mistaken.

Rather, everything that modifies the widget-based UI goes through a message queue. Calls to `setText()` do not update the screen – they just pop a message on a queue telling the operating system to update the screen. The operating system pops these messages off of this queue and does what the messages require.

The queue is processed by one thread, variously called the "main application thread" and the "UI thread". So long as that thread can keep

processing messages, the screen will update, user input will be handled, and so on.

However, the main application thread is also used for nearly all callbacks into your activity. Your `onCreate()`, `onClick()`, `onListItemClick()`, and similar methods are all called on the main application thread. While your code is executing in these methods, Android is not processing messages on the queue, and so the screen does not update, user input is not handled, and so on.

This, of course, is bad. So bad, that if you take more than a few seconds to do work on the main application thread, Android may display the dreaded "Application Not Responding" dialog (ANR for short), and your activity may be killed off.

Hence, you want to make sure that all of your work on the main application thread happens quickly. This means that anything slow should be done in a background thread, so as not to tie up the main application thread. This includes things like:

- Internet access, such as sending data to a Web service or downloading an image
- Significant file operations, since flash storage can be remarkably slow at times
- Any sort of complex calculations

Fortunately, Android supports threads using the standard `Thread` class from Java, plus all of the wrappers and control structures you would expect, such as the `java.util.concurrent` class package.

However, there is one big limitation: you cannot modify the UI from a background thread. You can only modify the UI from the main application thread.

Hence, you need to get long-running work moved into background threads, but those threads need to do something to arrange to update the UI using

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the main application thread. Fortunately, Android provides a wide range of tools to do just that, and these tools are the primary focus of this chapter.

Making Progress with ProgressBars

If you are going to fork background threads to do work on behalf of the user, you will want to think about keeping the user informed that work is going on. This is particularly true if the user is effectively waiting for that background work to complete.

The typical approach to keeping users informed of progress is some form of progress bar, like you see when you copy a bunch of files from place to place in many desktop operating systems. Android supports this through the ProgressBar widget.

A ProgressBar keeps track of progress, defined as an integer, with 0 indicating no progress has been made. You can define the maximum end of the range – what value indicates progress is complete – via setMax(). By default, a ProgressBar starts with a progress of 0, though you can start from some other position via setProgress().

If you prefer your progress bar to be indeterminate, use setIndeterminate(), setting it to true.

In your Java code, you can either positively set the amount of progress that has been made (via setProgress()) or increment the progress from its current amount (via incrementProgressBy()). You can find out how much progress has been made via getProgress().

There are other alternatives – ProgressDialog, progress indicator in the activity's title bar, etc. – but a ProgressBar is a good place to start.

Getting Through the Handlers

The most flexible means of making an Android-friendly background thread is to create an instance of a `Handler` subclass. You only need one `Handler` object per activity, and you do not need to manually register it or anything – merely creating the instance is sufficient to register it with the Android threading subsystem.

Your background thread can communicate with the `Handler`, which will do all of its work on the activity's UI thread. This is important, as UI changes, such as updating widgets, should only occur on the activity's UI thread.

You have two options for communicating with the `Handler`: messages and `Runnable` objects.

Messages

To send a `Message` to a `Handler`, first invoke `obtainMessage()` to get the `Message` object out of the pool. There are a few flavors of `obtainMessage()`, allowing you to just create empty `Message` objects, or ones populated with message identifiers and arguments. The more complicated your `Handler` processing needs to be, the more likely it is you will need to put data into the `Message` to help the `Handler` distinguish different events.

Then, you send the `Message` to the `Handler` via its message queue, using one of the `sendMessage...()` family of methods, such as:

- `sendMessage()` puts the message on the queue immediately

- `sendMessageAtFrontOfQueue()` puts the message on the queue immediately, and moreover puts it at the front of the message queue (versus the back, as is the default), so your message takes priority over all others

- `sendMessageAtTime()` puts the message on the queue at the stated time, expressed in the form of milliseconds based on system uptime (`SystemClock.uptimeMillis()`)

- sendMessageDelayed() puts the message on the queue after a delay, expressed in milliseconds

- sendEmptyMessage(), which sends an empty Message object to the queue, allowing you to skip the obtainMessage() step if you were planning on leaving it empty anyway

To process these messages, your Handler needs to implement handleMessage(), which will be called with each message that appears on the message queue. There, the handler can update the UI as needed. However, it should still do that work quickly, as other UI work is suspended until the Handler is done.

For example, let's create a ProgressBar and update it via a Handler. Here is the layout from the Threads/Handler sample project:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <ProgressBar android:id="@+id/progress"
    style="?android:attr/progressBarStyleHorizontal"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content" />
</LinearLayout>
```

The ProgressBar, in addition to setting the width and height as normal, also employs the style property. This particular style indicates this ProgressBar should be drawn as the traditional horizontal bar showing the amount of work that has been completed.

And here is the Java:

```java
package com.commonsware.android.threads;

import android.app.Activity;
import android.os.Bundle;
import android.os.Handler;
import android.os.Message;
import android.widget.ProgressBar;
import java.util.concurrent.atomic.AtomicBoolean;
```

```java
public class HandlerDemo extends Activity {
  ProgressBar bar;
  Handler handler=new Handler() {
    @Override
    public void handleMessage(Message msg) {
      bar.incrementProgressBy(5);
    }
  };
  AtomicBoolean isRunning=new AtomicBoolean(false);

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    bar=(ProgressBar)findViewById(R.id.progress);
  }

  public void onStart() {
    super.onStart();
    bar.setProgress(0);

    Thread background=new Thread(new Runnable() {
      public void run() {
        try {
          for (int i=0;i<20 && isRunning.get();i++) {
            Thread.sleep(1000);
            handler.sendMessage(handler.obtainMessage());
          }
        }
        catch (Throwable t) {
          // just end the background thread
        }
      }
    });

    isRunning.set(true);
    background.start();
  }

  public void onStop() {
    super.onStop();
    isRunning.set(false);
  }
}
```

As part of constructing the Activity, we create an instance of Handler, with our implementation of handleMessage(). Basically, for any message received, we update the ProgressBar by 5 points, then exit the message handler.

We then take advantage of onStart() and onStop(). In onStart(), we set up a background thread. In a real system, this thread would do something meaningful. Here, we just sleep one second, post a Message to the Handler, and repeat for a total of 20 passes. This, combined with the 5-point increase in the ProgressBar position, will march the bar clear across the screen, as the default maximum value for ProgressBar is 100. You can adjust that maximum via setMax(), such as setting the maximum to be the number of database rows you are processing, and updating once per row.

Note that we then *leave* onStart(). This is crucial. The onStart() method is invoked on the activity UI thread, so it can update widgets and such. However, that means we need to get out of onStart(), both to let the Handler get its work done, and also so Android does not think our activity is stuck.

The resulting activity is simply a horizontal progress bar:
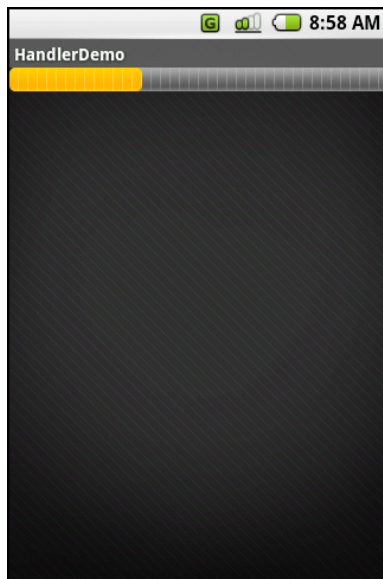
Figure 68. The HandlerDemo sample application

Note, though, that while ProgressBar samples like this one show your code arranging to update the progress on the UI thread, for this specific widget, that is not necessary. At least as of Android 1.5, ProgressBar is now "UI

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thread safe", in that you can update it from any thread, and it will handle the details of performing the actual UI update on the UI thread.

Runnables

If you would rather not fuss with `Message` objects, you can also pass `Runnable` objects to the `Handler`, which will run those `Runnable` objects on the activity UI thread. `Handler` offers a set of `post...()` methods for passing `Runnable` objects in for eventual processing.

Just as `Handler` supports `post()` and `postDelayed()` to add `Runnable` objects to the event queue, you can use those same methods on any `View` (i.e., any widget or container). This slightly simplifies your code, in that you can then skip the `Handler` object.

Where, Oh Where Has My UI Thread Gone?

Sometimes, you may not know if you are currently executing on the UI thread of your application. For example, if you package some of your code in a JAR for others to reuse, you might not know whether your code is being executed on the UI thread or from a background thread.

To help combat this problem, `Activity` offers `runOnUiThread()`. This works similar to the `post()` methods on `Handler` and `View`, in that it queues up a `Runnable` to run on the UI thread...if you are not on the UI thread right now. If you already are on the UI thread, it invokes the `Runnable` immediately. This gives you the best of both worlds: no delay if you are on the UI thread, yet safety in case you are not.

Asyncing Feeling

Android 1.5 introduced a new way of thinking about background operations: `AsyncTask`. In one (reasonably) convenient class, Android will handle all of the chores of doing work on the UI thread versus on a background thread. Moreover, Android itself allocates and removes that

background thread. And, it maintains a small work queue, further accentuating the "fire and forget" feel to AsyncTask.

The Theory

There is a saying, popular in marketing circles: "When a man buys a 1/4" drill bit at a hardware store, he does not want a 1/4" drill bit – he wants 1/4" holes". Hardware stores cannot sell holes, so they sell the next-best thing: devices (drills and drill bits) that make creating holes easy.

Similarly, Android developers who have struggled with background thread management do not strictly want background threads – they want work to be done off the UI thread, so users are not stuck waiting and activities do not get the dreaded "application not responding" (ANR) error. And while Android cannot magically cause work to not consume UI thread time, Android can offer things that make such background operations easier and more transparent. AsyncTask is one such example.

To use AsyncTask, you must:

- Create a subclass of AsyncTask, commonly as a private inner class of something that uses the task (e.g., an activity)
- Override one or more AsyncTask methods to accomplish the background work, plus whatever work associated with the task that needs to be done on the UI thread (e.g., update progress)
- When needed, create an instance of the AsyncTask subclass and call execute() to have it begin doing its work

What you do *not* have to do is:

- Create your own background thread
- Terminate that background thread at an appropriate time
- Call all sorts of methods to arrange for bits of processing to be done on the UI thread

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AsyncTask, Generics, and Varargs

Creating a subclass of `AsyncTask` is not quite as easy as, say, implementing the `Runnable` interface. `AsyncTask` uses generics, and so you need to specify three data types:

- The type of information that is needed to process the task (e.g., URLs to download)

- The type of information that is passed within the task to indicate progress

- The type of information that is passed when the task is completed to the post-task code

What makes this all the more confusing is that the first two data types are actually used as varargs, meaning that an array of these types is used within your `AsyncTask` subclass.

This should become clearer as we work our way towards an example.

The Stages of AsyncTask

There are four methods you can override in `AsyncTask` to accomplish your ends.

The one you must override, for the task class to be useful, is `doInBackground()`. This will be called by `AsyncTask` on a background thread. It can run as long as it needs to in order to accomplish whatever work needs to be done for this specific task. Note, though, that tasks are meant to be finite – using `AsyncTask` for an infinite loop is not recommended.

The `doInBackground()` method will receive, as parameters, a varargs array of the first of the three data types listed above – the data needed to process the task. So, if your task's mission is to download a collection of URLs, `doInBackground()` will receive those URLs to process.

The `doInBackground()` method must return a value of the third data type listed above – the result of the background work.

You may wish to override `onPreExecute()`. This method is called, from the UI thread, before the background thread executes `doInBackground()`. Here, you might initialize a `ProgressBar` or otherwise indicate that background work is commencing.

Also, you may wish to override `onPostExecute()`. This method is called, from the UI thread, after `doInBackground()` completes. It receives, as a parameter, the value returned by `doInBackground()` (e.g., success or failure flag). Here, you might dismiss the `ProgressBar` and make use of the work done in the background, such as updating the contents of a list.

In addition, you may wish to override `onProgressUpdate()`. If `doInBackground()` calls the task's `publishProgress()` method, the object(s) passed to that method are provided to `onProgressUpdate()`, but in the UI thread. That way, `onProgressUpdate()` can alert the user as to the progress that has been made on the background work, such as updating a `ProgressBar` or continuing an animation. The `onProgressUpdate()` method will receive a varargs of the second data type from the above list – the data published by `doInBackground()` via `publishProgress()`.

A Sample Task

As mentioned earlier, implementing an `AsyncTask` is not quite as easy as implementing a `Runnable`. However, once you get past the generics and varargs, it is not too bad.

For example, below you will find an implementation of a `ListActivity` that uses an `AsyncTask`, from the Threads/Asyncer sample project:

```
package com.commonsware.android.async;

import android.app.ListActivity;
import android.os.AsyncTask;
import android.os.Bundle;
import android.os.SystemClock;
```

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```java
import android.widget.ArrayAdapter;
import android.widget.Toast;
import java.util.ArrayList;

public class AsyncDemo extends ListActivity {
  private static final String[] items={"lorem", "ipsum", "dolor",
                                       "sit", "amet", "consectetuer",
                                       "adipiscing", "elit", "morbi",
                                       "vel", "ligula", "vitae",
                                       "arcu", "aliquet", "mollis",
                                       "etiam", "vel", "erat",
                                       "placerat", "ante",
                                       "porttitor", "sodales",
                                       "pellentesque", "augue",
                                       "purus"};
  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    setListAdapter(new ArrayAdapter<String>(this,
                       android.R.layout.simple_list_item_1,
                       new ArrayList()));

    new AddStringTask().execute();
  }

  class AddStringTask extends AsyncTask<Void, String, Void> {
    @Override
    protected Void doInBackground(Void... unused) {
      for (String item : items) {
        publishProgress(item);
        SystemClock.sleep(200);
      }

      return(null);
    }

    @Override
    protected void onProgressUpdate(String... item) {
      ((ArrayAdapter)getListAdapter()).add(item[0]);
    }

    @Override
    protected void onPostExecute(Void unused) {
      Toast
        .makeText(AsyncDemo.this, "Done!", Toast.LENGTH_SHORT)
        .show();
    }
  }
}
```

This is another variation on the *lorem ipsum* list of words, used frequently throughout this book. This time, rather than simply hand the list of words to an ArrayAdapter, we simulate having to work to create these words in the background using AddStringTask, our AsyncTask implementation.

Let's examine this piece by piece:

The AddStringTask Declaration

```
class AddStringTask extends AsyncTask<Void, String, Void> {
```

Here, we use the generics to set up the specific types of data we are going to leverage in AddStringTask. Specifically:

- We do not need any configuration information in this case, so our first type is Void

- We want to pass each string "generated" by our background task to onProgressUpdate(), so we can add it to our list, so our second type is String

- We do not have any results, strictly speaking (beyond the updates), so our third type is Void

The doInBackground() Method

```
@Override
protected Void doInBackground(Void... unused) {
  for (String item : items) {
    publishProgress(item);
    SystemClock.sleep(200);
  }

  return(null);
}
```

The doInBackground() method is invoked in a background thread. Hence, we can take as long as we like. In a production application, we would be, perhaps, iterating over a list of URLs and downloading each. Here, we iterate over our static list of *lorem ipsum* words, call publishProgress() for each, and then sleep 200 milliseconds to simulate real work being done.

Since we elected to have no configuration information, we should not need parameters to `doInBackground()`. However, the contract with `AsyncTask` says we need to accept a varargs of the first data type, which is why our method parameter is `Void... unused`.

Since we elected to have no results, we should not need to return anything. Again, though, the contract with `AsyncTask` says we have to return an object of the third data type. Since that data type is `Void`, our returned object is `null`.

The onProgressUpdate() Method

```
@Override
protected void onProgressUpdate(String... item) {
  ((ArrayAdapter)getListAdapter()).add(item[0]);
}
```

The `onProgressUpdate()` method is called on the UI thread, and we want to do something to let the user know we are progressing on loading up these strings. In this case, we simply add the string to the `ArrayAdapter`, so it gets appended to the end of the list.

The `onProgressUpdate()` method receives a `String...` varargs because that is the second data type in our class declaration. Since we are only passing one string per call to `publishProgress()`, we only need to examine the first entry in the varargs array.

The onPostExecute() Method

```
@Override
protected void onPostExecute(Void unused) {
  Toast
    .makeText(AsyncDemo.this, "Done!", Toast.LENGTH_SHORT)
    .show();
}
```

The `onPostExecute()` method is called on the UI thread, and we want to do something to indicate that the background work is complete. In a real

system, there may be some `ProgressBar` to dismiss or some animation to stop. Here, we simply raise a `Toast`.

Since we elected to have no results, we should not need any parameters. The contract with `AsyncTask` says we have to accept a single value of the third data type. Since that data type is `Void`, our method parameter is `Void unused`.
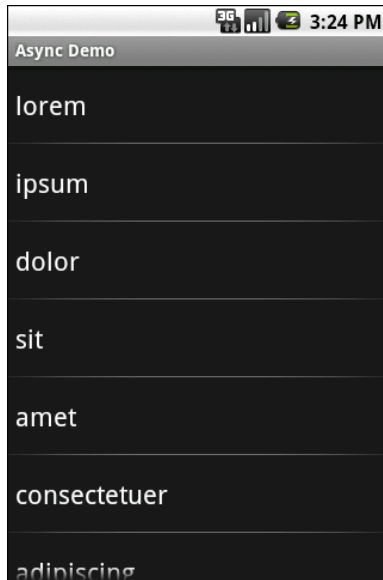
The Activity

```
new AddStringTask().execute();
```

To use `AddStringsTask`, we simply create an instance and call `execute()` on it. That starts the chain of events eventually leading to the background thread doing its work.

If `AddStringsTask` required configuration parameters, we would have not used `Void` as our first data type, and the constructor would accept zero or more parameters of the defined type. Those values would eventually be passed to `doInBackground()`.

The Results

If you build, install, and run this project, you will see the list being populated in "real time" over a few seconds, followed by a `Toast` indicating completion.

Figure 69. The AsyncDemo, partway through loading the list of words

Threads and Rotation

One problem with the default destroy-and-create cycle that activities go through on an orientation change comes from background threads. If the activity has started some background work – through an AsyncTask, for example – and then the activity is destroyed and re-created, somehow the AsyncTask needs to know about this. Otherwise, the AsyncTask might well send updates and final results to the *old* activity, with the new activity none the wiser. In fact, the new activity might start up the background work *again*, wasting resources.

One way to deal with this is to disable the destroy-and-create cycle is to take over configuration changes, as described in a previous section. Another alternative is to have a smarter activity and AsyncTask. You can see an example of that in the Rotation/RotationAsync sample project. This project uses a ProgressBar, much like the Handler demo from earlier in this chapter . It also has a TextView to indicate when the background work is completed, initially invisible:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
  <ProgressBar android:id="@+id/progress"
    style="?android:attr/progressBarStyleHorizontal"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
  />
  <TextView android:id="@+id/completed"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:text="Work completed!"
      android:visibility="invisible"
  />
</LinearLayout>
```

The "business logic" is for an AsyncTask to do some (fake) work in the background, updating the ProgressBar along the way, and making the TextView visible when it is finished. More importantly, it needs to do this in such a way as to behave properly if the screen is rotated:

- We cannot "lose" our AsyncTask, having it continue doing work and updating the wrong activity

- We cannot start a second AsyncTask, thereby doubling our workload

- We need to have the UI correctly reflect our work's progress or completion

Manual Activity Association

Earlier in this chapter, we showed the use of an AsyncTask that was implemented as a regular inner class of the Activity class. That works well when you are not concerned about rotation. For example, if the AsyncTask is not affecting the user interface – such as uploading a photo – rotation will not be an issue for you. Having the AsyncTask as an inner class of the Activity means you get ready access to the Activity for any place where you need a Context.

However, for the rotation scenario, a regular inner class will work poorly. The AsyncTask will think it knows the Activity it is supposed to work with,

but in reality it will be holding onto an implicit reference to the old activity, not one after an orientation change.

So, in RotationAsync, the RotationAwareTask class is a static inner class. This means RotationAwareTask does not have any implicit reference to any RotationAsync Activity (old or new):

```java
import android.app.Activity;
import android.os.AsyncTask;
import android.os.Bundle;
import android.os.SystemClock;
import android.util.Log;
import android.view.View;
import android.widget.ProgressBar;

public class RotationAsync extends Activity {
  private ProgressBar bar=null;
  private RotationAwareTask task=null;

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    bar=(ProgressBar)findViewById(R.id.progress);

    task=(RotationAwareTask)getLastNonConfigurationInstance();

    if (task==null) {
      task=new RotationAwareTask(this);
      task.execute();
    }
    else {
      task.attach(this);
      updateProgress(task.getProgress());

      if (task.getProgress()>=100) {
        markAsDone();
      }
    }
  }

  @Override
  public Object onRetainNonConfigurationInstance() {
    task.detach();

    return(task);
  }

  void updateProgress(int progress) {
```

```
  bar.setProgress(progress);
}

void markAsDone() {
  findViewById(R.id.completed).setVisibility(View.VISIBLE);
}

static class RotationAwareTask extends AsyncTask<Void, Void, Void> {
  RotationAsync activity=null;
  int progress=0;

  RotationAwareTask(RotationAsync activity) {
    attach(activity);
  }

  @Override
  protected Void doInBackground(Void... unused) {
    for (int i=0;i<20;i++) {
      SystemClock.sleep(500);
      publishProgress();
    }

    return(null);
  }

  @Override
  protected void onProgressUpdate(Void... unused) {
    if (activity==null) {
      Log.w("RotationAsync", "onProgressUpdate() skipped - no activity");
    }
    else {
      progress+=5;
      activity.updateProgress(progress);
    }
  }

  @Override
  protected void onPostExecute(Void unused) {
    if (activity==null) {
      Log.w("RotationAsync", "onPostExecute() skipped - no activity");
    }
    else {
      activity.markAsDone();
    }
  }

  void detach() {
    activity=null;
  }

  void attach(RotationAsync activity) {
    this.activity=activity;
  }
```

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```
    int getProgress() {
      return(progress);
    }
  }
}
```

Since we want `RotationAwareTask` to update the current `RotationAsync` `Activity`, we supply that `Activity` when we create the task, via the constructor. `RotationAwareTask` also has `attach()` and `detach()` methods to change what `Activity` the task knows about, as we will see shortly.

Flow of Events

When `RotationAsync` starts up for the first time, it creates a new instance of the `RotationAwareTask` class and executes it. At this point, the task has a reference to the `RotationAsync` `Activity` and can do its (fake) work, telling `RotationAsync` to update the progress along the way.

Now, suppose that during the middle of the `doInBackground()` processing, the user rotates the screen.

Our `Activity` will be called with `onRetainNonConfigurationInstance()`. Here, we want to do two things:

1. Since this `Activity` instance is being destroyed, we need to make sure the task no longer holds onto a reference to it. Hence, we call `detach()`, causing the task to set its `RotationAsync` data member (`activity`) to `null`.

2. We return the `RotationAwareTask` object, so that our new `RotationAsync` instance can get access to it

Eventually, the new `RotationAsync` instance will be created. In `onCreate()`, we try to get access to any current `RotationAwareTask` instance via `getNonConfigurationInstance()`. If that was `null`, then we know that this is a newly-created activity, and so we create a new task. If, however, `getNonConfigurationInstance()` returned the task object from the old `RotationAsync` instance, we hold onto it and update our UI to reflect the current progress that has been made. We also `attach()` the new

`RotationAsync` to the `RotationAwareTask`, so as further progress is made, the task can notify the proper activity.

The net result is that our `ProgressBar` smoothly progresses from 0 to 100, even while rotations are going on.

Why This Works

Most callback methods in Android are driven by messages on the message queue being processed by the main application thread. Normally, this queue is being processed whenever the main application thread is not otherwise busy, such as running our code.

However, when a configuration change occurs, like a screen rotation, that no longer holds true.

In between the call to `onRetainNonConfiguration()` instance of the old activity and the completion of `onCreate()` of the new activity, the message queue is left alone.

So, let us suppose that, in between `onRetainNonConfiguration()` activity and the subsequent `onCreate()`, our `AsyncTask`'s background work completes. This will trigger `onPostExecute()` to be called...eventually. However, since `onPostExecute()` is actually launched from a message on the message queue, `onPostExecute()` will not be called until after our `onCreate()` has completed.

Hence, our `AsyncTask` can keep running during the configuration change, so long as we do two things:

1. In `onCreate()` of the new activity instance, we update the `AsyncTask` to have it work with our new activity, rather than the old one

2. We do not attempt to use the activity from `doInBackground()`

And Now, The Caveats

Background threads, while eminently possible using the Android `Handler` system, are not all happiness and warm puppies. Background threads not only add complexity, but they have real-world costs in terms of available memory, CPU, and battery life.

To that end, there are a wide range of scenarios you need to account for with your background thread, including:

- The possibility that users will interact with your activity's UI while the background thread is chugging along. If the work that the background thread is doing is altered or invalidated by the user input, you will need to communicate this to the background thread. Android includes many classes in the `java.util.concurrent` package that will help you communicate safely with your background thread.

- The possibility that the activity will be killed off while background work is going on. For example, after starting your activity, the user might have a call come in, followed by a text message, followed by a need to look up a contact…all of which might be sufficient to kick your activity out of memory. The next chapter will cover the various events Android will take your activity through; hook the proper ones and be sure to shut down your background thread cleanly when you have the chance.

- The possibility that your user will get irritated if you chew up a lot of CPU time and battery life without giving any payback. Tactically, this means using `ProgressBar` or other means of letting the user know that something is happening. Strategically, this means you still need to be efficient at what you do – background threads are no panacea for sluggish or pointless code.

- The possibility that you will encounter an error during background processing. For example, if you are gathering information off the Internet, the device might lose connectivity. Alerting the user of the problem via a Notification and shutting down the background thread may be your best option.

Creating Intent Filters

Up to now, the focus of this book has been on activities opened directly by the user from the device's launcher. This, of course, is the most obvious case for getting your activity up and visible to the user. And, in many cases it is the primary way the user will start using your application.

However, remember that the Android system is based upon lots of loosely-coupled components. What you might accomplish in a desktop GUI via dialog boxes, child windows, and the like are mostly supposed to be independent activities. While one activity will be "special", in that it shows up in the launcher, the other activities all need to be reached...somehow.

The "how" is via intents.

An intent is basically a message that you pass to Android saying, "Yo! I want to do...er...something! Yeah!" How specific the "something" is depends on the situation – sometimes you know exactly what you want to do (e.g., open up one of your other activities), and sometimes you do not.

In the abstract, Android is all about intents and receivers of those intents. So, now that we are well-versed in creating activities, let's dive into intents, so we can create more complex applications while simultaneously being "good Android citizens".

What's Your Intent?

When Sir Tim Berners-Lee cooked up the Hypertext Transfer Protocol – HTTP – he set up a system of verbs plus addresses in the form of URLs. The address indicated a resource, such as a Web page, graphic, or server-side program. The verb indicated what should be done: GET to retrieve it, POST to send form data to it for processing, etc.

Intents are similar, in that they represent an action plus context. There are more actions and more components to the context with Android intents than there are with HTTP verbs and resources, but the concept is still the same.

Just as a Web browser knows how to process a verb+URL pair, Android knows how to find activities or other application logic that will handle a given intent.

Pieces of Intents

The two most important pieces of an intent are the action and what Android refers to as the "data". These are almost exactly analogous to HTTP verbs and URLs – the action is the verb, and the "data" is a `Uri`, such as `content://contacts/people/1` representing a contact in the contacts database. Actions are constants, such as `ACTION_VIEW` (to bring up a viewer for the resource), `ACTION_EDIT` (to edit the resource), or `ACTION_PICK` (to choose an available item given a `Uri` representing a collection, such as `content://contacts/people`).

If you were to create an intent combining `ACTION_VIEW` with a content Uri of `content://contacts/people/1`, and pass that intent to Android, Android would know to find and open an activity capable of viewing that resource.

There are other criteria you can place inside an intent (represented as an Intent object), besides the action and "data" `Uri`, such as:

- A category. Your "main" activity will be in the LAUNCHER category, indicating it should show up on the launcher menu. Other activities will probably be in the DEFAULT or ALTERNATIVE categories.

- A MIME type, indicating the type of resource you want to operate on, if you do not know a collection Uri.

- A component, which is to say, the class of the activity that is supposed to receive this intent. Using components this way obviates the need for the other properties of the intent. However, it does make the intent more fragile, as it assumes specific implementations.

- "Extras", which is a Bundle of other information you want to pass along to the receiver with the intent, that the receiver might want to take advantage of. What pieces of information a given receiver can use is up to the receiver and (hopefully) is well-documented.

You will find rosters of the standard actions and categories in the Android SDK documentation for the Intent class.

Intent Routing

As noted above, if you specify the target component in your intent, Android has no doubt where the intent is supposed to be routed to – it will launch the named activity. This might be OK if the target intent is in your application. It definitely is not recommended for sending intents to other applications. Component names, by and large, are considered private to the application and are subject to change. Content Uri templates and MIME types are the preferred ways of identifying services you wish third-party code to supply.

If you do not specify the target component, then Android has to figure out what activities (or other receivers) are eligible to receive the intent. Note the use of the plural "activities", as a broadly-written intent might well resolve to several activities. That is the...ummm...intent (pardon the pun), as you will see later in this chapter. This routing approach is referred to as implicit routing.

Basically, there are three rules, all of which must be true for a given activity to be eligible for a given intent:

1. The activity must support the specified action

2. The activity must support the stated MIME type (if supplied)

3. The activity must support all of the categories named in the intent

The upshot is that you want to make your intents specific enough to find the right receiver(s), and no more specific than that.

This will become clearer as we work through some examples later in this chapter.

Stating Your Intent(ions)

All Android components that wish to be notified via intents must declare intent filters, so Android knows which intents should go to that component. To do this, you need to add `intent-filter` elements to your `AndroidManifest.xml` file.

All of the example projects have intent filters defined, courtesy of the Android application-building script (`android create project` or the IDE equivalent). They look something like this:

```
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="com.commonsware.android.skeleton">
    <application>
        <activity android:name=".Now" android:label="Now">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
    </application>
</manifest>
```

Note the `intent-filter` element under the activity element. Here, we declare that this activity:

- Is the main activity for this application

- It is in the LAUNCHER category, meaning it gets an icon in the Android main menu

Because this activity is the main one for the application, Android knows this is the component it should launch when somebody chooses the application from the main menu.

You are welcome to have more than one action or more than one category in your intent filters. That indicates that the associated component (e.g., activity) handles multiple different sorts of intents.

More than likely, you will also want to have your secondary (non-MAIN) activities specify the MIME type of data they work on. Then, if an intent is targeted for that MIME type – either directly, or indirectly by the Uri referencing something of that type – Android will know that the component handles such data.

For example, you could have an activity declared like this:

```
<activity android:name=".TourViewActivity">
  <intent-filter>
    <action android:name="android.intent.action.VIEW" />
    <category android:name="android.intent.category.DEFAULT" />
    <data android:mimeType="vnd.android.cursor.item/vnd.commonsware.tour" />
  </intent-filter>
</activity>
```

This activity will get launched by an intent requesting to view a Uri representing a vnd.android.cursor.item/vnd.commonsware.tour piece of content. That Intent could come from another activity in the same application (e.g., the MAIN activity for this application) or from another activity in another Android application that happens to know a Uri that this activity handles.

Narrow Receivers

In the examples shown above, the intent filters were set up on activities. Sometimes, tying intents to activities is not exactly what we want:

- Some system events might cause us to want to trigger something in a service rather than an activity

- Some events might need to launch different activities in different circumstances, where the criteria are not solely based on the intent itself, but some other state (e.g., if we get intent X and the database has a Y, then launch activity M; if the database does not have a Y, then launch activity N)

For these cases, Android offers the receiver, defined as a class implementing the BroadcastReceiver interface. Broadcast receivers are disposable objects designed to receive intents – specifically, broadcast intents – and take action.

The BroadcastReceiver interface has only one method: onReceive(). Receivers implement that method, where they do whatever it is they wish to do upon an incoming intent. To declare an receiver, add a receiver element to your AndroidManifest.xml file:

```
<receiver android:name=".MyIntentReceiverClassName" />
```

An receiver is only alive for as long as it takes to process onReceive() – as soon as that method returns, the receiver instance is subject to garbage collection and will not be reused. This means receivers are somewhat limited in what they can do, mostly to avoid anything that involves any sort of callback. For example, they cannot bind to a service, and they cannot open a dialog box.

The exception is if the BroadcastReceiver is implemented on some longer-lived component, such as an activity or service – in that case, the receiver lives as long as its "host" does (e.g., until the activity is frozen). However, in this case, you cannot declare the receiver via AndroidManifest.xml. Instead, you need to call registerReceiver() on your Activity's onResume() callback

to declare interest in an intent, then call `unregisterReceiver()` from your `Activity`'s `onPause()` when you no longer need those intents.

The Pause Caveat

There is one hiccup with using Intent objects to pass arbitrary messages around: it only works when the receiver is active. To quote from the documentation for `BroadcastReceiver`:

> *If registering a receiver in your `Activity.onResume()` implementation, you should unregister it in `Activity.onPause()`. (You will not receive intents when paused, and this will cut down on unnecessary system overhead). Do not unregister in `Activity.onSaveInstanceState()`, because this will not be called if the user moves back in the history stack.*

Hence, you can only really use the `Intent` framework as an arbitrary message bus if:

- Your receiver does not care if it misses messages because it was not active, or

- You provide some means of getting the receiver "caught up" on messages it missed while it was inactive, or

- Your receiver is registered in the manifest

Launching Activities and Sub-Activities

The theory behind the Android UI architecture is that developers should decompose their application into distinct activities. For example, a calendar application could have activities for viewing the calendar, viewing a single event, editing an event (including adding a new one), and so forth.

This, of course, implies that one of your activities has the means to start up another activity. For example, if somebody clicks on an event from the view-calendar activity, you might want to show the view-event activity for that event. This means that, somehow, you need to be able to cause the view-event activity to launch and show a specific event (the one the user clicked upon).

This can be further broken down into two scenarios:

1. You know what activity you want to launch, probably because it is another activity in your own application

2. You have a content `Uri` to...something, and you want your users to be able to do...something with it, but you do not know up front what the options are

This chapter covers the first scenario; the companion advanced Android book handles the second.

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Peers and Subs

One key question you need to answer when you decide to launch an activity is: does your activity need to know when the launched activity ends?

For example, suppose you want to spawn an activity to collect authentication information for some Web service you are connecting to – maybe you need to authenticate with OpenID in order to use an OAuth service. In this case, your main activity will need to know when the authentication is complete so it can start to use the Web service.

On the other hand, imagine an email application in Android. When the user elects to view an attachment, neither you nor the user necessarily expect the main activity to know when the user is done viewing that attachment.

In the first scenario, the launched activity is clearly subordinate to the launching activity. In that case, you probably want to launch the child as a sub-activity, which means your activity will be notified when the child activity is complete.

In the second scenario, the launched activity is more a peer of your activity, so you probably want to launch the "child" just as a regular activity. Your activity will not be informed when the "child" is done, but, then again, your activity really does not need to know.

Start 'Em Up

The two pieces for starting an activity are an intent and your choice of how to start it up.

Make an Intent

As discussed in a previous chapter, intents encapsulate a request, made to Android, for some activity or other receiver to do something.

If the activity you intend to launch is one of your own, you may find it simplest to create an explicit intent, naming the component you wish to launch. For example, from within your activity, you could create an intent like this:

```
new Intent(this, HelpActivity.class);
```

This would stipulate that you wanted to launch the `HelpActivity`. This activity would need to be named in your `AndroidManifest.xml` file, though not necessarily with any intent filter, since you are trying to request it directly.

Or, you could put together an intent for some `Uri`, requesting a particular action:

```
Uri uri=Uri.parse("geo:"+lat.toString()+","+lon.toString());
Intent i=new Intent(Intent.ACTION_VIEW, uri);
```

Here, given that we have the latitude and longitude of some position (`lat` and `lon`, respectively) of type `Double`, we construct a `geo` scheme `Uri` and create an intent requesting to view this `Uri` (`ACTION_VIEW`).

Make the Call

Once you have your intent, you need to pass it to Android and get the child activity to launch. You have two choices:

1. The simplest option is to call `startActivity()` with the `Intent` – this will cause Android to find the best-match activity and pass the intent to it for handling. Your activity will not be informed when the "child" activity is complete.

2. You can call `startActivityForResult()`, passing it the `Intent` and a number (unique to the calling activity). Android will find the best-match activity and pass the intent over to it. However, your activity will be notified when the child activity is complete via the `onActivityResult()` callback (see below).

With `startActivityForResult()`, as noted, you can implement the `onActivityResult()` callback to be notified when the child activity has completed its work. The callback receives the unique number supplied to `startActivityForResult()`, so you can determine which child activity is the one that has completed. You also get:

- A result code, from the child activity calling `setResult()`. Typically this is `RESULT_OK` or `RESULT_CANCELED`, though you can create your own return codes (pick a number starting with `RESULT_FIRST_USER`)

- An optional `String` containing some result data, possibly a URL to some internal or external resource – for example, a `ACTION_PICK` intent typically returns the selected bit of content via this data string

- An optional `Bundle` containing additional information beyond the result code and data string

To demonstrate launching a peer activity, take a peek at the `Activities/Launch` sample application. The XML layout is fairly straightforward: two fields for the latitude and longitude, plus a button:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <TableLayout
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:stretchColumns="1,2"
  >
    <TableRow>
      <TextView
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:paddingLeft="2dip"
        android:paddingRight="4dip"
        android:text="Location:"
      />
      <EditText android:id="@+id/lat"
        android:layout_width="fill_parent"
        android:layout_height="wrap_content"
        android:cursorVisible="true"
        android:editable="true"
        android:singleLine="true"
```

```
        android:layout_weight="1"
      />
      <EditText android:id="@+id/lon"
        android:layout_width="fill_parent"
        android:layout_height="wrap_content"
        android:cursorVisible="true"
        android:editable="true"
        android:singleLine="true"
        android:layout_weight="1"
      />
    </TableRow>
  </TableLayout>
  <Button android:id="@+id/map"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:text="Show Me!"
    android:onClick="showMe"
  />
</LinearLayout>
```

The button's `showMe()` callback method simply takes the latitude and longitude, pours them into a `geo` scheme `Uri`, then starts the activity.

```
package com.commonsware.android.activities;

import android.app.Activity;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.view.View;
import android.widget.EditText;

public class LaunchDemo extends Activity {
  private EditText lat;
  private EditText lon;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    lat=(EditText)findViewById(R.id.lat);
    lon=(EditText)findViewById(R.id.lon);
  }

  public void showMe(View v) {
    String _lat=lat.getText().toString();
    String _lon=lon.getText().toString();
    Uri uri=Uri.parse("geo:"+_lat+","+_lon);

    startActivity(new Intent(Intent.ACTION_VIEW, uri));
```

```
  }
}
```

The activity is not much to look at:
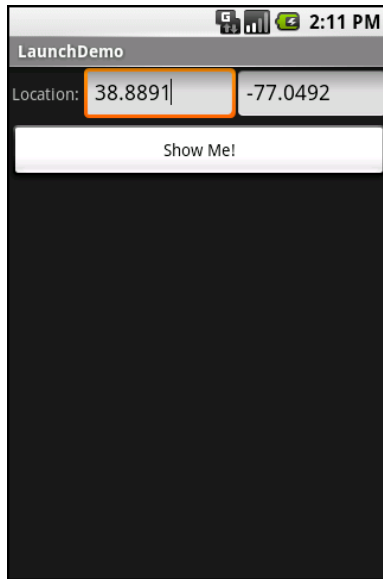
Figure 70. The LaunchDemo sample application, with a location filled in

If you fill in a location (e.g., 38.8891 latitude and -77.0492 longitude) and click the button, the resulting map is more interesting. Note that this is the built-in Android map activity – we did not create our own activity to display this map.
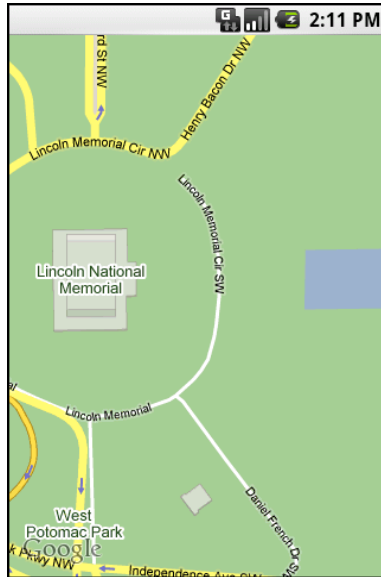
**Figure 71. The map launched by Launch Demo, showing the Lincoln Memorial
in Washington DC**

In a later chapter, you will see how you can create maps in your own
activities, in case you need greater control over how the map is displayed.

Tabbed Browsing, Sort Of

One of the main features of the modern desktop Web browser is tabbed
browsing, where a single browser window can show several pages split
across a series of tabs. On a mobile device, this may not make a lot of sense,
given that you lose screen real estate for the tabs themselves.

In this book, however, we do not let little things like sensibility stop us, so
let us demonstrate a tabbed browser, using TabActivity and Intent objects.

As you may recall from the section on tabbed views from earlier in this
book, a tab can have a View as its contents. It can also have an Activity as its
contents. If you want to use an Activity as the content of a tab, you provide
an Intent that will launch the desired Activity; Android's tab-management
framework will then pour the Activity's user interface into the tab.

Your natural instinct might be to use an `http:` Uri the way we used a `geo:` Uri in the previous example:

```
Intent i=new Intent(Intent.ACTION_VIEW);
i.setData(Uri.parse("http://commonsware.com"));
```

That way, you could use the built-in Browser application and get all of the features that it offers.

Alas, this does not work. You cannot host other applications' activities in your tabs, only your own activities, for security reasons.

So, we dust off our `WebView` demos from the chapter on WebKit and use those instead, repackaged as `Activities/IntentTab`.

Here is the source to the main activity, the one hosting the `TabView`:

```
package com.commonsware.android.intenttab;

import android.app.Activity;
import android.app.TabActivity;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.webkit.WebView;
import android.widget.TabHost;

public class IntentTabDemo extends TabActivity {
  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);

    TabHost host=getTabHost();
    Intent i=new Intent(this, CWBrowser.class);

    i.putExtra(CWBrowser.URL, "http://commonsware.com");
    host.addTab(host.newTabSpec("one")
            .setIndicator("CW")
            .setContent(i));

    i=new Intent(i);
    i.putExtra(CWBrowser.URL, "http://www.android.com");
    host.addTab(host.newTabSpec("two")
            .setIndicator("Android")
            .setContent(i));
```

```
  }
}
```

As you can see, we are using TabActivity as the base class, and so we do not need our own layout XML – TabActivity supplies it for us. All we do is get access to the TabHost and add two tabs, each specifying an Intent that directly refers to another class. In this case, our two tabs will each host a CWBrowser, with a URL to load supplied via an Intent extra.

The CWBrowser activity is simple modification to the earlier browser demos:

```java
package com.commonsware.android.intenttab;

import android.app.Activity;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.webkit.WebView;

public class CWBrowser extends Activity {
  public static final String URL="com.commonsware.android.intenttab.URL";
  private WebView browser;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);

    browser=new WebView(this);
    setContentView(browser);
    browser.loadUrl(getIntent().getStringExtra(URL));
  }
}
```

They simply load a different URL into the browser: the CommonsWare home page in one, the Android home page in the other.

The resulting UI shows what tabbed browsing could look like on Android:
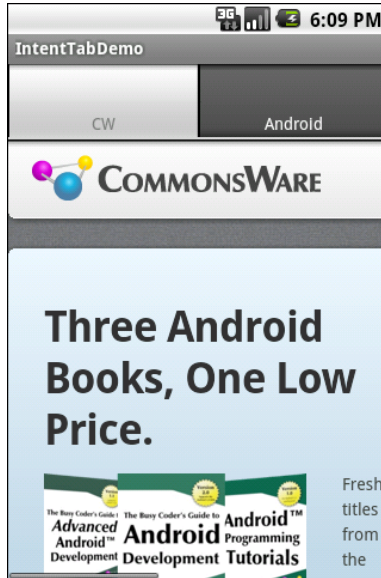
Figure 72. The IntentTabDemo sample application, showing the first tab
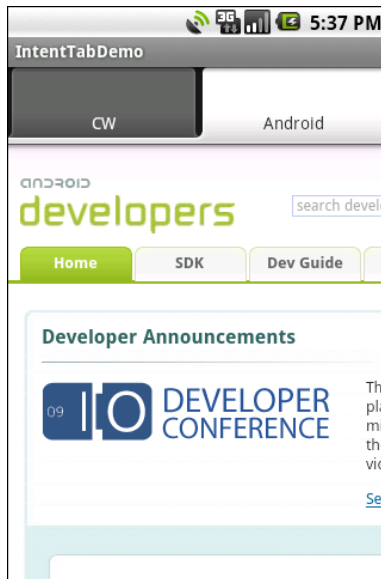
Figure 73. The IntentTabDemo sample application, showing the second tab

However, this approach is rather wasteful. There is a fair bit of overhead in creating an activity, that one does not need just to populate tabs in a TabHost. In particular, it increases the amount of stack space needed by your

application, and running out of stack space is a significant problem in Android, as will be described in a later chapter.

PART III – Data Stores, Network Services, and APIs

Accessing Files

While Android offers structured storage, via preferences and databases, sometimes a simple file will suffice. Android offers two models for accessing files: one for files pre-packaged with your application, and one for files created on-device by your application.

You And The Horse You Rode In On

Let's suppose you have some static data you want to ship with the application, such as a list of words for a spell-checker. The easiest way to deploy that is to put the file in the `res/raw` directory, so it gets put in the Android application `.apk` file as part of the packaging process as a raw resource.

To access this file, you need to get yourself a `Resources` object. From an activity, that is as simple as calling `getResources()`. A `Resources` object offers `openRawResource()` to get an `InputStream` on the file you specify. Rather than a path, `openRawResource()` expects an integer identifier for the file as packaged. This works just like accessing widgets via `findViewById()` – if you put a file named `words.xml` in `res/raw`, the identifier is accessible in Java as `R.raw.words`.

Since you can only get an `InputStream`, you have no means of modifying this file. Hence, it is really only useful for static reference data. Moreover, since it is unchanging until the user installs an updated version of your

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application package, either the reference data has to be valid for the foreseeable future, or you will need to provide some means of updating the data. The simplest way to handle that is to use the reference data to bootstrap some other modifiable form of storage (e.g., a database), but this makes for two copies of the data in storage. An alternative is to keep the reference data as-is but keep modifications in a file or database, and merge them together when you need a complete picture of the information. For example, if your application ships a file of URLs, you could have a second file that tracks URLs added by the user or reference URLs that were deleted by the user.

In the `Files/Static` sample project, you will find a reworking of the listbox example from earlier, this time using a static XML file instead of a hardwired array in Java. The layout is the same:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent" >
  <TextView
    android:id="@+id/selection"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
  />
  <ListView
    android:id="@android:id/list"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:drawSelectorOnTop="false"
  />
</LinearLayout>
```

In addition to that XML file, you also need an XML file with the words to show in the list:

```xml
<words>
  <word value="lorem" />
  <word value="ipsum" />
  <word value="dolor" />
  <word value="sit" />
  <word value="amet" />
  <word value="consectetuer" />
  <word value="adipiscing" />
  <word value="elit" />
```

```
  <word value="morbi" />
  <word value="vel" />
  <word value="ligula" />
  <word value="vitae" />
  <word value="arcu" />
  <word value="aliquet" />
  <word value="mollis" />
  <word value="etiam" />
  <word value="vel" />
  <word value="erat" />
  <word value="placerat" />
  <word value="ante" />
  <word value="porttitor" />
  <word value="sodales" />
  <word value="pellentesque" />
  <word value="augue" />
  <word value="purus" />
</words>
```

While this XML structure is not exactly a model of space efficiency, it will suffice for a demo.

The Java code now must read in that XML file, parse out the words, and put them someplace for the list to pick up:

```java
public class StaticFileDemo extends ListActivity {
  TextView selection;
  ArrayList<String> items=new ArrayList<String>();

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    selection=(TextView)findViewById(R.id.selection);

    try {
      InputStream in=getResources().openRawResource(R.raw.words);
      DocumentBuilder builder=DocumentBuilderFactory
                                .newInstance()
                                .newDocumentBuilder();
      Document doc=builder.parse(in, null);
      NodeList words=doc.getElementsByTagName("word");

      for (int i=0;i<words.getLength();i++) {
        items.add(((Element)words.item(i)).getAttribute("value"));
      }

      in.close();
    }
    catch (Throwable t) {
      Toast
```

```
        .makeText(this, "Exception: "+t.toString(), Toast.LENGTH_LONG)
        .show();
    }

    setListAdapter(new ArrayAdapter<String>(this,
                            android.R.layout.simple_list_item_1,
                            items));
  }

  public void onListItemClick(ListView parent, View v, int position,
                long id) {
    selection.setText(items.get(position).toString());
  }
}
```

The differences mostly lie within onCreate(). We get an InputStream for the XML file (getResources().openRawResource(R.raw.words)), then use the built-in XML parsing logic to parse the file into a DOM Document, pick out the word elements, then pour the value attributes into an ArrayList for use by the ArrayAdapter.

The resulting activity looks the same as before, since the list of words is the same, just relocated:
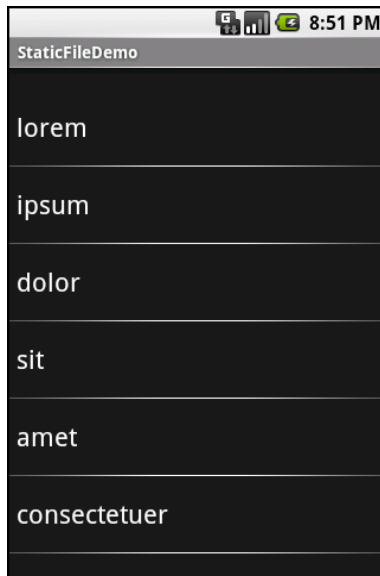
Figure 74. The StaticFileDemo sample application

Of course, there are even easier ways to have XML files available to you as pre-packaged files, such as by using an XML resource. That is covered in the next chapter. However, while this example used XML, the file could just as easily have been a simple one-word-per-line list, or in some other format not handled natively by the Android resource system.

Readin' 'n Writin'

Reading and writing your own, application-specific data files is nearly identical to what you might do in a desktop Java application. The key is to use openFileInput() and openFileOutput() on your Activity or other Context to get an InputStream and OutputStream, respectively. From that point forward, it is not much different than regular Java I/O logic:

- Wrap those streams as needed, such as using an InputStreamReader or OutputStreamWriter for text-based I/O

- Read or write the data

- Use close() to release the stream when done

If two applications both try reading a notes.txt file via openFileInput(), they will each access their own edition of the file. If you need to have one file accessible from many places, you probably want to create a content provider, as will be described in an upcoming chapter.

Note that openFileInput() and openFileOutput() do not accept file paths (e.g., path/to/file.txt), just simple filenames.

Below you will see the layout for the world's most trivial text editor, pulled from the Files/ReadWrite sample application:

```xml
<?xml version="1.0" encoding="utf-8"?>
<EditText xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/editor"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:singleLine="false"
  android:gravity="top"
  />
```

All we have here is a large text-editing widget...which is pretty boring.

The Java is only slightly more complicated:

```java
package com.commonsware.android.readwrite;

import android.app.Activity;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.Toast;
import java.io.BufferedReader;
import java.io.File;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.io.OutputStream;
import java.io.OutputStreamWriter;

public class ReadWriteFileDemo extends Activity {
  private final static String NOTES="notes.txt";
  private EditText editor;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    editor=(EditText)findViewById(R.id.editor);
  }

  public void onResume() {
    super.onResume();

    try {
      InputStream in=openFileInput(NOTES);

      if (in!=null) {
        InputStreamReader tmp=new InputStreamReader(in);
        BufferedReader reader=new BufferedReader(tmp);
        String str;
        StringBuilder buf=new StringBuilder();

        while ((str = reader.readLine()) != null) {
          buf.append(str+"\n");
        }

        in.close();
        editor.setText(buf.toString());
      }
    }
    catch (java.io.FileNotFoundException e) {
      // that's OK, we probably haven't created it yet
```

```
    }
    catch (Throwable t) {
      Toast
        .makeText(this, "Exception: "+t.toString(), Toast.LENGTH_LONG)
        .show();
    }
  }

  public void onPause() {
    super.onPause();

    try {
      OutputStreamWriter out=
          new OutputStreamWriter(openFileOutput(NOTES, 0));

      out.write(editor.getText().toString());
      out.close();
    }
    catch (Throwable t) {
      Toast
        .makeText(this, "Exception: "+t.toString(), Toast.LENGTH_LONG)
        .show();
    }
  }
}
```

First, we hook into onResume(), so we get control when our editor is coming back to life, from a fresh launch or after having been frozen. We use openFileInput() to read in notes.txt and pour the contents into the text editor. If the file is not found, we assume this is the first time the activity was run (or the file was deleted by other means), and we just leave the editor empty.

Finally, we hook into onPause(), so we get control as our activity gets hidden by another activity or is closed, such as via our "Close" button. Here, we use openFileOutput() to open notes.txt, into which we pour the contents of the text editor.

The net result is that we have a persistent notepad: whatever is typed in will remain until deleted, surviving our activity being closed (e.g., via the BACK button), the phone being turned off, or similar situations.
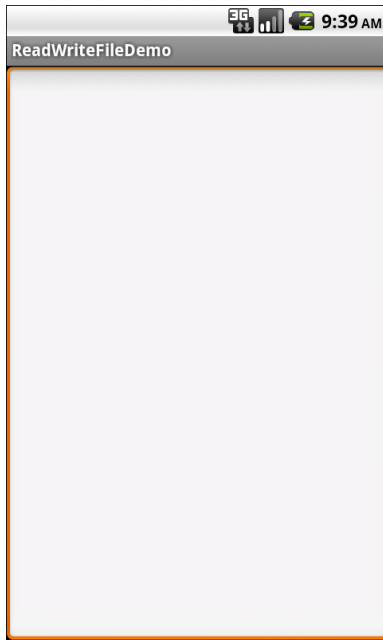
Figure 75. The ReadWriteFileDemo sample application, as initially launched
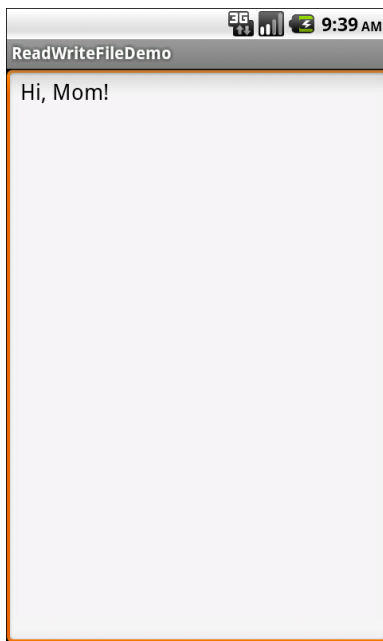
Figure 76. The same application, after entering some text

You are also welcome to read and write files on "external storage" (a.k.a., the SD card). Use `Environment.getExternalStorageDirectory()` to obtain a `File` object at the root of the SD card. Starting with Android 1.6, you will also need to hold permissions to work with external storage (e.g., `WRITE_EXTERNAL_STORAGE`) – the concept of permissions will be covered in a later chapter.

Bear in mind that external storage is accessible by all applications, whereas `openFileInput()` and `openFileOutput()` are in an application-private area.

Also bear in mind that not all devices will have external storage. For example, the HTC Incredible has 8GB of on-board flash, readable by applications in the `/emmc` directory. However, while it has a micro-SD card slot, some devices ship without a card installed. `getExternalStorageDirectory()` on the Incredible returns the path to the SD card, even if there is no such card.

If you intend to rely upon external storage, be sure to also use `getExternalStorageState()` (a static method on the `Environment` class) to determine if there is an SD card installed and available. Beyond the case of devices missing a card, it is also possible that the user has the SD card mounted on her PC or Mac. The SD card can be accessed by the host computer, or by the device, but not by both at the same time. `getExternalStorageState()` will let you know if you can use external storage at that moment.

Working with Resources

Resources are static bits of information held outside the Java source code. You have seen one type of resource – the layout – frequently in the examples in this book. There are many other types of resource, such as images and strings, that you can take advantage of in your Android applications.

The Resource Lineup

Resources are stored as files under the `res/` directory in your Android project layout. With the exception of raw resources (`res/raw/`), all the other types of resources are parsed for you, either by the Android packaging system or by the Android system on the device or emulator. So, for example, when you lay out an activity's UI via a layout resource (`res/layout/`), you do not have to parse the layout XML yourself – Android handles that for you.

In addition to layout resources (first seen in an earlier chapter) and animation resources (introduced in another earlier chapter), there are several other types of resource available to you, including:

- Images (`res/drawable/`), for putting static icons or other pictures in a user interface
- Raw (`res/raw/`), for putting arbitrary files that have meaning to your application but not necessarily to Android frameworks

- Strings, colors, arrays, and dimensions (`res/values/`), to both give these sorts of constants symbolic names and to keep them separate from the rest of the code (e.g., for internationalization and localization)

- XML (`res/xml/`), for static XML files containing your own data and structure

String Theory

Keeping your labels and other bits of text outside the main source code of your application is generally considered to be a very good idea. In particular, it helps with internationalization (I18N) and localization (L10N), covered later in this chapter. Even if you are not going to translate your strings to other languages, it is easier to make corrections if all the strings are in one spot instead of scattered throughout your source code.

Android supports regular externalized strings, along with "string formats", where the string has placeholders for dynamically-inserted information. On top of that, Android supports simple text formatting, called "styled text", so you can make your words be bold or italic intermingled with normal text.

Plain Strings

Generally speaking, all you need to do is have an XML file in the `res/values` directory (typically named `res/values/strings.xml`), with a `resources` root element, and one child `string` element for each string you wish to encode as a resource. The `string` element takes a `name` attribute, which is the unique name for this string, and a single text element containing the text of the string:

```
<resources>
  <string name="quick">The quick brown fox...</string>
  <string name="laughs">He who laughs last...</string>
</resources>
```

The only tricky part is if the string value contains a quote (") or an apostrophe ('). In those cases, you will want to escape those values, by

preceding them with a backslash (e.g., `These are the times that try men\'s souls`). Or, if it is just an apostrophe, you could enclose the value in quotes (e.g., `"These are the times that try men's souls."`).

You can then reference this string from a layout file (as `@string/...`, where the ellipsis is the unique name – e.g., `@string/laughs`). Or you can get the string from your Java code by calling `getString()` with the resource ID of the string resource, that being the unique name prefixed with `R.string.` (e.g., `getString(R.string.quick)`).

String Formats

As with other implementations of the Java language, Android's Dalvik VM supports string formats. Here, the string contains placeholders representing data to be replaced at runtime by variable information (e.g., `My name is %1$s`). Plain strings stored as resources can be used as string formats:

```
String strFormat=getString(R.string.my_name);
String strResult=String.format(strFormat, "Tim");
((TextView)findViewById(R.id.some_label)).setText(strResult);
```

There is also a flavor of `getString()` that does the `String.format()` call for you:

```
String strResult=getString(R.string.my_name, "Tim");
((TextView)findViewById(R.id.some_label)).setText(strResult);
```

Styled Text

If you want really rich text, you should have raw resources containing HTML, then pour those into a WebKit widget. However, for light HTML formatting, using inline elements like `<b>`, `<i>`, and `<u>`, you can just use them in a string resource:

```
<resources>
  <string name="b">This has <b>bold</b> in it.</string>
```

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```
  <string name="i">Whereas this has <i>italics</i>!</string>
</resources>
```

You can access these via `getText()`, where you will get back an object supporting the `android.text.Spanned` interface and therefore has all of the formatting applied:

```
((TextView)findViewById(R.id.another_label))
           .setText(getText(R.string.b));
```

Styled Text and Formats

Where styled text gets tricky is with styled string formats, as `String.format()` works on `String` objects, not `Spanned` objects with formatting instructions. If you really want to have styled string formats, here is the workaround:

1. Entity-escape the angle brackets in the string resource (e.g., `this is <b>%1$s</b>`)

2. Retrieve the string resource as normal, though it will not be styled at this point (e.g., `getString(R.string.funky_format)`)

3. Generate the format results, being sure to escape any string values you substitute in, in case they contain angle brackets or ampersands

   ```
   String.format(getString(R.string.funky_format),
                 TextUtils.htmlEncode(strName));
   ```

4. Convert the entity-escaped HTML into a `Spanned` object via `Html.fromHtml()`

   ```
   someTextView.setText(Html
                        .fromHtml(resultFromStringFormat));
   ```

To see this in action, let's look at the `Resources/Strings` demo. Here is the layout file:

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
```

```
   >
  <LinearLayout
    android:orientation="horizontal"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    >
    <Button android:id="@+id/format"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:text="@string/btn_name"
      android:onClick="applyFormat"
      />
    <EditText android:id="@+id/name"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      />
  </LinearLayout>
  <TextView android:id="@+id/result"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    />
</LinearLayout>
```

As you can see, it is just a button, a field, and a label. The intent is for somebody to enter their name in the field, then click the button to cause the label to be updated with a formatted message containing their name.

The `Button` in the layout file references a string resource (`@string/btn_name`), so we need a string resource file (`res/values/strings.xml`):

```
<?xml version="1.0" encoding="utf-8"?>
<resources>
  <string name="app_name">StringsDemo</string>
  <string name="btn_name">Name:</string>
  <string name="funky_format">My name is &lt;b&gt;%1$s&lt;/b&gt;</string>
</resources>
```

The `app_name` resource is automatically created by the `android create project` command. The `btn_name` string is the caption of the `Button`, while our styled string format is in `funky_format`.

Finally, to hook all this together, we need a pinch of Java:

```
package com.commonsware.android.strings;

import android.app.Activity;
```

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```java
import android.os.Bundle;
import android.text.TextUtils;
import android.text.Html;
import android.view.View;
import android.widget.EditText;
import android.widget.TextView;

public class StringsDemo extends Activity {
  EditText name;
  TextView result;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    name=(EditText)findViewById(R.id.name);
    result=(TextView)findViewById(R.id.result);
  }

  public void applyFormat(View v) {
    String format=getString(R.string.funky_format);
    String simpleResult=String.format(format,
                    TextUtils.htmlEncode(name.getText().toString()));
    result.setText(Html.fromHtml(simpleResult));
  }
}
```

The string resource manipulation can be found in `applyFormat()`, which is called when the button is clicked. First, we get our format via `getString()` – something we could have done at `onCreate()` time for efficiency. Next, we format the value in the field using this format, getting a `String` back, since the string resource is in entity-encoded HTML. Note the use of `TextUtils.htmlEncode()` to entity-encode the entered name, in case somebody decides to use an ampersand or something. Finally, we convert the simple HTML into a styled text object via `Html.fromHtml()` and update our label.

When the activity is first launched, we have an empty label:
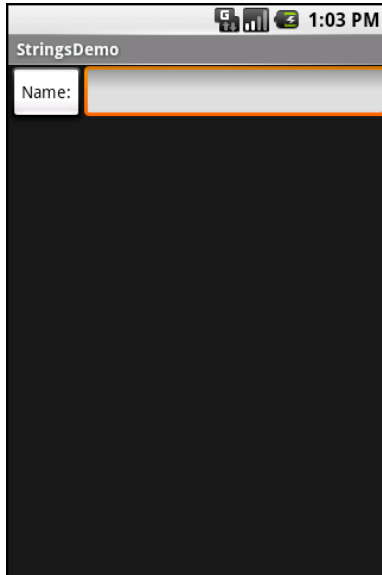
Figure 77. The StringsDemo sample application, as initially launched

but if we fill in a name and click the button, we get:
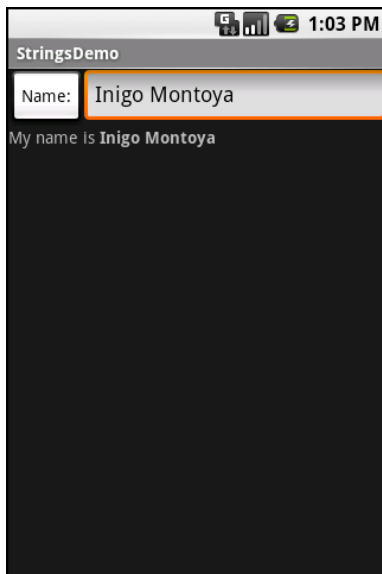
Figure 78. The same application, after filling in some heroic figure's name

---

Got the Picture?

Android supports images in the PNG, JPEG, and GIF formats. GIF is officially discouraged, however; PNG is the overall preferred format. Images can be used anywhere that requires a `Drawable`, such as the image and background of an `ImageView`.

Using images is simply a matter of putting your image files in `res/drawable/` and then referencing them as a resource. Within layout files, images are referenced as `@drawable/...` where the ellipsis is the base name of the file (e.g., for `res/drawable/foo.png`, the resource name is `@drawable/foo`). In Java, where you need an image resource ID, use `R.drawable.` plus the base name (e.g., `R.drawable.foo`).

So, let's update the previous example to use an icon for the button instead of the string resource. This can be found as `Resources/Images`. First, we slightly adjust the layout file, using an `ImageButton` and referencing a drawable named `@drawable/icon`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:orientation="vertical"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  >
  <LinearLayout
    android:orientation="horizontal"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    >
    <ImageButton android:id="@+id/format"
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:src="@drawable/icon"
      android:onClick="applyFormat"
      />
    <EditText android:id="@+id/name"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      />
  </LinearLayout>
  <TextView android:id="@+id/result"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
```

```
    />
</LinearLayout>
```

Next, we need to put an image file in res/drawable with a base name of icon. In this case, we use a 32x32 PNG file from the Nuvola icon set. Finally, we twiddle the Java source, replacing our Button with an ImageButton:

```java
package com.commonsware.android.images;

import android.app.Activity;
import android.os.Bundle;
import android.text.TextUtils;
import android.text.Html;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.TextView;

public class ImagesDemo extends Activity {
  EditText name;
  TextView result;

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);

    name=(EditText)findViewById(R.id.name);
    result=(TextView)findViewById(R.id.result);
  }

  public void applyFormat(View v) {
    String format=getString(R.string.funky_format);
    String simpleResult=String.format(format,
                  TextUtils.htmlEncode(name.getText().toString()));
    result.setText(Html.fromHtml(simpleResult));
  }
}
```

Now, our button has the desired icon:
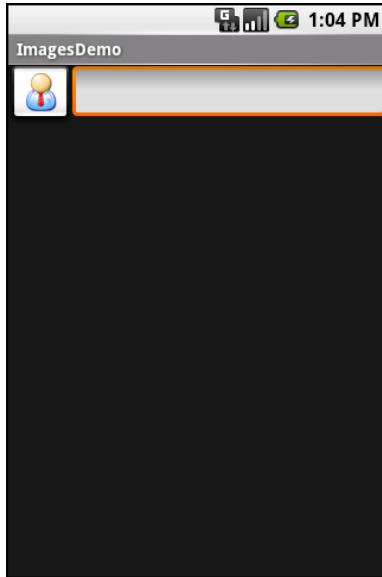
Figure 79. The ImagesDemo sample application

XML: The Resource Way

If you wish to package static XML with your application, you can use an XML resource. Simply put the XML file in res/xml/, and you can access it by getXml() on a Resources object, supplying it a resource ID of R.xml. plus the base name of your XML file. So, in an activity, with an XML file of words.xml, you could call getResources().getXml(R.xml.words).

This returns an instance of an XmlPullParser, found in the org.xmlpull.v1 Java namespace. An XML pull parser is event-driven: you keep calling next() on the parser to get the next event, which could be START_TAG, END_TAG, END_DOCUMENT, etc. On a START_TAG event, you can access the tag's name and attributes; a single TEXT event represents the concatenation of all text nodes that are direct children of this element. By looping, testing, and invoking per-element logic, you parse the file.

To see this in action, let's rewrite the Java code for the Files/Static sample project to use an XML resource. This new project, Resources/XML, requires that you place the words.xml file from Static not in res/raw/, but in

res/xml/. The layout stays the same, so all that needs replacing is the Java source:

```
package com.commonsware.android.resources;

import android.app.Activity;
import android.os.Bundle;
import android.app.ListActivity;
import android.view.View;
import android.widget.AdapterView;
import android.widget.ArrayAdapter;
import android.widget.ListView;
import android.widget.TextView;
import android.widget.Toast;
import java.io.InputStream;
import java.util.ArrayList;
import org.xmlpull.v1.XmlPullParser;
import org.xmlpull.v1.XmlPullParserException;

public class XMLResourceDemo extends ListActivity {
  TextView selection;
  ArrayList<String> items=new ArrayList<String>();

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
    selection=(TextView)findViewById(R.id.selection);

    try {
      XmlPullParser xpp=getResources().getXml(R.xml.words);

      while (xpp.getEventType()!=XmlPullParser.END_DOCUMENT) {
        if (xpp.getEventType()==XmlPullParser.START_TAG) {
          if (xpp.getName().equals("word")) {
            items.add(xpp.getAttributeValue(0));
          }
        }

        xpp.next();
      }
    }
    catch (Throwable t) {
      Toast
        .makeText(this, "Request failed: "+t.toString(), Toast.LENGTH_LONG)
        .show();
    }

    setListAdapter(new ArrayAdapter<String>(this,
                        android.R.layout.simple_list_item_1,
                        items));
  }
}
```

```
  public void onListItemClick(ListView parent, View v, int position,
                  long id) {
    selection.setText(items.get(position).toString());
  }
}
```

Now, inside our `try...catch` block, we get our `XmlPullParser` and loop until the end of the document. If the current event is `START_TAG` and the name of the element is `word` (`xpp.getName().equals("word")`), then we get the one-and-only attribute and pop that into our list of items for the selection widget. Since we're in complete control over the XML file, it is safe enough to assume there is exactly one attribute. But, if you were not as comfortable that the XML is properly defined, you might consider checking the attribute count (`getAttributeCount()`) and the name of the attribute (`getAttributeName()`) before blindly assuming the `0`-index attribute is what you think it is.

The result looks the same as before, albeit with a different name in the title bar:
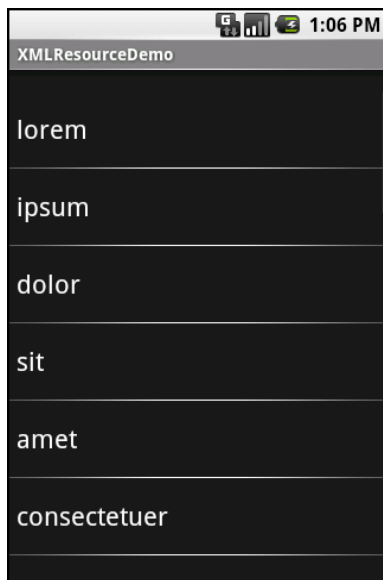
Figure 80. The XMLResourceDemo sample application

Miscellaneous Values

In the `res/values/` directory, in addition to string resources, you can place one (or more) XML files describing other simple resources, such as dimensions, colors, and arrays. We have already seen uses of dimensions and colors in previous examples, where they were passed as simple strings (e.g., `"10px"`) as parameters to calls. You can, of course, set these up as Java static final objects and use their symbolic names...but this only works inside Java source, not in layout XML files. By putting these values in resource XML files, you can reference them from both Java and layouts, plus have them centrally located for easy editing.

Resource XML files have a root element of `resources`; everything else is a child of that root.

Dimensions

Dimensions are used in several places in Android to describe distances, such as a widget's padding. While this book usually uses pixels (e.g., `10px` for ten pixels), there are several different units of measurement available to you:

- `in` and `mm` for inches and millimeters, respectively, based on the actual size of the screen

- `pt` for points, which in publishing terms is 1/72nd of an inch (again, based on the actual physical size of the screen)

- `dip` and `sp` for device-independent pixels and scale-independent pixels – one pixel equals one `dip` for a 160dpi resolution screen, with the ratio scaling based on the actual screen pixel density (scale-independent pixels also take into account the user's preferred font size)

To encode a dimension as a resource, add a `dimen` element, with a `name` attribute for your unique name for this resource, and a single child text element representing the value:

```
<resources>
  <dimen name="thin">10px</dimen>
  <dimen name="fat">1in</dimen>
</resources>
```

In a layout, you can reference dimensions as `@dimen/...`, where the ellipsis is a placeholder for your unique name for the resource (e.g., `thin` and `fat` from the sample above). In Java, you reference dimension resources by the unique name prefixed with `R.dimen.` (e.g., `Resources.getDimen(R.dimen.thin)`).

Colors

Colors in Android are hexadecimal RGB values, also optionally specifying an alpha channel. You have your choice of single-character hex values or double-character hex values, leaving you with four styles:

- #RGB

- #ARGB

- #RRGGBB

- #AARRGGBB

These work similarly to their counterparts in Cascading Style Sheets (CSS).

You can, of course, put these RGB values as string literals in Java source or layout resources. If you wish to turn them into resources, though, all you need to do is add `color` elements to the resources file, with a `name` attribute for your unique name for this color, and a single text element containing the RGB value itself:

```
<resources>
  <color name="yellow_orange">#FFD555</color>
  <color name="forest_green">#005500</color>
  <color name="burnt_umber">#8A3324</color>
</resources>
```

In a layout, you can reference colors as `@color/...`, replacing the ellipsis with your unique name for the color (e.g., `burnt_umber`). In Java, you

reference color resources by the unique name prefixed with `R.color`. (e.g., `Resources.getColor(R.color.forest_green)`).

Arrays

Array resources are designed to hold lists of simple strings, such as a list of honorifics (Mr., Mrs., Ms., Dr., etc.).

In the resource file, you need one `string-array` element per array, with a `name` attribute for the unique name you are giving the array. Then, add one or more child `item` elements, each of which having a single text element with the value for that entry in the array:

```xml
<?xml version="1.0" encoding="utf-8"?>
<resources>
  <string-array name="cities">
    <item>Philadelphia</item>
    <item>Pittsburgh</item>
    <item>Allentown/Bethlehem</item>
    <item>Erie</item>
    <item>Reading</item>
    <item>Scranton</item>
    <item>Lancaster</item>
    <item>Altoona</item>
    <item>Harrisburg</item>
  </string-array>
  <string-array name="airport_codes">
    <item>PHL</item>
    <item>PIT</item>
    <item>ABE</item>
    <item>ERI</item>
    <item>RDG</item>
    <item>AVP</item>
    <item>LNS</item>
    <item>AOO</item>
    <item>MDT</item>
  </string-array>
</resources>
```

From your Java code, you can then use `Resources.getStringArray()` to get a `String[]` of the items in the list. The parameter to `getStringArray()` is your unique name for the array, prefixed with `R.array`. (e.g., `Resources.getStringArray(R.array.honorifics)`).

Different Strokes for Different Folks

One set of resources may not fit all situations where your application may be used. One obvious area comes with string resources and dealing with internationalization (I18N) and localization (L10N). Putting strings all in one language works fine – probably at least for the developer – but only covers one language.

That is not the only scenario where resources might need to differ, though. Here are others:

- **Screen orientation**: is the screen in a portrait orientation? Landscape? Is the screen square and, therefore, does not really have an orientation?

- **Screen size**: how many pixels does the screen have, so you can size your resources accordingly (e.g., large versus small icons)?

- **Touchscreen**: does the device have a touchscreen? If so, is the touchscreen set up to be used with a stylus or a finger?

- **Keyboard**: what keyboard does the user have (QWERTY, numeric, neither), either now or as an option?

- **Other input**: does the device have some other form of input, like a directional pad or click-wheel?

The way Android currently handles this is by having multiple resource directories, with the criteria for each embedded in their names.

Suppose, for example, you want to support strings in both English and Spanish. Normally, for a single-language setup, you would put your strings in a file named `res/values/strings.xml`. To support both English and Spanish, you would create two folders, `res/values-en/` and `res/values-es/`, where the value after the hyphen is the ISO 639-1 two-letter code for the language you want. Your English-language strings would go in `res/values-en/strings.xml` and the Spanish ones in `res/values-es/strings.xml`. Android will choose the proper file based on the user's device settings.

An even better approach is for you to consider some language to be your default, and put those strings in `res/values/strings.xml`. Then, create other resource directories for your translations (e.g., `res/values-es/strings.xml` for Spanish). Android will try to match a specific language set of resources; failing that, it will fall back to the default of `res/values/strings.xml`.

Seems easy, right?

Where things start to get complicated is when you need to use multiple disparate criteria for your resources. For example, let us suppose you want to develop both for the T-Mobile G1, the Samsung Galaxy Tab, and the Motorola Charm.

- The T-Mobile G1 has a normal-size, medium-density screen and a hardware keyboard

- The Samsung Galaxy Tab has a large size, high-density screen and no hardware keyboard

- The Motorola Charm has a small size, medium-density screen and a hardware keyboard

You may want to have somewhat different layouts for these devices, to take advantage of different screen real estate and different input options. Specifically:

- You want different layouts for each combination of size, orientation, and keyboard

- You want different drawables for each density

Once you get into these sorts of situations, though, all sorts of rules come into play, such as:

- The configuration options (e.g., `-en`) have a particular order of precedence, and they must appear in the directory name in that order. The Android documentation outlines the specific order in which these options can appear. For the purposes of this example, screen size is more important than screen orientation, which is

more important than screen density, which is more important than whether or not the device has a keyboard.

- There can only be one value of each configuration option category per directory.

- Options are case sensitive

So, for the scenario described above, in theory, we would need the following directories, representing the possible combinations:

- `res/layout-large-port-mdpi-qwerty`
- `res/layout-large-port-mdpi-nokeys`
- `res/layout-large-port-hdpi-qwerty`
- `res/layout-large-port-hdpi-nokeys`
- `res/layout-large-land-mdpi-qwerty`
- `res/layout-large-land-mdpi-nokeys`
- `res/layout-large-land-hdpi-qwerty`
- `res/layout-large-land-hdpi-nokeys`
- `res/layout-normal-port-mdpi-qwerty`
- `res/layout-normal-port-mdpi-nokeys`
- `res/layout-normal-port-finger-qwerty`
- `res/layout-normal-port-hdpi-nokeys`
- `res/layout-normal-land-mdpi-qwerty`
- `res/layout-normal-land-mdpi-nokeys`
- `res/layout-normal-land-hdpi-qwerty`
- `res/layout-normal-land-hdpi-nokeys`
- `res/drawable-large-port-mdpi-qwerty`
- `res/drawable-large-port-mdpi-nokeys`
- `res/drawable-large-port-hdpi-qwerty`
- `res/drawable-large-port-hdpi-nokeys`
- `res/drawable-large-land-mdpi-qwerty`
- `res/drawable-large-land-mdpi-nokeys`
- `res/drawable-large-land-hdpi-qwerty`

- `res/drawable-large-land-hdpi-nokeys`

- `res/drawable-normal-port-mdpi-qwerty`

- `res/drawable-normal-port-mdpi-nokeys`

- `res/drawable-normal-port-finger-qwerty`

- `res/drawable-normal-port-hdpi-nokeys`

- `res/drawable-normal-land-mdpi-qwerty`

- `res/drawable-normal-land-mdpi-nokeys`

- `res/drawable-normal-land-hdpi-qwerty`

- `res/drawable-normal-land-hdpi-nokeys`

Don't panic! We will shorten this list in just a moment!

Note that there is nothing preventing you from also having a directory with the unadorned base name (`res/layout`). In fact, this is really a good idea, in case future editions of the Android runtime introduce other configuration options you did not consider – having a default layout might make the difference between your application working or failing on that new device.

Also, we can cut the number of required directories a lot by decoding the rules Android uses for determining which, among a set of candidates, is the "right" resource directory to use:

1. First up, Android tosses out ones that are specifically invalid. So, for example, if the screen size of the device is "normal", the `-large` directories would be dropped as candidates, since they call for some other size.

2. Next, Android counts the number of matches for each folder, and only pays attention to those with the most matches.

3. Finally, Android goes in the order of precedence of the options – in other words, it goes from left to right in the directory name.

Also, our drawables are only varying by density, and our layouts are not varying by density, so we can clear out a lot of combinations by focusing on only the relevant platform differences.

So we could skate by with only the following configurations:

- `res/layout-large-land-qwerty`
- `res/layout-large-qwerty`
- `res/layout-large-land`
- `res/layout-large`
- `res/layout-normal-land-qwerty`
- `res/layout-normal-qwerty`
- `res/layout-normal-land`
- `res/layout`
- `res/drawable-hdpi`
- `res/drawable`

Here, we take advantage of the fact that specific matches take precedence over "unspecified" values. So, a device with a QWERTY keyboard will choose a resource with `qwerty` in the directory over a resource that does not specify its keyboard type.

We could refine this even further, to only cover the specific devices we are targeting (e.g., there is no `large` device with `qwerty`):

- `res/layout-large-land`
- `res/layout-large`
- `res/layout-land-qwerty`
- `res/layout-qwerty`
- `res/layout-land`
- `res/layout`
- `res/drawable-hdpi`
- `res/drawable`

If we did not care about having different layouts for whether the device had a hardware keyboard, we could drop the two `-qwerty` resource sets.

We will see these resource sets again in the chapter on supporting multiple screen sizes, later in the book.

Using Preferences

Android has many different ways for you to store data for long-term use by your activity. The simplest to use is the preferences system.

Android allows activities and applications to keep preferences, in the form of key/value pairs (akin to a `Map`), that will hang around between invocations of an activity. As the name suggests, the primary purpose is for you to store user-specified configuration details, such as the last feed the user looked at in your feed reader, or what sort order to use by default on a list, or whatever. Of course, you can store in the preferences whatever you like, so long as it is keyed by a `String` and has a primitive value (`boolean`, `String`, etc.)

Preferences can either be for a single activity or shared among all activities in an application. Other components, such as services, also can work with shared preferences.

Getting What You Want

To get access to the preferences, you have three APIs to choose from:

1. `getPreferences()` from within your `Activity`, to access activity-specific preferences

2. `getSharedPreferences()` from within your `Activity` (or other application `Context`), to access application-level preferences

3. `getDefaultSharedPreferences()`, on `PreferenceManager`, to get the shared preferences that work in concert with Android's overall preference framework

The first two take a security mode parameter – for now, pass in `0`. The `getSharedPreferences()` method also takes a name of a set of preferences – `getPreferences()` effectively calls `getSharedPreferences()` with the activity's class name as the preference set name. The `getDefaultSharedPreferences()` method takes the `Context` for the preferences (e.g., your `Activity`).

All of those methods return an instance of `SharedPreferences`, which offers a series of getters to access named preferences, returning a suitably-typed result (e.g., `getBoolean()` to return a boolean preference). The getters also take a default value, which is returned if there is no preference set under the specified key.

Stating Your Preference

Given the appropriate `SharedPreferences` object, you can use `edit()` to get an "editor" for the preferences. This object has a set of setters that mirror the getters on the parent `SharedPreferences` object. It also has:

- `remove()` to get rid of a single named preference
- `clear()` to get rid of all preferences
- `commit()` to persist your changes made via the editor

The last one is important – if you modify preferences via the editor and fail to `commit()` the changes, those changes will evaporate once the editor goes out of scope.

Conversely, since the preferences object supports live changes, if one part of your application (say, an activity) modifies shared preferences, another part of your application (say, a service) will have access to the changed value immediately.

And Now, a Word From Our Framework

Beginning with the 0.9 SDK, Android has introduced a framework for managing preferences. Ironically, this framework does not change anything shown above. Instead, the framework is more for presenting a consistent set of preference-setting options for users, so different applications do not have to "reinvent the wheel".

The linchpin to the preferences framework is yet another XML data structure. You can describe your application's preferences in an XML file stored in your project's `res/xml/` directory. Given that, Android can present a pleasant UI for manipulating those preferences, which are then stored in the `SharedPreferences` you get back from `getDefaultSharedPreferences()`.

Below, you will find the preference XML for the `Prefs/Simple` preferences sample project:

```
<PreferenceScreen
  xmlns:android="http://schemas.android.com/apk/res/android">
  <CheckBoxPreference
    android:key="checkbox"
    android:title="Checkbox Preference"
    android:summary="Check it on, check it off" />
  <RingtonePreference
    android:key="ringtone"
    android:title="Ringtone Preference"
    android:showDefault="true"
    android:showSilent="true"
    android:summary="Pick a tone, any tone" />
</PreferenceScreen>
```

The root of the preference XML is a `PreferenceScreen` element. We will explain why it is named that later in this chapter; for now, take it on faith that it is a sensible name.

One of the things you can have inside a `PreferenceScreen` element, not surprisingly, are preference definitions. These are subclasses of `Preference`, such as `CheckBoxPreference` or `RingtonePreference`, as shown above. As one might expect, these allow you to check a checkbox or choose a ringtone, respectively. In the case of `RingtonePreference`, you have your option of

allowing users to choose the system default ringtone, or to choose "silence" as a ringtone.

Letting Users Have Their Say

Given that you have set up the preference XML, you can use a nearly-built-in activity for allowing your users to set their preferences. The activity is nearly "built-in" because you merely need to subclass it and point it to your preference XML, plus hook the activity into the rest of your application.

So, for example, here is the EditPreferences activity of the Prefs/Simple project:

```
package com.commonsware.android.simple;

import android.app.Activity;
import android.os.Bundle;
import android.preference.PreferenceActivity;


public class EditPreferences extends PreferenceActivity {
  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);

    addPreferencesFromResource(R.xml.preferences);
  }
}
```

As you can see, there is not much *to* see. All you need to do is call addPreferencesFromResource() and specify the XML resource containing your preferences.

You will also need to add this as an activity to your AndroidManifest.xml file:

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="com.commonsware.android.simple">
    <application android:label="@string/app_name"
        android:icon="@drawable/cw">
        <activity
            android:name=".SimplePrefsDemo"
            android:label="@string/app_name">
```

```
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
        <activity
            android:name=".EditPreferences"
            android:label="@string/app_name">
        </activity>
    </application>
</manifest>
```

And you will need to arrange to invoke the activity, such as from a menu option, here pulled from SimplePrefsDemo:

```
public boolean onCreateOptionsMenu(Menu menu) {
   menu.add(Menu.NONE, EDIT_ID, Menu.NONE, "Edit Prefs")
       .setIcon(R.drawable.misc)
       .setAlphabeticShortcut('e');

   return(super.onCreateOptionsMenu(menu));
}

@Override
public boolean onOptionsItemSelected(MenuItem item) {
   switch (item.getItemId()) {
     case EDIT_ID:
       startActivity(new Intent(this, EditPreferences.class));
       return(true);
   }

   return(super.onOptionsItemSelected(item));
}
}
```

However, that is all that is needed, and it really is not that much code outside of the preferences XML. What you get for your effort is an Android-supplied preference UI:
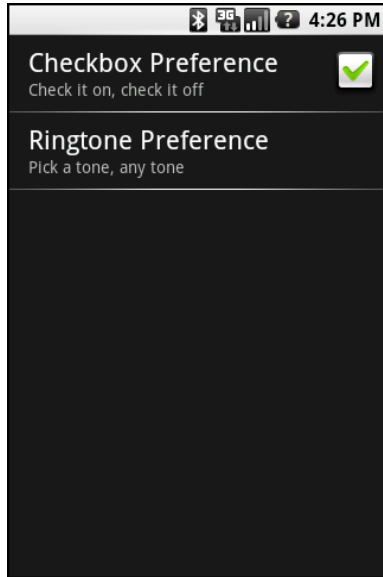
Figure 81. The Simple project's preferences UI

The checkbox can be directly checked or unchecked. To change the ringtone preference, just click on the entry in the preference list to bring up a selection dialog:
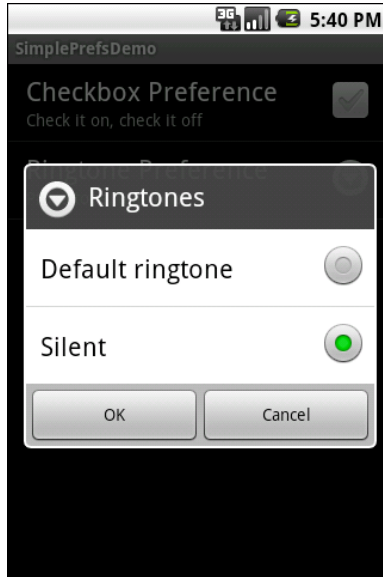
Figure 82. Choosing a ringtone preference

Note that there is no explicit "save" or "commit" button or menu on the PreferenceActivity – changes are persisted automatically.

The SimplePrefsDemo activity, beyond having the aforementioned menu, also displays the current preferences via a TableLayout:

```
<?xml version="1.0" encoding="utf-8"?>
<TableLayout
  xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
>
  <TableRow>
    <TextView
        android:text="Checkbox:"
        android:paddingRight="5px"
    />
    <TextView android:id="@+id/checkbox"
    />
  </TableRow>
  <TableRow>
    <TextView
        android:text="Ringtone:"
        android:paddingRight="5px"
    />
    <TextView android:id="@+id/ringtone"
```

```
    />
  </TableRow>
</TableLayout>
```

The fields for the table are found in `onCreate()`:

```
public void onCreate(Bundle savedInstanceState) {
  super.onCreate(savedInstanceState);
  setContentView(R.layout.main);

  checkbox=(TextView)findViewById(R.id.checkbox);
  ringtone=(TextView)findViewById(R.id.ringtone);
}
```

The fields are updated on each `onResume()`:

```
public void onResume() {
  super.onResume();

  SharedPreferences prefs=PreferenceManager
                           .getDefaultSharedPreferences(this);

  checkbox.setText(new Boolean(prefs
                              .getBoolean("checkbox", false))
                    .toString());
  ringtone.setText(prefs.getString("ringtone", "<unset>"));
}
```

This means the fields will be updated when the activity is opened and after the preferences activity is left (e.g., via the back button):
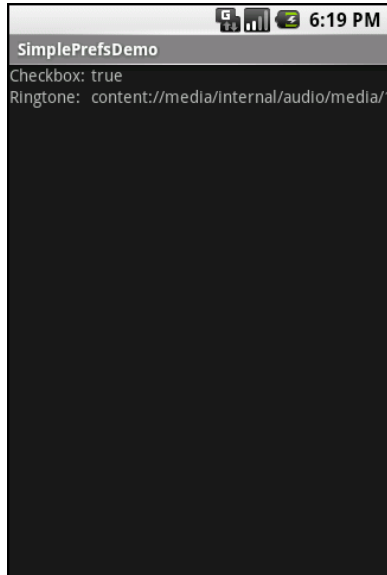
Figure 83. The Simple project's list of saved preferences

Adding a Wee Bit O' Structure

If you have a lot of preferences for users to set, having them all in one big list may become troublesome. Android's preference UI gives you a few ways to impose a bit of structure on your bag of preferences, including categories and screens.

Categories are added via a `PreferenceCategory` element in your preference XML and are used to group together related preferences. Rather than have your preferences all as children of the root `PreferenceScreen`, you can put a few `PreferenceCategory` elements in the `PreferenceScreen`, and then put your preferences in their appropriate categories. Visually, this adds a divider with the category title between groups of preferences.

If you have lots and lots of preferences – more than is convenient for users to scroll through – you can also put them on separate "screens" by introducing the `PreferenceScreen` element.

Yes, *that* `PreferenceScreen` element.

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Any children of `PreferenceScreen` go on their own screen. If you nest `PreferenceScreens`, the parent screen displays the screen as a placeholder entry – tapping that entry brings up the child screen.

For example, from the `Prefs/Structured` sample project, here is a preference XML file that contains both `PreferenceCategory` and nested `PreferenceScreen` elements:

```xml
<PreferenceScreen
  xmlns:android="http://schemas.android.com/apk/res/android">
  <PreferenceCategory android:title="Simple Preferences">
    <CheckBoxPreference
      android:key="checkbox"
      android:title="Checkbox Preference"
      android:summary="Check it on, check it off"
    />
    <RingtonePreference
      android:key="ringtone"
      android:title="Ringtone Preference"
      android:showDefault="true"
      android:showSilent="true"
      android:summary="Pick a tone, any tone"
    />
  </PreferenceCategory>
  <PreferenceCategory android:title="Detail Screens">
    <PreferenceScreen
      android:key="detail"
      android:title="Detail Screen"
      android:summary="Additional preferences held in another page">
      <CheckBoxPreference
        android:key="checkbox2"
        android:title="Another Checkbox"
        android:summary="On. Off. It really doesn't matter."
      />
    </PreferenceScreen>
  </PreferenceCategory>
</PreferenceScreen>
```

The result, when you use this preference XML with your `PreferenceActivity` implementation, is a categorized list of elements:
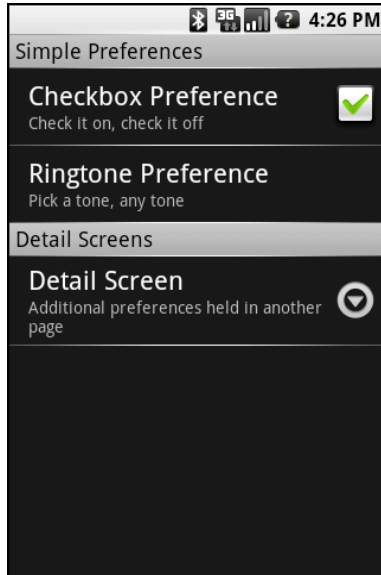
Figure 84. The Structured project's preference UI, showing categories and a screen placeholder

And, if you tap on the Detail Screen entry, you are taken to the child preference screen:
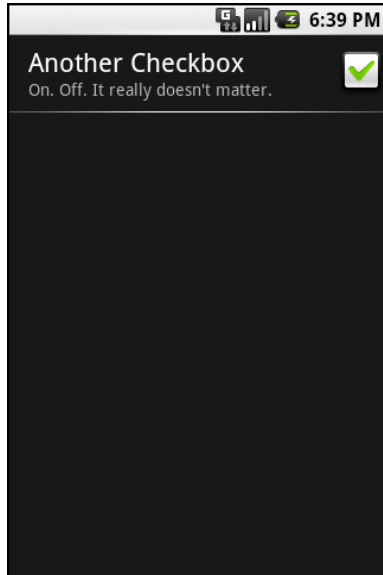
Figure 85. The child preference screen of the Structured project's preference UI

The Kind Of Pop-Ups You Like

Of course, not all preferences are checkboxes and ringtones.

For others, like entry fields and lists, Android uses pop-up dialogs. Users do not enter their preference directly in the preference UI activity, but rather tap on a preference, fill in a value, and click OK to commit the change.

Structurally, in the preference XML, fields and lists are not significantly different from other preference types, as seen in this preference XML from the `Prefs/Dialogs` sample project:

```
<PreferenceScreen
  xmlns:android="http://schemas.android.com/apk/res/android">
  <PreferenceCategory android:title="Simple Preferences">
    <CheckBoxPreference
      android:key="checkbox"
      android:title="Checkbox Preference"
      android:summary="Check it on, check it off"
    />
    <RingtonePreference
```

```
      android:key="ringtone"
      android:title="Ringtone Preference"
      android:showDefault="true"
      android:showSilent="true"
      android:summary="Pick a tone, any tone"
    />
  </PreferenceCategory>
  <PreferenceCategory android:title="Detail Screens">
    <PreferenceScreen
      android:key="detail"
      android:title="Detail Screen"
      android:summary="Additional preferences held in another page">
      <CheckBoxPreference
        android:key="checkbox2"
        android:title="Another Checkbox"
        android:summary="On. Off. It really doesn't matter."
      />
    </PreferenceScreen>
  </PreferenceCategory>
  <PreferenceCategory android:title="Other Preferences">
    <EditTextPreference
      android:key="text"
      android:title="Text Entry Dialog"
      android:summary="Click to pop up a field for entry"
      android:dialogTitle="Enter something useful"
    />
    <ListPreference
      android:key="list"
      android:title="Selection Dialog"
      android:summary="Click to pop up a list to choose from"
      android:entries="@array/cities"
      android:entryValues="@array/airport_codes"
      android:dialogTitle="Choose a Pennsylvania city" />
  </PreferenceCategory>
</PreferenceScreen>
```

With the field (`EditTextPreference`), in addition to the title and summary you put on the preference itself, you can also supply the title to use for the dialog.

With the list (`ListPreference`), you supply both a dialog title and two string-array resources: one for the display names, one for the values. These need to be in the same order – the index of the chosen display name determines which value is stored as the preference in the `SharedPreferences`. For example, here are the arrays for use by the `ListPreference` shown above:

```
<?xml version="1.0" encoding="utf-8"?>
<resources>
  <string-array name="cities">
```

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```
   <item>Philadelphia</item>
   <item>Pittsburgh</item>
   <item>Allentown/Bethlehem</item>
   <item>Erie</item>
   <item>Reading</item>
   <item>Scranton</item>
   <item>Lancaster</item>
   <item>Altoona</item>
   <item>Harrisburg</item>
 </string-array>
 <string-array name="airport_codes">
   <item>PHL</item>
   <item>PIT</item>
   <item>ABE</item>
   <item>ERI</item>
   <item>RDG</item>
   <item>AVP</item>
   <item>LNS</item>
   <item>AOO</item>
   <item>MDT</item>
 </string-array>
</resources>
```

When you bring up the preference UI, you start with another category with another pair of preference entries:
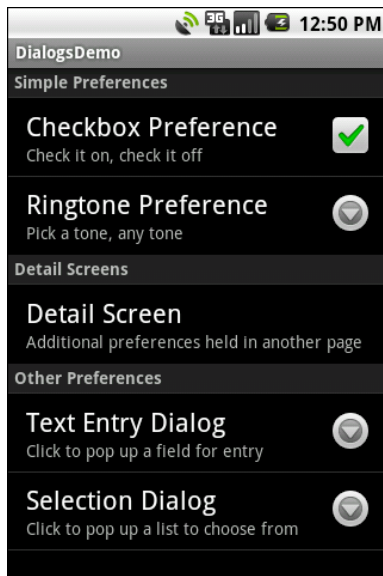
Figure 86. The preference screen of the Dialogs project's preference UI

Tapping the Text Entry Dialog one brings up...a text entry dialog – in this case, with the prior preference entry pre-filled-in:
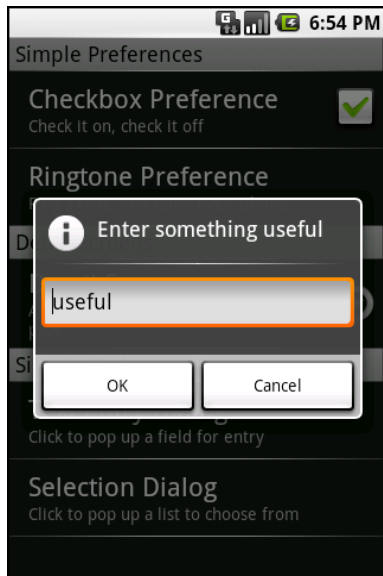
Figure 87. Editing a text preference

Tapping the Selection Dialog one brings up...a selection dialog, showing the display names from the one array:
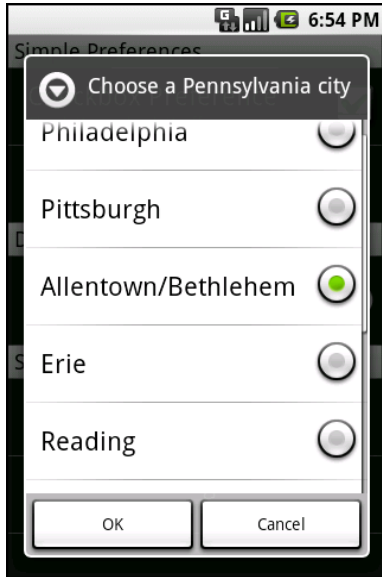
Figure 88. Editing a list preference

Managing and Accessing Local Databases

SQLite is a very popular embedded database, as it combines a clean SQL interface with a very small memory footprint and decent speed. Moreover, it is public domain, so everyone can use it. Lots of firms (Adobe, Apple, Google, Sun, Symbian) and open source projects (Mozilla, PHP, Python) all ship products with SQLite.

For Android, SQLite is "baked into" the Android runtime, so every Android application can create SQLite databases. Since SQLite uses a SQL interface, it is fairly straightforward to use for people with experience in other SQL-based databases. However, its native API is not JDBC, and JDBC might be too much overhead for a memory-limited device like a phone, anyway. Hence, Android programmers have a different API to learn – the good news being is that it is not that difficult.

This chapter will cover the basics of SQLite use in the context of working on Android. It by no means is a thorough coverage of SQLite as a whole. If you want to learn more about SQLite and how to use it in environments other than Android, a fine book is The Definitive Guide to SQLite by Michael Owens.

Much of the sample code shown in this chapter comes from the `Database/Constants` application. This application presents a list of physical constants, with names and values culled from Android's `SensorManager`:
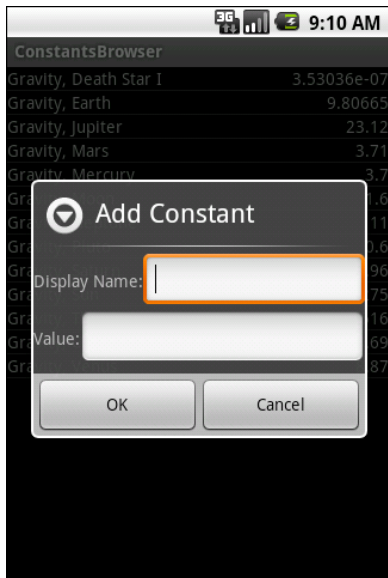
Figure 89. The Constants sample application, as initially launched

You can pop up a menu to add a new constant, which brings up a dialog to fill in the name and value of the constant:

Figure 90. The Constants sample application's add-constant dialog

The constant is then added to the list. A long-tap on an existing constant will bring up a context menu with a "Delete" option – after confirmation, that will delete the constant.

And, of course, all of this is stored in a SQLite database.

A Quick SQLite Primer

SQLite, as the name suggests, uses a dialect of SQL for queries (SELECT), data manipulation (INSERT, et. al.), and data definition (CREATE TABLE, et. al.). SQLite has a few places where it deviates from the SQL-92 standard, no different than most SQL databases. The good news is that SQLite is so space-efficient that the Android runtime can include all of SQLite, not some arbitrary subset to trim it down to size.

The biggest difference from other SQL databases you will encounter is probably the data typing. While you can specify the data types for columns in a CREATE TABLE statement, and while SQLite will use those as a hint, that is as far as it goes. You can put whatever data you want in whatever column you want. Put a string in an INTEGER column? Sure! No problem! Vice versa? Works too! SQLite refers to this as "manifest typing", as described in the documentation:

> In manifest typing, the datatype is a property of the value itself, not of the column in which the value is stored. SQLite thus allows the user to store any value of any datatype into any column regardless of the declared type of that column.

In addition, there are a handful of standard SQL features not supported in SQLite, notably FOREIGN KEY constraints, nested transactions, RIGHT OUTER JOIN and FULL OUTER JOIN, and some flavors of ALTER TABLE.

Beyond that, though, you get a full SQL system, complete with triggers, transactions, and the like. Stock SQL statements, like SELECT, work pretty much as you might expect.

If you are used to working with a major database, like Oracle, you may look upon SQLite as being a "toy" database. Please bear in mind that Oracle and SQLite are meant to solve different problems, and that you will not be seeing a full copy of Oracle on a phone any time soon, in all likelihood.

Start at the Beginning

No databases are automatically supplied to you by Android. If you want to use SQLite, you have to create your own database, then populate it with your own tables, indexes, and data.

To create and open a database, your best option is to craft a subclass of `SQLiteOpenHelper`. This class wraps up the logic to create and upgrade a database, per your specifications, as needed by your application. Your subclass of `SQLiteOpenHelper` will need three methods:

- The constructor, chaining upward to the `SQLiteOpenHelper` constructor. This takes the `Context` (e.g., an `Activity`), the name of the database, an optional cursor factory (typically, just pass `null`), and an integer representing the version of the database schema you are using.

- `onCreate()`, which passes you a `SQLiteDatabase` object that you use to populate with tables and initial data, as appropriate.

- `onUpgrade()`, which passes you a `SQLiteDatabase` object and the old and new version numbers, so you can figure out how best to convert the database from the old schema to the new one. The simplest, albeit least friendly, approach is to simply drop the old tables and create new ones.

For example, here is a `DatabaseHelper` class from `Database/Constants` that, in `onCreate()`, creates a table and adds a number of rows, and in `onUpgrade()` "cheats" by dropping the existing table and executing `onCreate()`:

```
package com.commonsware.android.constants;

import android.content.ContentValues;
import android.content.Context;
import android.database.Cursor;
```

```
import android.database.SQLException;
import android.database.sqlite.SQLiteOpenHelper;
import android.database.sqlite.SQLiteDatabase;
import android.hardware.SensorManager;

public class DatabaseHelper extends SQLiteOpenHelper {
  private static final String DATABASE_NAME="db";
  public static final String TITLE="title";
  public static final String VALUE="value";

  public DatabaseHelper(Context context) {
    super(context, DATABASE_NAME, null, 1);
  }

  @Override
  public void onCreate(SQLiteDatabase db) {
    db.execSQL("CREATE TABLE constants (_id INTEGER PRIMARY KEY AUTOINCREMENT,
title TEXT, value REAL);");

    ContentValues cv=new ContentValues();

    cv.put(TITLE, "Gravity, Death Star I");
    cv.put(VALUE, SensorManager.GRAVITY_DEATH_STAR_I);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Earth");
    cv.put(VALUE, SensorManager.GRAVITY_EARTH);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Jupiter");
    cv.put(VALUE, SensorManager.GRAVITY_JUPITER);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Mars");
    cv.put(VALUE, SensorManager.GRAVITY_MARS);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Mercury");
    cv.put(VALUE, SensorManager.GRAVITY_MERCURY);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Moon");
    cv.put(VALUE, SensorManager.GRAVITY_MOON);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Neptune");
    cv.put(VALUE, SensorManager.GRAVITY_NEPTUNE);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Pluto");
    cv.put(VALUE, SensorManager.GRAVITY_PLUTO);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Saturn");
```

```
    cv.put(VALUE, SensorManager.GRAVITY_SATURN);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Sun");
    cv.put(VALUE, SensorManager.GRAVITY_SUN);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, The Island");
    cv.put(VALUE, SensorManager.GRAVITY_THE_ISLAND);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Uranus");
    cv.put(VALUE, SensorManager.GRAVITY_URANUS);
    db.insert("constants", TITLE, cv);

    cv.put(TITLE, "Gravity, Venus");
    cv.put(VALUE, SensorManager.GRAVITY_VENUS);
    db.insert("constants", TITLE, cv);
  }

  @Override
  public void onUpgrade(SQLiteDatabase db, int oldVersion, int newVersion) {
    android.util.Log.w("Constants", "Upgrading database, which will destroy all
old data");
    db.execSQL("DROP TABLE IF EXISTS constants");
    onCreate(db);
  }
}
```

We will take a closer look at what onCreate() is doing – in terms of execSQL() and insert() calls – later in this chapter.

To use your SQLiteOpenHelper subclass, create and hold onto an instance of it. Then, when you need a SQLiteDatabase object to do queries or data modifications, ask your SQLiteOpenHelper to getReadableDatabase() or getWriteableDatabase(), depending upon whether or not you will be changing its contents. For example, our ConstantsBrowser activity opens the database in onCreate() as part of doing a query:

```
constantsCursor=db
                .getReadableDatabase()
                .rawQuery("SELECT _ID, title, value "+
                        "FROM constants ORDER BY title",
                        null);
```

When you are done with the database (e.g., your activity is being closed), simply call close() on your SQLiteOpenHelper to release your connection.

Setting the Table

For creating your tables and indexes, you will need to call execSQL() on your SQLiteDatabase, providing the DDL statement you wish to apply against the database. Barring a database error, this method returns nothing.

So, for example, you can call execSQL() to create the constants table, as shown in the DatabaseHelper onCreate() method:

```
db.execSQL("CREATE TABLE constants (_id INTEGER PRIMARY KEY AUTOINCREMENT, title
TEXT, value REAL);");
```

This will create a table, named constants, with a primary key column named _id that is an auto-incremented integer (i.e., SQLite will assign the value for you when you insert rows), plus two data columns: title (text) and value (a float, or "real" in SQLite terms). SQLite will automatically create an index for you on your primary key column – you could add other indexes here via some CREATE INDEX statements, if you so chose to.

Most likely, you will create tables and indexes when you first create the database, or possibly when the database needs upgrading to accommodate a new release of your application. If you do not change your table schemas, you might never drop your tables or indexes, but if you do, just use execSQL() to invoke DROP INDEX and DROP TABLE statements as needed.

Makin' Data

Given that you have a database and one or more tables, you probably want to put some data in them and such. You have two major approaches for doing this.

You can always use execSQL(), just like you did for creating the tables. The execSQL() method works for any SQL that does not return results, so it can handle INSERT, UPDATE, DELETE, etc. just fine.

Your alternative is to use the `insert()`, `update()`, and `delete()` methods on the `SQLiteDatabase` object, which eliminate much of the SQL syntax required to do basic operations.

For example, here we `insert()` a new row into our `constants` table:

```
private void processAdd(DialogWrapper wrapper) {
  ContentValues values=new ContentValues(2);

  values.put("title", wrapper.getTitle());
  values.put("value", wrapper.getValue());

  db.getWritableDatabase().insert("constants", "title", values);
  constantsCursor.requery();
}
```

These methods make use of `ContentValues` objects, which implement a `Map`-esque interface, albeit one that has additional methods for working with SQLite types. For example, in addition to `get()` to retrieve a value by its key, you have `getAsInteger()`, `getAsString()`, and so forth.

The `insert()` method takes the name of the table, the name of one column as the "null column hack", and a `ContentValues` with the initial values you want put into this row. The "null column hack" is for the case where the `ContentValues` instance is empty – the column named as the "null column hack" will be explicitly assigned the value `NULL` in the SQL `INSERT` statement generated by `insert()`. This is required due to a quirk in SQLite's support for the SQL `INSERT` statement.

The `update()` method takes the name of the table, a `ContentValues` representing the columns and replacement values to use, an optional `WHERE` clause, and an optional list of parameters to fill into the `WHERE` clause, to replace any embedded question marks (`?`). Since `update()` only replaces columns with fixed values, versus ones computed based on other information, you may need to use `execSQL()` to accomplish some ends. The `WHERE` clause and parameter list works akin to the positional SQL parameters you may be used to from other SQL APIs.

The delete() method works akin to update(), taking the name of the table, the optional WHERE clause, and the corresponding parameters to fill into the WHERE clause. For example, here we delete() a row from our constants table, given its _ID:

```
private void processDelete(long rowId) {
  String[] args={String.valueOf(rowId)};

  db.getWritableDatabase().delete("constants", "_ID=?", args);
  constantsCursor.requery();
}
```

What Goes Around, Comes Around

As with INSERT, UPDATE, and DELETE, you have two main options for retrieving data from a SQLite database using SELECT:

1. You can use rawQuery() to invoke a SELECT statement directly, or

2. You can use query() to build up a query from its component parts

Confounding matters further is the SQLiteQueryBuilder class and the issue of cursors and cursor factories. Let's take all of this one piece at a time.

Raw Queries

The simplest solution, at least in terms of the API, is rawQuery(). Simply call it with your SQL SELECT statement. The SELECT statement can include positional parameters; the array of these forms your second parameter to rawQuery(). So, we wind up with:

```
constantsCursor=db
                .getReadableDatabase()
                .rawQuery("SELECT _ID, title, value "+
                        "FROM constants ORDER BY title",
                        null);
```

The return value is a Cursor, which contains methods for iterating over results (see below).

If your queries are pretty much "baked into" your application, this is a very straightforward way to use them. However, it gets complicated if parts of the query are dynamic, beyond what positional parameters can really handle. For example, if the set of columns you need to retrieve is not known at compile time, puttering around concatenating column names into a comma-delimited list can be annoying...which is where `query()` comes in.

Regular Queries

The `query()` method takes the discrete pieces of a SELECT statement and builds the query from them. The pieces, in order that they appear as parameters to `query()`, are:

- The name of the table to query against

- The list of columns to retrieve

- The `WHERE` clause, optionally including positional parameters

- The list of values to substitute in for those positional parameters

- The `GROUP BY` clause, if any

- The `HAVING` clause, if any

- The `ORDER BY` clause, if any

These can be `null` when they are not needed (except the table name, of course):

```
String[] columns={"ID", "inventory"};
String[] parms={"snicklefritz"};
Cursor result=db.query("widgets", columns, "name=?",
                       parms, null, null, null);
```

Building with Builders

Yet another option is to use `SQLiteQueryBuilder`, which offers much richer query-building options, particularly for nasty queries involving things like the union of multiple sub-query results. More importantly, the

SQLiteQueryBuilder interface dovetails nicely with the ContentProvider interface for executing queries. Hence, a common pattern for your content provider's query() implementation is to create a SQLiteQueryBuilder, fill in some defaults, then allow it to build up (and optionally execute) the full query combining the defaults with what is provided to the content provider on the query request.

For example, here is a snippet of code from a content provider using SQLiteQueryBuilder:

```
@Override
public Cursor query(Uri url, String[] projection, String selection,
                    String[] selectionArgs, String sort) {
  SQLiteQueryBuilder qb=new SQLiteQueryBuilder();

  qb.setTables(getTableName());

  if (isCollectionUri(url)) {
    qb.setProjectionMap(getDefaultProjection());
  }
  else {
    qb.appendWhere(getIdColumnName()+"="+url.getPathSegments().get(1));
  }

  String orderBy;

  if (TextUtils.isEmpty(sort)) {
    orderBy=getDefaultSortOrder();
  } else {
    orderBy=sort;
  }

  Cursor c=qb.query(db, projection, selection, selectionArgs,
                    null, null, orderBy);
  c.setNotificationUri(getContext().getContentResolver(), url);
  return c;
}
```

Here, we see:

- A SQLiteQueryBuilder is constructed
- It is told the table to use for the query (setTables(getTableName()))
- It is either told the default set of columns to return (setProjectionMap()), or is given a piece of a WHERE clause to identify

a particular row in the table by an identifier extracted from the `Uri` supplied to the `query()` call (`appendWhere()`)

- Finally, it is told to execute the query, blending the preset values with those supplied on the call to `query()` (`qb.query(db, projection, selection, selectionArgs, null, null, orderBy)`)

Instead of having the `SQLiteQueryBuilder` execute the query directly, we could have called `buildQuery()` to have it generate and return the SQL `SELECT` statement we needed, which we could then execute ourselves.

Using Cursors

No matter how you execute the query, you get a `Cursor` back. This is the Android/SQLite edition of the database cursor, a concept used in many database systems. With the cursor, you can:

- Find out how many rows are in the result set via `getCount()`

- Iterate over the rows via `moveToFirst()`, `moveToNext()`, and `isAfterLast()`

- Find out the names of the columns via `getColumnNames()`, convert those into column numbers via `getColumnIndex()`, and get values for the current row for a given column via methods like `getString()`, `getInt()`, etc.

- Re-execute the query that created the cursor via `requery()`

- Release the cursor's resources via `close()`

For example, here we iterate over a `widgets` table entries:

```
Cursor result=
  db.rawQuery("SELECT ID, name, inventory FROM widgets", null);

result.moveToFirst();

while (!result.isAfterLast()) {
 int id=result.getInt(0);
 String name=result.getString(1);
 int inventory=result.getInt(2);

 // do something useful with these
```

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```
 result.moveToNext();
}

result.close();
```

You can also wrap a `Cursor` in a `SimpleCursorAdapter` or other implementation, then hand the resulting adapter to a `ListView` or other selection widget. Note, though, that if you are going to use `CursorAdapter` or its subclasses (like `SimpleCursorAdapter`), your result set of your query must contain an integer column named `_ID` that is unique for the result set.

For example, after retrieving the sorted list of constants, we pop those into the `ListView` for the `ConstantsBrowser` activity in just a few lines of code:

```
ListAdapter adapter=new SimpleCursorAdapter(this,
                     R.layout.row, constantsCursor,
                     new String[] {"title", "value"},
                     new int[] {R.id.title, R.id.value});

setListAdapter(adapter);
```

Custom CursorAdapters

You may recall from an earlier chapter that you can override `getView()` in `ArrayAdapter` to provide more custom control over how rows are displayed.

However, `CursorAdapter` and its subclasses have a default implementation of `getView()`. What `getView()` does is inspect the supplied `View` to recycle and, if it is `null`, calls `newView()` then `bindView()`, or just calls `bindView()` if it is not `null`. If you are extending `CursorAdapter` – used for displaying results of a database or content provider query – you should override `newView()` and `bindView()` instead of `getView()`.

All this does is remove your `if()` test you would have had in `getView()` and putting each branch of that test in an independent method, akin to the following:

```
public View newView(Context context, Cursor cursor,
                    ViewGroup parent) {
```

```
  LayoutInflater inflater=getLayoutInflater();
  View row=inflater.inflate(R.layout.row, null);
  ViewWrapper wrapper=new ViewWrapper(row);

  row.setTag(wrapper);

  return(row);
}

public void bindView(View row, Context context, Cursor cursor) {
  ViewWrapper wrapper=(ViewWrapper)row.getTag();

  // actual logic to populate row from Cursor goes here
}
```

Making Your Own Cursors

There may be circumstances in which you want to use your own `Cursor` subclass, rather than the stock implementation provided by Android. In those cases, you can use `queryWithFactory()` and `rawQueryWithFactory()` that take a `SQLiteDatabase.CursorFactory` instance as a parameter. The factory, as one might expect, is responsible for creating new cursors via its `newCursor()` implementation.

Finding and implementing a valid use for this facility is left as an exercise for the reader. Suffice it to say that you should not need to create your own cursor classes much, if at all, in ordinary Android development.

Flash: Sounds Faster Than It Is

Your database will be stored on flash memory, normally the on-board flash for the device.

Reading data off of flash is relatively quick. While the memory is not especially fast, there is no "seek time" to move hard drive heads around like you find with magnetic media, and so performing a query against a SQLite database will tend to be speedy.

Writing data to flash is another matter entirely.

Sometimes, this may happen fairly quickly, on the order of a couple of milliseconds. Sometimes, though, it may take hundreds of milliseconds, even for writing small amounts of data. Moreover, flash tends to get slower the more full it is, so the speed your users will see varies even more.

The net result is that you should seriously consider doing all database write operations off the main application thread, such as via an `AsyncTask`, as is described in the chapter on threads. This way, the database write operations will not slow down your user interface.

Note that the emulator behaves differently, because it is typically using a file on your hard drive for storing data, rather than flash. While the emulator tends to be much slower than hardware for CPU and GPU operations, the emulator will tend to be much faster for writing data to flash. Hence, just because you are not seeing any UI slowdowns due to database I/O in the emulator, do not assume that will be the same when your code is running on a real Android device.

Data, Data, Everywhere

If you are used to developing for other databases, you are also probably used to having tools to inspect and manipulate the contents of the database, beyond merely the database's API. With Android's emulator, you have two main options for this.

First, the emulator is supposed to bundle in the `sqlite3` console program and makes it available from the `adb shell` command. Once you are in the emulator's shell, just execute `sqlite3`, providing it the path to your database file. Your database file can be found at:

```
/data/data/your.app.package/databases/your-db-name
```

Here `your.app.package` is the Java package for your application (e.g., `com.commonsware.android`) and `your-db-name` is the name of your database, as supplied to `createDatabase()`.

The `sqlite3` program works, and if you are used to poking around your tables using a console interface, you are welcome to use it. If you prefer something a little bit friendlier, you can always copy the SQLite database off the device onto your development machine, then use a SQLite-aware client program to putter around. Note, though, that you are working off a copy of the database; if you want your changes to go back to the device, you will need to transfer the database back over.

To get the database off the device, you can use the `adb pull` command (or the equivalent in your IDE, or the File Manager in DDMS), which takes the path to the on-device database and the local destination as parameters. To store a modified database on the device, use `adb push`, which takes the local path to the database and the on-device destination as parameters.

One of the most-accessible SQLite clients is the SQLite Manager extension for Firefox, as it works across all platforms.
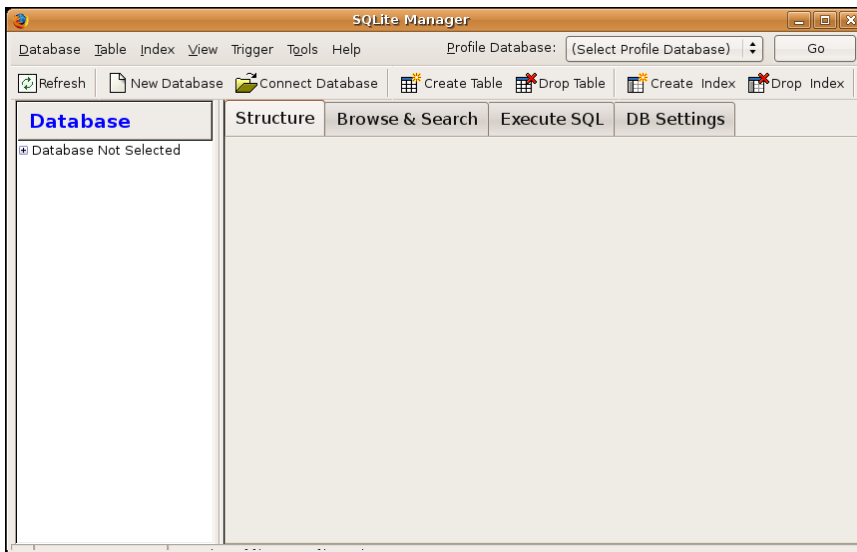
Figure 91. the SQLite Manager Firefox extension

You can find other client tools on the SQLite Web site.

Leveraging Java Libraries

Java has as many, if not more, third-party libraries than any other modern programming language. Here, "third-party libraries" refer to the innumerable JARs that you can include in a server or desktop Java application – the things that the Java SDKs themselves do not provide.

In the case of Android, the Dalvik VM at its heart is not precisely Java, and what it provides in its SDK is not precisely the same as any traditional Java SDK. That being said, many Java third-party libraries still provide capabilities that Android lacks natively and therefore may be of use to you in your project, for the ones you can get working with Android's flavor of Java.

This chapter explains what it will take for you to leverage such libraries and the limitations on Android's support for arbitrary third-party code.

Ants and Jars

You have two choices for integrating third-party code into your project: use source code, or use pre-packaged JARs.

If you choose to use their source code, all you need to do is copy it into your own source tree (under `src/` in your project), so it can sit alongside your existing code, then let the compiler perform its magic.

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If you choose to use an existing JAR, perhaps one for which you do not have the source code, you will need to teach your build chain how to use the JAR. First, place the JAR in the `libs/` directory in your Android project. Then, if you are using an IDE, you probably need to add the JAR to your build path (Ant will automatically pick up all JARs found in `libs/`) – this is definitely required for Eclipse.

And that's it. Adding third-party code to your Android application is fairly easy.

Getting to actually *work* may be somewhat more complicated, however.

The Outer Limits

Not all available Java code will work well with Android. There are a number of factors to consider, including:

- **Expected Platform APIs**: Does the code assume a newer JVM than the one Android is based on? Or, does the code assume the existence of Java APIs that ship with J2SE but not with Android, such as Swing?

- **Size**: Existing Java code designed for use on desktops or servers need not worry too much about on-disk size, or, to some extent, even in-RAM size. Android, of course, is short on both. Using third-party Java code, particularly when pre-packaged as JARs, may balloon the size of your application.

- **Performance**: Does the Java code effectively assume a much more powerful CPU than what you may find on many Android devices? Just because a desktop can run it without issue does not mean your average mobile phone will handle it well.

- **Interface**: Does the Java code assume a console interface? Or is it a pure API that you can wrap your own interface around?

- Operating System: Does the Java code assume the existence of certain console programs? Does the Java code assume it can use a Windows DLL?

- Language Version: Was the JAR compiled with an older version of Java (1.4.2 or older)? Was the JAR compiled with a different compiler than the official one from Sun (e.g., GCJ)?

- Dependencies: Does the Java code depend on other third-party JARs that might have some of these problems as well? Does the Java code depend upon third-party libraries (e.g., the org.json JSON library) that are built into Android, but the third party expects a different version of that library?

One trick for addressing some of these concerns is to use open source Java code, and actually work with the code to make it more Android-friendly. For example, if you are only using 10% of the third-party library, maybe it's worthwhile to recompile the subset of the project to be only what you need, or at least removing the unnecessary classes from the JAR. The former approach is safer, in that you get compiler help to make sure you are not discarding some essential piece of code, though it may be more tedious to do.

Following the Script

Unlike other mobile device operating systems, Android has no restrictions on what you can run on it, so long as you can do it in Java using the Dalvik VM. This includes incorporating your own scripting language into your application, something that is expressly prohibited on some other devices.

One possible Java scripting language is BeanShell. BeanShell gives you Java-compatible syntax with implicit typing and no compilation required.

So, to add BeanShell scripting, you need to put the BeanShell interpreter's JAR file in your `libs/` directory. The 2.0b4 JAR available for download from the BeanShell site, unfortunately, does not work out of the box with the Android 0.9 and newer SDKs, perhaps due to the compiler that was used to build it. Instead, you should probably check out the source code from Subversion and execute `ant jarcore` to build it, then copy the resulting JAR (in BeanShell's `dist/` directory) to your own project's `libs/`. Or, just use the

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BeanShell JAR that accompanies the source code for this book, up on the CommonsWare site, in the `Java/AndShell` project.

From there, using BeanShell on Android is no different than using BeanShell in any other Java environment:

1. Create an instance of the BeanShell `Interpreter` class

2. Set any "globals" for the script's use via `Interpreter#set()`

3. Call `Interpreter#eval()` to run the script and, optionally, get the result of the last statement

For example, here is the XML layout for the world's smallest BeanShell IDE:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
<Button
    android:id="@+id/eval"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:text="Go!"
    android:onClick="go"
    />
<EditText
    android:id="@+id/script"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:singleLine="false"
    android:gravity="top"
    />
</LinearLayout>
```

Couple that with the following activity implementation:

```java
package com.commonsware.android.andshell;

import android.app.Activity;
import android.app.AlertDialog;
import android.os.Bundle;
import android.view.View;
import android.widget.EditText;
import android.widget.Toast;
import bsh.Interpreter;
```

```
public class MainActivity extends Activity {
  private Interpreter i=new Interpreter();

  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
  }

  public void go(View v) {
    EditText script=(EditText)findViewById(R.id.script);
    String src=script.getText().toString();

    try {
      i.set("context", MainActivity.this);
      i.eval(src);
    }
    catch (bsh.EvalError e) {
      AlertDialog.Builder builder=
                new AlertDialog.Builder(MainActivity.this);

      builder
        .setTitle("Exception!")
        .setMessage(e.toString())
        .setPositiveButton("OK", null)
        .show();
    }
  }
}
```

Compile and run it (including incorporating the BeanShell JAR as mentioned above), and install it on the emulator. Fire it up, and you get a trivial IDE, with a large text area for your script and a big "Go!" button to execute it:
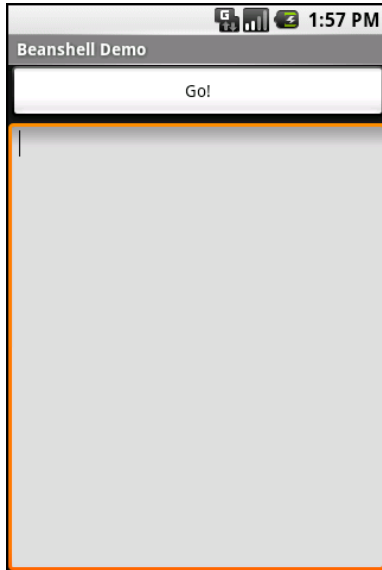
Figure 92. The AndShell BeanShell IDE

```
import android.widget.Toast;

Toast.makeText(context, "Hello, world!", Toast.LENGTH_LONG).show();
```

Note the use of context to refer to the activity when making the Toast. That is the global set by the activity to reference back to itself. You could call this global variable anything you want, so long as the set() call and the script code use the same name.

Then, click the Go! button, and you get:
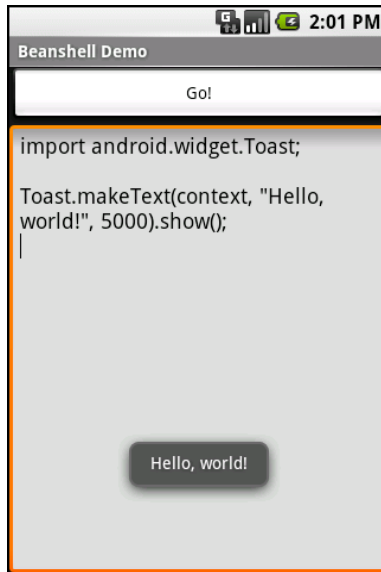
Figure 93. The AndShell BeanShell IDE, executing some code

And now, some caveats...

First, not all scripting languages will work. For example, those that implement their own form of just-in-time (JIT) compilation, generating Java bytecodes on the fly, would probably have to be augmented to generate Dalvik VM bytecodes instead of those for stock Java implementations. Simpler languages that execute off of parsed scripts, calling Java reflection APIs to call back into compiled classes, will likely work better. Even there, though, not every feature of the language may work, if it relies upon some facility in a traditional Java API that does not exist in Dalvik – for example, there could be stuff hidden inside BeanShell or the add-on JARs that does not work on today's Android.

Second, scripting languages without JIT will inevitably be slower than compiled Dalvik applications. Slower may mean users experience sluggishness. Slower definitely means more battery life is consumed for the same amount of work. So, building a whole Android application in BeanShell, simply because you feel it is easier to program in, may cause your users to be unhappy.

Third, scripting languages that expose the whole Java API, like BeanShell, can pretty much do anything the underlying Android security model allows. So, if your application has the READ_CONTACTS permission, expect any BeanShell scripts your application runs to have the same permission.

Last, but certainly not least, is that language interpreter JARs tend to be...portly. The BeanShell JAR used in this example is 200KB. That is not ridiculous, considering what it does, but it will make applications that use BeanShell that much bigger to download, take up that much more space on the device, etc.

Reviewing the Script

Since this chapter covers scripting in Android, you may be interested to know that you have options beyond embedding BeanShell directly in your project.

Some experiments have been conducted with other JVM-based programming languages, such as JRuby and Jython. At present, their support for Android is incomplete, but progress is being made.

Beyond that, though, there is the Scripting Layer for Android (SL4A). SL4A allows you to write scripts in a wide range of scripting languages, beyond BeanShell, such as:

- Perl
- Python
- JRuby
- Lua
- Javascript (implemented via Rhino, the Mozilla Javascript interpreter written in Java)
- PHP

These scripts are not full-fledged applications, though the SL4A team is working on allowing you to turn them into APK files complete with basic UIs. For on-device development, SL4A is a fine choice.

Communicating via the Internet

The expectation is that most, if not all, Android devices will have built-in Internet access. That could be WiFi, cellular data services (EDGE, 3G, etc.), or possibly something else entirely. Regardless, most people – or at least those with a data plan or WiFi access – will be able to get to the Internet from their Android phone.

Not surprisingly, the Android platform gives developers a wide range of ways to make use of this Internet access. Some offer high-level access, such as the integrated WebKit browser component we saw in an earlier chapter. If you want, you can drop all the way down to using raw sockets. Or, in between, you can leverage APIs – both on-device and from 3rd-party JARs – that give you access to specific protocols: HTTP, XMPP, SMTP, and so on.

The emphasis of this book is on the higher-level forms of access: the WebKit component and Internet-access APIs, as busy coders should be trying to reuse existing components versus rolling one's own on-the-wire protocol wherever possible.

REST and Relaxation

Android does not have built-in SOAP or XML-RPC client APIs. However, it does have the Apache HttpClient library baked in. You can either layer a SOAP/XML-RPC layer atop this library, or use it "straight" for accessing REST-style Web services. For the purposes of this book, "REST-style Web

services" is defined as "simple HTTP requests for ordinary URLs over the full range of HTTP verbs, with formatted payloads (XML, JSON, etc.) as responses".

More expansive tutorials, FAQs, and HOWTOs can be found at the HttpClient Web site. Here, we'll cover the basics, while checking the weather.

HTTP Operations via Apache HttpClient

The first step to using HttpClient is, not surprisingly, to create an `HttpClient` object. The client object handles all HTTP requests upon your behalf. Since `HttpClient` is an interface, you will need to actually instantiate some implementation of that interface, such as `DefaultHttpClient`.

Those requests are bundled up into `HttpRequest` instances, with different `HttpRequest` implementations for each different HTTP verb (e.g., `HttpGet` for HTTP `GET` requests). You create an `HttpRequest` implementation instance, fill in the URL to retrieve and other configuration data (e.g., form values if you are doing an HTTP `POST` via `HttpPost`), then pass the method to the client to actually make the HTTP request via `execute()`.

What happens at this point can be as simple or as complicated as you want. You can get an `HttpResponse` object back, with response code (e.g,. `200` for OK), HTTP headers, and the like. Or, you can use a flavor of `execute()` that takes a `ResponseHandler<String>` as a parameter – the net result there being that `execute()` returns just the `String` representation of the response body. In practice, this is not a recommended approach, because you really should be checking your HTTP response codes for errors. However, for trivial applications, like book examples, the `ResponseHandler<String>` approach works just fine.

For example, let's take a look at the `Internet/Weather` sample project. This implements an activity that retrieves weather data for your current location from the National Weather Service (**NOTE**: this probably only works for geographic locations in the US). That data is converted into an HTML page,

which is poured into a WebKit widget for display. Rebuilding this demo using a ListView is left as an exercise for the reader. Also, since this sample is relatively long, we will only show relevant pieces of the Java code here in this chapter, though you can always download the full source from the CommonsWare Web site.

To make this a bit more interesting, we use the Android location services to figure out where we are...sort of. The full details of how that works is described in the chapter on location services.

In the onResume() method, we toggle on location updates, so we will be informed where we are now and when we move a significant distance (10km). When a location is available – either at the start or based on movement – we retrieve the National Weather Service data via our updateForecast() method:

```
private void updateForecast(Location loc) {
  String url=String.format(format, loc.getLatitude(),
                           loc.getLongitude());
  HttpGet getMethod=new HttpGet(url);

  try {
    ResponseHandler<String> responseHandler=new BasicResponseHandler();
    String responseBody=client.execute(getMethod,
                                       responseHandler);
    buildForecasts(responseBody);

    String page=generatePage();

    browser.loadDataWithBaseURL(null, page, "text/html",
                                "UTF-8", null);
  }
  catch (Throwable t) {
    android.util.Log.e("WeatherDemo", "Exception fetching data", t);
    Toast
      .makeText(this, "Request failed: "+t.toString(), Toast.LENGTH_LONG)
      .show();
  }
}
```

The updateForecast() method takes a Location as a parameter, obtained from the location update process. For now, all you need to know is that Location sports getLatitude() and getLongitude() methods that return the latitude and longitude of the device's position, respectively.

We hold the URL to the National Weather Service XML in a string resource, and pour in the latitude and longitude at runtime. Given our HttpClient object created in onCreate(), we populate an HttpGet with that customized URL, then execute that method. Given the resulting XML from the REST service, we build the forecast HTML page (see below) and pour that into the WebKit widget. If the HttpClient blows up with an exception, we provide that error as a Toast.

Note that we also shut down the HttpClient object in onDestroy().

Parsing Responses

The response you get will be formatted using some system – HTML, XML, JSON, whatever. It is up to you, of course, to pick out what information you need and do something useful with it. In the case of the WeatherDemo, we need to extract the forecast time, temperature, and icon (indicating sky conditions and precipitation) and generate an HTML page from it.

Android includes:

- Three XML parsers: the traditional W3C DOM (org.w3c.dom), a SAX parser (org.xml.sax), and the XML pull parser discussed in the chapter on resources
- A JSON parser (org.json)

You are also welcome to use third-party Java code, where possible, to handle other formats, such as a dedicated RSS/Atom parser for a feed reader. The use of third-party Java code is discussed in a separate chapter.

For WeatherDemo, we use the W3C DOM parser in our buildForecasts() method:

```java
void buildForecasts(String raw) throws Exception {
  DocumentBuilder builder=DocumentBuilderFactory
                          .newInstance()
                          .newDocumentBuilder();
  Document doc=builder.parse(new InputSource(new StringReader(raw)));
  NodeList times=doc.getElementsByTagName("start-valid-time");
```

```
  for (int i=0;i<times.getLength();i++) {
    Element time=(Element)times.item(i);
    Forecast forecast=new Forecast();

    forecasts.add(forecast);
    forecast.setTime(time.getFirstChild().getNodeValue());
  }

  NodeList temps=doc.getElementsByTagName("value");

  for (int i=0;i<temps.getLength();i++) {
    Element temp=(Element)temps.item(i);
    Forecast forecast=forecasts.get(i);

    forecast.setTemp(new Integer(temp.getFirstChild().getNodeValue()));
  }

  NodeList icons=doc.getElementsByTagName("icon-link");

  for (int i=0;i<icons.getLength();i++) {
    Element icon=(Element)icons.item(i);
    Forecast forecast=forecasts.get(i);

    forecast.setIcon(icon.getFirstChild().getNodeValue());
  }
}
```

The National Weather Service XML format is...curiously structured, relying heavily on sequential position in lists versus the more object-oriented style you find in formats like RSS or Atom. That being said, we can take a few liberties and simplify the parsing somewhat, taking advantage of the fact that the elements we want (start-valid-time for the forecast time, value for the temperature, and icon-link for the icon URL) are all unique within the document.

The HTML comes in as an InputStream and is fed into the DOM parser. From there, we scan for the start-valid-time elements and populate a set of Forecast models using those start times. Then, we find the temperature value elements and icon-link URLs and fill those in to the Forecast objects.

In turn, the generatePage() method creates a rudimentary HTML table with the forecasts:

```
String generatePage() {
  StringBuilder bufResult=new StringBuilder("<html><body><table>");
```

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```
  bufResult.append("<tr><th width=\"50%\">Time</th>"+
                    "<th>Temperature</th><th>Forecast</th></tr>");

  for (Forecast forecast : forecasts) {
    bufResult.append("<tr><td align=\"center\">");
    bufResult.append(forecast.getTime());
    bufResult.append("</td><td align=\"center\">");
    bufResult.append(forecast.getTemp());
    bufResult.append("</td><td><img src=\"");
    bufResult.append(forecast.getIcon());
    bufResult.append("\"></td></tr>");
  }

  bufResult.append("</table></body></html>");

  return(bufResult.toString());
}
```

The result looks like this:
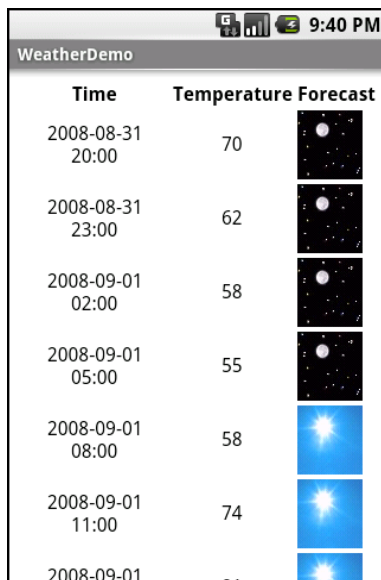
Figure 94. The WeatherDemo sample application

Stuff To Consider

If you need to use SSL, bear in mind that the default `HttpClient` setup does not include SSL support. Mostly, this is because you need to decide how to

handle SSL certificate presentation – do you blindly accept all certificates, even self-signed or expired ones? Or do you want to ask the user if they really want to use some strange certificates?

Similarly, `HttpClient`, by default, is designed for single-threaded use. If you will be using `HttpClient` from some other place where multiple threads might be an issue, you can readily set up `HttpClient` to support multiple threads.

For these sorts of topics, you are best served by checking out the HttpClient Web site for documentation and support.

AndroidHttpClient

Starting in Android 2.2 (API level 8), you can use the `AndroidHttpClient` class, found in the `android.net.http` package. This is an implementation of the `HttpClient` interface, like `DefaultHttpClient`. However, it is pre-configured with settings that the core Android team feels make sense for the platform.

What you gain is:

- SSL management
- A direct way to specify the user agent string – this is supplied in your call to the static `newInstance()` method to get an instance of `AndroidHttpClient`
- Utility methods for working with material compressed via GZIP, for parsing dates in HTTP headers, etc.

What you lose is automatic cookie storage. A regular `DefaultHttpClient` will cache cookies in memory and use them on subsequent requests where they are needed. `AndroidHttpClient` does not. There are ways to fix that, by using an `HttpContext` object, as is described in the `AndroidHttpClient` documentation.

Since this class is only available in Android 2.2 and beyond, it may not make sense to do much with it until such time as you are only supporting API level 8 or higher.

PART IV – Services

Services: The Theory

As noted previously, Android services are for long-running processes that may need to keep running even when decoupled from any activity. Examples include playing music even if the "player" activity gets garbage-collected, polling the Internet for RSS/Atom feed updates, and maintaining an online chat connection even if the chat client loses focus due to an incoming phone call.

Services are created when manually started (via an API call) or when some activity tries connecting to the service via inter-process communication (IPC). Services will live until specifically shut down or until Android is desperate for RAM and destroys them prematurely. Running for a long time has its costs, though, so services need to be careful not to use too much CPU or keep radios active too much of the time, lest the service cause the device's battery to get used up too quickly.

This chapter outlines the basic theory behind creating and consuming services. The next chapter will outline a few specific patterns for services, ones that may closely match your particular needs. Hence, this chapter is short on code examples – you will find them and more in the next chapter.

Why Services?

Services are a "Swiss Army knife" for a wide range of functions that do not require direct access to an activity's user interface, such as:

- Performing operations that need to continue even if the user leaves the application's activities, like a long download (as seen with the Android Market) or playing music (as seen with Android music apps)

- Performing operations that need to exist regardless of activities coming and going, such as maintaining a chat connection in support of a chat application

- Providing a local API to remote APIs, such as might be provided by a Web service

- Performing periodic work without user intervention, akin to cron jobs or Windows scheduled tasks

Even things like home screen app widgets often involve a service to assist with long-running work.

Many applications will not need any services. Very few applications will need more than one. However, the service is a powerful tool for an Android developer's toolbox and is a subject with which any qualified Android developer should be familiar.

Setting Up a Service

Creating a service implementation shares many characteristics with building an activity. You inherit from an Android-supplied base class, override some lifecycle methods, and hook the service into the system via the manifest.

The Service Class

Just as an activity in your application extends either `Activity` or an Android-supplied `Activity` subclass, a service in your application extends either `Service` or an Android-supplied `Service` subclass. The most common `Service` subclass is `IntentService`, used primarily for the command pattern, described later in this chapter. That being said, many services simply extend `Service`.

Lifecycle Methods

Just as activities have `onCreate()`, `onResume()`, `onPause()` and kin, `Service` implementations have their own lifecycle methods, such as:

1. `onCreate()`, which, as with activities, is called when the service process is created, by any means

2. `onStartCommand()`, which is called each time the service is sent a command via `startService()`

3. `onBind()`, which is called whenever a client binds to the service via `bindService()`

4. `onDestroy()` which is called as the service is being shut down

As with activities, services initialize whatever they need in `onCreate()` and clean up those items in `onDestroy()`. And, as with activities, the `onDestroy()` method of a service might not be called, if Android terminates the entire application process, such as for emergency RAM reclamation.

The `onStartCommand()` and `onBind()` lifecycle methods will be implemented based on your choice of communicating to the client, as will be explained later in this chapter.

Manifest Entry

Finally, you need to add the service to your `AndroidManifest.xml` file, for it to be recognized as an available service for use. That is simply a matter of adding a `<service>` element as a child of the `application` element, providing `android:name` to reference your service class.

Since the service class is in the same Java namespace as everything else in this application, we can use the shorthand (`"WeatherPlusService"` or `".WeatherPlusService"`) to reference our class.

If you wish to require some permission of those who wish to start or bind to the service, add an `android:permission` attribute naming the permission you are mandating – see the chapter on permissions for more details.

For example, here is a manifest showing the `<service>` element:

```xml
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
      package="com.commonsware.android.downloader"
      android:versionCode="1"
      android:versionName="1.0">
  <uses-permission android:name="android.permission.INTERNET" />
  <uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE" />
    <application android:label="@string/app_name">
        <activity android:name="DownloaderDemo"
                  android:label="@string/app_name">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />
                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
        <service android:name="Downloader" />
    </application>
</manifest>
```

Communicating To Services

Clients of services – frequently activities, though not necessarily – have two main ways to send requests or information to a service. One approach is to send a command, which creates no lasting connection to the service. The other approach is to bind to the service, establishing a bi-directional communications channel that lasts as long as the client needs it.

Sending Commands with startService()

The simplest way to work with a service is to call `startService()`. The `startService()` method takes an Intent parameter, much like `startActivity()` does. In fact, the `Intent` supplied to `startService()` has the same two-part role as it does with `startActivity()`:

1. Identify the service to communicate with

2. Supply parameters, in the form of Intent extras, to tell the service what it is supposed to do

For a local service – the focus of this book – the simplest form of Intent is one that identifies the class that implements the Intent (e.g., new Intent(this, MyService.class);).

The call to startService() is asynchronous, so the client will not block. The service will be created if it is not already running, and it will receive the Intent via a call to the onStartCommand() lifecycle method. The service can do whatever it needs to in onStartCommand(), but since onStartCommand() is called on the main application thread, it should do its work very quickly. Anything that might take a while should be delegated to a background thread.

The onStartCommand() method can return one of several values, mostly to indicate to Android what should happen if the service's process should be killed while it is running. The most likely return values are:

• START_STICKY, meaning that the service should be moved back into the started state (as if onStartCommand() had been called), but do not re-deliver the Intent to onStartCommand()

• START_REDELIVER_INTENT, meaning that the service should be restarted via a call to onStartCommand(), supplying the same Intent as was delivered this time

• START_NOT_STICKY, meaning that the service should remain stopped until explicitly started by application code

By default, calling startService() not only sends the command, but tells Android to keep the service running until something tells it to stop. One way to stop a service is to call stopService(), supplying the same Intent used with startService(), or at least one that is equivalent (e.g., identifies the same class). At that point, the service will stop and will be destroyed. Note that stopService() does not employ any sort of reference counting, so three calls to startService() will result in a single service running, which will be stopped by a call to stopService().

Another possibility for stopping a service is to have the service call `stopSelf()` on itself. You might do this if you use `startService()` to have a service begin running and doing some work on a background thread, then having the service stop itself when that background work is completed.

Binding with bindService()

Binding allows a service to expose an API to activities (or other services) that bind to it. When an activity (or other client) binds to a service, it primarily is requesting to be able to access the public API exposed by that service via the service's "binder", as returned by the service's `onBind()` method. When doing this, the activity can also indicate, via the `BIND_AUTO_CREATE` flag, to have Android automatically start up the service if it is not already running.

The service's "binder" is usually a subclass of `Binder`, on which you can put whatever methods you want to expose to clients. For local services, you can have as many methods as you want, with whatever method signatures (parameters, return type, etc.) that you want. The service returns an instance of the `Binder` subclass in `onBind()`.

Clients call `bindService()`, supplying the `Intent` that identifies the service, a `ServiceConnection` object representing the client side of the binding, and an optional `BIND_AUTO_CREATE` flag. As with `startService()`, `bindService()` is asynchronous. The client will not know anything about the status of the binding until the `ServiceConnection` object is called with `onServiceConnected()`. This not only indicates the binding has been established, but for local services it provides the `Binder` object that the service returned via `onBind()`. At this point, the client can use the `Binder` to ask the service to do work on its behalf. Note that if the service is not already running, and if you provide `BIND_AUTO_CREATE`, then the service will be created first before being bound to the client. If you skip `BIND_AUTO_CREATE`, `bindService()` will return `false`, indicating there was no existing service to bind to.

Eventually, the client will need to call `unbindService()`, to indicate it no longer needs to communicate with the service. For example, an activity might call `bindService()` in its `onCreate()` method, then call `unbindService()` in its `onDestroy()` method. The call to `unbindService()` eventually triggers `onServiceDisconnected()` to be called on the `ServiceConnection` object – at this point, the client can no longer safely use the `Binder` object.

If there are no other bound clients to the service, Android will shut down the service as well, releasing its memory. Hence, we do not need to call `stopService()` ourselves – Android handles that, if needed, as a side effect of unbinding.

If the client is an activity, there are two important steps to take to ensure that the binding survives a configuration change, like a screen rotation:

1. Instead of calling `bindService()` on the activity itself, call `bindService()` on the Application Context (obtained via `getApplicationContext()`).

2. Make sure the `ServiceConnection` gets from the old instance of the activity to the new one, probably via `onRetainNonConfigurationInstance()`.

This allows the binding to persist between activity instances.

Communicating From Services

Of course, the approaches listed in the previous section only work for a client calling out to a service. The reverse is also frequently needed, so the service can let an activity or something know about asynchronous events.

Callback/Listener Objects

An activity or other service client can provide some sort of "callback" or "listener" object to the service, which the service could then call when needed. To make this work, you would need to:

1. Define a Java interface for that listener object

2. Give the service a public API to register and retract listeners

3. Have the service use those listeners at appropriate times, to notify those who registered the listener of some event

4. Have the activity register and retract a listener as needed

5. Have the activity respond to the listener-based events in some suitable fashion

The biggest catch is to make sure that the activity retracts the listeners when it is done. Listener objects generally know their activity, explicitly (via a data member) or implicitly (by being implemented as an inner class). If the service is holding onto defunct listener objects, the corresponding activities will linger in memory, even if the activities are not being used by Android any more. This represents a big memory leak. You may wish to use WeakReferences, SoftReferences, or similar constructs to ensure that if an activity is destroyed, any listeners it registers with your service will not keep that activity in memory.

Broadcast Intents

An alternative approach, first mentioned in the chapter on Intent filters, is to have the service send a broadcast Intent that can be picked up by the activity...assuming the activity is still around and is not paused. The service can call sendBroadcast(), supplying an Intent that identifies the broadcast, designed to be picked up by a BroadcastReceiver. This could be a component-specific broadcast (e.g., new Intent(this, MyReceiver.class)), if the BroadcastReceiver is registered in the manifest. Or, it can be based on some action string, perhaps one even documented and designed for third-party applications to listen for.

The activity, in turn, can register a BroadcastReceiver via registerReceiver(), though this approach will only work for Intent objects specifying some action, not ones identifying a particular component. But, when the activity's BroadcastReceiver receives the broadcast, it can do what it wants to inform the user or otherwise update itself.

Pending Results

Your activity can call `createPendingResult()`. This returns a `PendingIntent` – an object that represents an `Intent` and the corresponding action to be performed upon that `Intent` (e.g., use it to start an activity). In this case, the `PendingIntent` will cause a result to be delivered to your activity's implementation of `onActivityResult()`, just as if another activity had been called with `startActivityForResult()` and, in turn, called `setResult()` to send back a result.

Since a `PendingIntent` is `Parcelable`, and can therefore be put into an `Intent` extra, your activity can pass this `PendingIntent` to the service. The service, in turn, can call one of several flavors of the `send()` method on the `PendingIntent`, to notify the activity (via `onActivityResult()`) of an event, possibly even supplying data (in the form of an `Intent`) representing that event.

Messenger

Yet another possibility is to use a `Messenger` object. A `Messenger` sends messages to an activity's `Handler`. Within a single activity, a `Handler` can be used to send messages to itself, as was demonstrated in the chapter on threads. However, between components – such as between an activity and a service – you will need a `Messenger` to serve as the bridge.

As with a `PendingIntent`, a `Messenger` is `Parcelable`, and so can be put into an `Intent` extra. The activity calling `startService()` or `bindService()` would attach a `Messenger` as an extra on the `Intent`. The service would obtain that `Messenger` from the `Intent`. When it is time to alert the activity of some event, the service would:

- Call `Message.obtain()` to get an empty `Message` object
- Populate that `Message` object as needed, with whatever data the service wishes to pass to the activity
- Call `send()` on the `Messenger`, supplying the `Message` as a parameter

The `Handler` will then receive the message via `handleMessage()`, on the main application thread, and so can update the UI or whatever is necessary.

Notifications

Another approach is for the service to let the user know directly about the work that was completed. To do that, a service can raise a Notification – putting an icon in the status bar and optionally shaking or beeping or something. This technique is covered in an upcoming chapter.

Basic Service Patterns

Now that you have seen the pieces that make up services and their clients, let us examine a few scenarios that employ services and how those scenarios might be implemented.

The Downloader

If you elect to download something from the Android Market, you are welcome to back out of the Market application entirely. This does not cancel the download – the download and installation run to completion, despite no Market activity being on-screen.

You may have similar circumstances in your application, from downloading a purchased e-book to downloading a map for a game to downloading a file from some sort of "drop box" file-sharing service.

The Design

This sort of situation is a perfect use for the command pattern and an `IntentService`. The `IntentService` has a background thread, so downloads can take as long as needed. An `IntentService` will automatically shut down when the work is done, so the service will not linger and you do not need to worry about shutting it down yourself. Your activity can simply send a command via `startService()` to the `IntentService` to tell it to go do the work.

Admittedly, things get a bit trickier when you want to have the activity find out when the download is complete. This example will show the use of `Messenger` for this.

The Service Implementation

Here is the implementation of this `IntentService`, named `Downloader`:

```
package com.commonsware.android.downloader;

import android.app.Activity;
import android.app.IntentService;
import android.content.Intent;
import android.os.Bundle;
import android.os.Environment;
import android.os.Message;
import android.os.Messenger;
import android.util.Log;
import java.io.File;
import java.io.FileOutputStream;
import java.io.IOException;
import org.apache.http.client.ResponseHandler;
import org.apache.http.client.HttpClient;
import org.apache.http.client.methods.HttpGet;
import org.apache.http.impl.client.BasicResponseHandler;
import org.apache.http.impl.client.DefaultHttpClient;

public class Downloader extends IntentService {
  public static final String
EXTRA_MESSENGER="com.commonsware.android.downloader.EXTRA_MESSENGER";
  private HttpClient client=null;

  public Downloader() {
    super("Downloader");
  }

  @Override
  public void onCreate() {
    super.onCreate();

    client=new DefaultHttpClient();
  }

  @Override
  public void onDestroy() {
    super.onDestroy();

    client.getConnectionManager().shutdown();
  }
```

```java
  @Override
  public void onHandleIntent(Intent i) {
    HttpGet getMethod=new HttpGet(i.getData().toString());
    int result=Activity.RESULT_CANCELED;

    try {
      ResponseHandler<byte[]> responseHandler=new ByteArrayResponseHandler();
      byte[] responseBody=client.execute(getMethod, responseHandler);
      File output=new File(Environment.getExternalStorageDirectory(),
                        i.getData().getLastPathSegment());

      if (output.exists()) {
        output.delete();
      }

      FileOutputStream fos=new FileOutputStream(output.getPath());

      fos.write(responseBody);
      fos.close();
      result=Activity.RESULT_OK;
    }
    catch (IOException e2) {
      Log.e(getClass().getName(), "Exception in download", e2);
    }

    Bundle extras=i.getExtras();

    if (extras!=null) {
      Messenger messenger=(Messenger)extras.get(EXTRA_MESSENGER);
      Message msg=Message.obtain();

      msg.arg1=result;

      try {
        messenger.send(msg);
      }
      catch (android.os.RemoteException e1) {
        Log.w(getClass().getName(), "Exception sending message", e1);
      }
    }
  }
}
```

In onCreate(), we obtain a DefaultHttpClient object, as was described in the chapter on Internet access. In onDestroy(), we shut down the client. This way, if several download requests are invoked in sequence, we can use a single DefaultHttpClient object – the IntentService will only shut down after all enqueued work has been completed.

The bulk of the work is accomplished in `onHandleIntent()`, which is called on the `IntentService`, on a background thread, every time `startService()` is called. For the `Intent`, we obtain the URL of the file to download via a call to `getData()` on the supplied `Intent`. Actually downloading the file uses the `DefaultHttpClient` object, along with an `HttpGet` object. However, since the file might be binary (e.g., MP3) instead of text, we cannot use a `BasicResponseHandler`. Instead, we use a `ByteArrayResponseHandler` — a custom `ResponseHandler` cloned from the source for `BasicResponseHandler`, but one that returns a `byte[]` instead of a `String`:

```
package com.commonsware.android.downloader;

import java.io.IOException;
import org.apache.http.HttpEntity;
import org.apache.http.HttpResponse;
import org.apache.http.StatusLine;
import org.apache.http.client.ResponseHandler;
import org.apache.http.client.HttpResponseException;
import org.apache.http.util.EntityUtils;

public class ByteArrayResponseHandler implements ResponseHandler<byte[]> {
  public byte[] handleResponse(final HttpResponse response)
                  throws IOException, HttpResponseException {
    StatusLine statusLine=response.getStatusLine();

    if (statusLine.getStatusCode()>=300) {
      throw new HttpResponseException(statusLine.getStatusCode(),
                                      statusLine.getReasonPhrase());
    }

    HttpEntity entity=response.getEntity();

    if (entity==null) {
      return(null);
    }

    return(EntityUtils.toByteArray(entity));
  }
}
```

Once the file is downloaded to external storage, we need to alert the activity that the work is completed. If the activity is interested in this sort of message, it will have attached a `Messenger` object as `EXTRA_MESSENGER` to the `Intent`. `Downloader` gets the `Messenger`, creates an empty `Message` object, and puts a result code in the `arg1` field of the `Message`. It then sends the `Message` to the activity. If the activity was destroyed before this point, the request to send the message will fail with a `RemoteObjectException`.

Since this is an `IntentService`, it will automatically shut down when `onHandleIntent()` completes, if there is no more work queued to be done.

Using the Service

The activity demonstrating the use of `Downloader` has a trivial UI, consisting of one large button:

```xml
<?xml version="1.0" encoding="utf-8"?>
<Button xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@+id/button"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
  android:text="Do the Download"
  android:onClick="doTheDownload"
/>
```

That UI is initialized in `onCreate()`, as usual:

```java
@Override
public void onCreate(Bundle savedInstanceState) {
  super.onCreate(savedInstanceState);
  setContentView(R.layout.main);

  b=(Button)findViewById(R.id.button);
}
```

When the user clicks the button, `doTheDownload()` is called to disable the button (to prevent accidental duplicate downloads) and call `startService()`:

```java
public void doTheDownload(View v) {
  b.setEnabled(false);

  Intent i=new Intent(this, Downloader.class);

  i.setData(Uri.parse("http://commonsware.com/Android/excerpt.pdf"));
  i.putExtra(Downloader.EXTRA_MESSENGER, new Messenger(handler));

  startService(i);
}
```

Here, the `Intent` we pass over has the URL of the file to download (in this case, a URL pointing to a PDF), plus a `Messenger` in the `EXTRA_MESSENGER` extra. That `Messenger` is created with an attachment to the activity's `Handler`:

```
private Handler handler=new Handler() {
  @Override
  public void handleMessage(Message msg) {
    b.setEnabled(true);

    Toast
      .makeText(DownloaderDemo.this, "Download complete!",
                Toast.LENGTH_LONG)
      .show();
  }
};
```

If the activity is still around when the download is complete, the `Handler` enables the button and displays a `Toast` to let the user know that the download is complete. Note that the activity is ignoring the result code supplied by the service, though in principle it could do something different in both the success and failure cases.

The Music Player

Most audio player applications in Android – for music, audiobooks, or whatever – do not require the user to remain in the player application itself. Rather, the user can go on and do other things with their device, with the audio playing in the background. This is similar in many respects to the download scenario from the previous section. However, in this case, the *user* is the one that controls when the work (playing audio) ends.

The Design

Once again, we will use `startService()`, since we want the service to run even when the activity starting it has been destroyed. However, this time, we will use a regular `Service`, rather than an `IntentService`. An `IntentService` is designed to do work and stop itself, whereas in this case, we want the user to be able to stop the music playback.

Since music playback is outside the scope of this book, the service will simply stub out those particular operations.

The Service Implementation

Here is the implementation of this `Service`, named `PlayerService`:

```java
package com.commonsware.android.fakeplayer;

import android.app.Service;
import android.content.Intent;
import android.os.Bundle;
import android.os.IBinder;
import android.util.Log;

public class PlayerService extends Service {
  public static final String EXTRA_PLAYLIST="EXTRA_PLAYLIST";
  public static final String EXTRA_SHUFFLE="EXTRA_SHUFFLE";
  private boolean isPlaying=false;

  @Override
  public int onStartCommand(Intent intent, int flags, int startId) {
    String playlist=intent.getStringExtra(EXTRA_PLAYLIST);
    boolean useShuffle=intent.getBooleanExtra(EXTRA_SHUFFLE, false);

    play(playlist, useShuffle);

    return(START_NOT_STICKY);
  }

  @Override
  public void onDestroy() {
    stop();
  }

  @Override
  public IBinder onBind(Intent intent) {
    return(null);
  }

  private void play(String playlist, boolean useShuffle) {
    if (!isPlaying) {
      Log.w(getClass().getName(), "Got to play()!");
      isPlaying=true;
    }
  }

  private void stop() {
    if (isPlaying) {
      Log.w(getClass().getName(), "Got to stop()!");
      isPlaying=false;
    }
  }
}
```

In this case, we really do not need anything for `onCreate()`, so that lifecycle method is skipped. On the other hand, we have to implement `onBind()`, because that is a required method of `Service` subclasses. `IntentService` implements `onBind()` for us, which is why that was not needed for the `Downloader` sample.

When the client calls `startService()`, `onStartCommand()` is called in `PlayerService`. Here, we get the `Intent` and pick out some extras to tell us what to play back (`EXTRA_PLAYLIST`) and other configuration details (e.g., `EXTRA_SHUFFLE`). `onStartCommand()` calls `play()`, which simply flags that we are playing and logs a message to LogCat – a real music player would use `MediaPlayer` to start playing the first song in the playlist. `onStartCommand()` returns `START_NOT_STICKY`, indicating that if Android has to kill off this service (e.g., low memory), it should not restart it once conditions improve.

`onDestroy()` stops the music from playing – theoretically, anyway – by calling a `stop()` method. Once again, this just logs a message to LogCat, plus updates our internal are-we-playing flag.

In the upcoming chapter on notifications, we will revisit this sample and discuss the use of `startForeground()` to make it easier for the user to get back to the music player, plus let Android know that the service is delivering part of the foreground experience and therefore should not be shut down.

Using the Service

The `FakePlayer` activity demonstrating the use of `PlayerService` has a UI twice as complex as the previous sample, consisting of two large buttons:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
  <Button
      android:layout_width="fill_parent"
      android:layout_height="fill_parent"
```

```
        android:layout_weight="1"
        android:text="Start the Player"
        android:onClick="startPlayer"
        />
    <Button
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:layout_weight="1"
        android:text="Stop the Player"
        android:onClick="stopPlayer"
        />
</LinearLayout>
```

The activity itself is not much more complex:

```
package com.commonsware.android.fakeplayer;

import android.app.Activity;
import android.content.Intent;
import android.os.Bundle;
import android.view.View;

public class FakePlayer extends Activity {
  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);
  }

  public void startPlayer(View v) {
    Intent i=new Intent(this, PlayerService.class);

    i.putExtra(PlayerService.EXTRA_PLAYLIST, "main");
    i.putExtra(PlayerService.EXTRA_SHUFFLE, true);

    startService(i);
  }

  public void stopPlayer(View v) {
    stopService(new Intent(this, PlayerService.class));
  }
}
```

The onCreate() method merely loads the UI. The startPlayer() method constructs an Intent with fake values for EXTRA_PLAYLIST and EXTRA_SHUFFLE, then calls startService(). After you press the top button, you will see the corresponding message in LogCat. Similarly, stopPlayer() calls stopService(), triggering the second LogCat message. Notably, you do not

need to keep the activity running in between those button clicks – you can exit the activity via BACK and come back later to stop the service.

The Web Service Interface

If you are going to consume a REST-style Web service, you may wish to create a Java client-side API for that service. This allows you to isolate details about the Web service (URLs, authorization credentials, etc.) in one place, with the rest of your application just able to use the published API. If the client-side API might involve state, such as a session ID or cached results, you may wish to use a service to implement the client-side API. In this case, the most natural form of service would be one that publishes a `Binder`, so clients can call a "real" API, that the service translates into HTTP requests.

In this case, we want to create a client-side Java API for the US National Weather Service's forecast Web service, so we can get a weather forecast (timestamps, projected temperatures, and projected precipitation) for a given latitude and longitude. As you may recall, we examined this Web service back in the chapter on Internet access.

The Design

To use the binding pattern, we will need to expose an API from a "binder" object. Since the weather forecast arrives in a singularly awful XML structure, we will have the binder be responsible for parsing the XML. Hence, we can say that the binder will have a `getForecast()` method and return an `ArrayList` of `Forecast` objects, each `Forecast` representing one timestamp/temperature/precipitation triple.

Once again, to supply the latitude and longitude of the forecast roster to retrieve, we will use a `Location` object, which will be obtained from GPS. This part of the sample will be described in greater detail in the chapter on location management.

Since the Web service call may take a while, it is unsafe to do this on the main application thread. In this sample, we will have the activity use an `AsyncTask` to call our weather API, so the service and binder can be ignorant of threading issues.

The Rotation Challenge

Back in the chapter on threading, we noted the issues involved with orientation changes (or other configuration changes) and background threads in activities. The solution was to use `onRetainNonConfigurationInstance()` with a static inner class `AsyncTask` implementation, which we would manually associate with the new, post-configuration-change activity.

That same problem crops up with the binding pattern as well, one of the reasons why binding is difficult to use. If you bind to a service from an activity, that binding will not magically pass to the new activity instance after an orientation change. Instead, you need to do two things:

1. Bind to the service not using the activity as the `Context`, but rather by using `getApplicationContext()`, as that `Context` is one that will live for the lifetime of your process

2. Pass the `ServiceConnection` representing this binding from the old activity instance to the new one as part of the configuration change

To accomplish the second feat, you will need to use the same `onRetainNonConfigurationInstance()` trick as was used with threads.

The Service Implementation

Our service-side logic is broken into three classes, `Forecast`, `WeatherBinder`, and `WeatherService`.

The Forecast

The Forecast class merely encapsulates the three pieces of the forecast data triple: the timestamp, the temperature, and the icon indicating the expected precipitation (if any):

```
package com.commonsware.android.weather;

class Forecast {
  String time="";
  Integer temp=null;
  String iconUrl="";

  String getTime() {
    return(time);
  }

  void setTime(String time) {
    this.time=time.substring(0,16).replace('T', ' ');
  }

  Integer getTemp() {
    return(temp);
  }

  void setTemp(Integer temp) {
    this.temp=temp;
  }

  String getIcon() {
    return(iconUrl);
  }

  void setIcon(String iconUrl) {
    this.iconUrl=iconUrl;
  }
}
```

The Binder

The WeatherBinder extends Binder, a requirement for the local binding pattern. Other than that, the API is up to us.

Hence, we expose three methods:

1. onCreate(), to be called when the WeatherBinder is set up, so we can get a DefaultHttpClient object to use with the Web service

2. onDestroy(), to be called when the WeatherBinder is no longer needed, so we can shut down that DefaultHttpClient object

3. getForecast(), the main public API for use by our activity, to retrieve an ArrayList of Forecast objects given a Location

```java
package com.commonsware.android.weather;

import android.app.Service;
import android.content.Context;
import android.content.Intent;
import android.location.Location;
import android.os.Binder;
import android.os.Bundle;
import java.io.IOException;
import java.io.StringReader;
import java.util.ArrayList;
import javax.xml.parsers.DocumentBuilder;
import javax.xml.parsers.DocumentBuilderFactory;
import org.apache.http.client.ResponseHandler;
import org.apache.http.client.HttpClient;
import org.apache.http.client.methods.HttpGet;
import org.apache.http.impl.client.BasicResponseHandler;
import org.apache.http.impl.client.DefaultHttpClient;
import org.w3c.dom.Document;
import org.w3c.dom.Element;
import org.w3c.dom.NodeList;
import org.xml.sax.InputSource;

public class WeatherBinder extends Binder {
  private String forecast=null;
  private HttpClient client=null;
  private String format=null;

  void onCreate(Context ctxt) {
    client=new DefaultHttpClient();
    format=ctxt.getString(R.string.url);
  }

  void onDestroy() {
    client.getConnectionManager().shutdown();
  }

  ArrayList<Forecast> getForecast(Location loc) throws Exception {
    String url=String.format(format, loc.getLatitude(),
                             loc.getLongitude());
    HttpGet getMethod=new HttpGet(url);
    ResponseHandler<String> responseHandler=new BasicResponseHandler();
    String responseBody=client.execute(getMethod, responseHandler);

    return(buildForecasts(responseBody));
  }
```

```
  private ArrayList<Forecast> buildForecasts(String raw) throws Exception {
    ArrayList<Forecast> forecasts=new ArrayList<Forecast>();
    DocumentBuilder builder=DocumentBuilderFactory
                            .newInstance()
                            .newDocumentBuilder();
    Document doc=builder.parse(new InputSource(new StringReader(raw)));
    NodeList times=doc.getElementsByTagName("start-valid-time");

    for (int i=0;i<times.getLength();i++) {
      Element time=(Element)times.item(i);
      Forecast forecast=new Forecast();

      forecasts.add(forecast);
      forecast.setTime(time.getFirstChild().getNodeValue());
    }

    NodeList temps=doc.getElementsByTagName("value");

    for (int i=0;i<temps.getLength();i++) {
      Element temp=(Element)temps.item(i);
      Forecast forecast=forecasts.get(i);

      forecast.setTemp(new Integer(temp.getFirstChild().getNodeValue()));
    }

    NodeList icons=doc.getElementsByTagName("icon-link");

    for (int i=0;i<icons.getLength();i++) {
      Element icon=(Element)icons.item(i);
      Forecast forecast=forecasts.get(i);

      forecast.setIcon(icon.getFirstChild().getNodeValue());
    }

    return(forecasts);
  }
}
```

Most of this is merely doing the Web service request using `DefaultHttpClient` and an `HttpGet` object, plus using the DOM parser to convert the XML into the Forecast objects.

The Service

The `WeatherService`, therefore, is fairly short, with the business logic delegated to `WeatherBinder`:

```
package com.commonsware.android.weather;
```

```
import android.app.Service;
import android.content.Intent;
import android.os.IBinder;

public class WeatherService extends Service {
  private final WeatherBinder binder=new WeatherBinder();

  @Override
  public void onCreate() {
    super.onCreate();

    binder.onCreate(this);
  }

  @Override
  public IBinder onBind(Intent intent) {
    return(binder);
  }

  @Override
  public void onDestroy() {
    super.onDestroy();

    binder.onDestroy();
  }
}
```

Our onCreate() and onDestroy() methods delegate to the WeatherBinder, and onBind() returns the WeatherBinder itself.

Using the Service

On the surface, the WeatherDemo activity should be simple:

- Bind to the service in onCreate()

- Arrange to get GPS fixes, in the form of Location objects

- When a fix comes in, use the WeatherBinder to get a forecast, convert it to HTML, and display it in a WebView

- Unbind from the service in onDestroy()

However, our decision to use the binding pattern and to have the activity deal with the background thread means there is more work involved than those bullet points.

First, here is the full `WeatherDemo` implementation:

```java
package com.commonsware.android.weather;

import android.app.Activity;
import android.app.AlertDialog;
import android.content.ComponentName;
import android.content.Context;
import android.content.Intent;
import android.content.IntentFilter;
import android.content.ServiceConnection;
import android.location.Location;
import android.location.LocationListener;
import android.location.LocationManager;
import android.os.AsyncTask;
import android.os.Bundle;
import android.os.DeadObjectException;
import android.os.RemoteException;
import android.os.IBinder;
import android.util.Log;
import android.webkit.WebView;
import java.util.ArrayList;

public class WeatherDemo extends Activity {
  private WebView browser;
  private LocationManager mgr=null;
  private State state=null;
  private boolean isConfigurationChanging=false;

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    browser=(WebView)findViewById(R.id.webkit);
    state=(State)getLastNonConfigurationInstance();

    if (state==null) {
      state=new State();
      getApplicationContext()
        .bindService(new Intent(this, WeatherService.class),
                     state.svcConn, BIND_AUTO_CREATE);
    }
    else if (state.lastForecast!=null) {
      showForecast();
    }

    state.attach(this);

    mgr=(LocationManager)getSystemService(LOCATION_SERVICE);
    mgr.requestLocationUpdates(LocationManager.GPS_PROVIDER,
                               3600000, 0, onLocationChange);
  }
```

```
  @Override
  public void onDestroy() {
    super.onDestroy();

    if (mgr!=null) {
      mgr.removeUpdates(onLocationChange);
    }

    if (!isConfigurationChanging) {
      getApplicationContext().unbindService(state.svcConn);
    }
  }

  @Override
  public Object onRetainNonConfigurationInstance() {
    isConfigurationChanging=true;

    return(state);
  }

  private void goBlooey(Throwable t) {
    AlertDialog.Builder builder=new AlertDialog.Builder(this);

    builder
      .setTitle("Exception!")
      .setMessage(t.toString())
      .setPositiveButton("OK", null)
      .show();
  }

  static String generatePage(ArrayList<Forecast> forecasts) {
    StringBuilder bufResult=new StringBuilder("<html><body><table>");

    bufResult.append("<tr><th width=\"50%\">Time</th>"+
                     "<th>Temperature</th><th>Forecast</th></tr>");

    for (Forecast forecast : forecasts) {
      bufResult.append("<tr><td align=\"center\">");
      bufResult.append(forecast.getTime());
      bufResult.append("</td><td align=\"center\">");
      bufResult.append(forecast.getTemp());
      bufResult.append("</td><td><img src=\"");
      bufResult.append(forecast.getIcon());
      bufResult.append("\"></td></tr>");
    }

    bufResult.append("</table></body></html>");

    return(bufResult.toString());
  }

  void showForecast() {
    browser.loadDataWithBaseURL(null, state.lastForecast,
                                "text/html", "UTF-8", null);
```

```
  }

  LocationListener onLocationChange=new LocationListener() {
    public void onLocationChanged(Location location) {
      if (state.weather!=null) {
        new FetchForecastTask(state).execute(location);
      }
      else {
        Log.w(getClass().getName(), "Unable to fetch forecast - no
WeatherBinder");
      }
    }

    public void onProviderDisabled(String provider) {
      // required for interface, not used
    }

    public void onProviderEnabled(String provider) {
      // required for interface, not used
    }

    public void onStatusChanged(String provider, int status,
                                Bundle extras) {
      // required for interface, not used
    }
  };

  static class FetchForecastTask extends AsyncTask<Location, Void, String> {
    Exception e=null;
    State state=null;

    FetchForecastTask(State state) {
      this.state=state;
    }

    @Override
    protected String doInBackground(Location... locs) {
      try {
        return(generatePage(state.weather.getForecast(locs[0])));
      }
      catch (Exception e) {
        this.e=e;
      }

      return(null);
    }

    @Override
    protected void onPostExecute(String page) {
      if (e==null) {
        state.lastForecast=page;
        state.activity.showForecast();
      }
      else {
```

```
      state.activity.goBlooey(e);
    }
  }
}

static class State {
  WeatherBinder weather=null;
  WeatherDemo activity=null;
  String lastForecast=null;

  void attach(WeatherDemo activity) {
    this.activity=activity;
  }

  ServiceConnection svcConn=new ServiceConnection() {
    public void onServiceConnected(ComponentName className,
                                   IBinder rawBinder) {
      weather=(WeatherBinder)rawBinder;
    }

    public void onServiceDisconnected(ComponentName className) {
      weather=null;
    }
  };
}
}
```

Now, let us look at the highlights of the service connection and the background thread.

Managing the State

We need to ensure that our `ServiceConnection` can be passed between activity instances on a configuration change. Hence, we have a `State` static inner class to hold that, plus two other bits of information: the `Activity` the state is associated with, and a `String` showing the last forecast we retrieved:

```
static class State {
  WeatherBinder weather=null;
  WeatherDemo activity=null;
  String lastForecast=null;

  void attach(WeatherDemo activity) {
    this.activity=activity;
  }

  ServiceConnection svcConn=new ServiceConnection() {
    public void onServiceConnected(ComponentName className,
```

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```
                                    IBinder rawBinder) {
      weather=(WeatherBinder)rawBinder;
    }

    public void onServiceDisconnected(ComponentName className) {
      weather=null;
    }
  };
}
```

The `lastForecast String` is to allow us to re-display the generated HTML after a configuration change. Otherwise, if the user rotates the screen, we will lose our forecast (only held in the old instance's `WebView`) and either have to retrieve a fresh one or wait for a GPS fix.

We return this `State` object from `onRetainNonConfigurationInstance()`:

```
@Override
public Object onRetainNonConfigurationInstance() {
  isConfigurationChanging=true;

  return(state);
}
```

In `onCreate()`, if there is no non-configuration instance, we create a fresh `State` and bind to the service, since we do not have a service connection at present. On the other hand, if `onCreate()` gets a `State` from `getLastNonConfigurationInstance()`, it simply holds onto that state and reloads our forecast in the `WebView`. In either case, `onCreate()` indicates to the `State` that the new activity instance is the current one:

```
@Override
public void onCreate(Bundle savedInstanceState) {
  super.onCreate(savedInstanceState);
  setContentView(R.layout.main);

  browser=(WebView)findViewById(R.id.webkit);
  state=(State)getLastNonConfigurationInstance();

  if (state==null) {
    state=new State();
    getApplicationContext()
      .bindService(new Intent(this, WeatherService.class),
                   state.svcConn, BIND_AUTO_CREATE);
  }
  else if (state.lastForecast!=null) {
```

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```
    showForecast();
  }

  state.attach(this);

  mgr=(LocationManager)getSystemService(LOCATION_SERVICE);
  mgr.requestLocationUpdates(LocationManager.GPS_PROVIDER,
                             3600000, 0, onLocationChange);
}
```

The AsyncTask

The `FetchForecastTask` subclass of `AsyncTask` itself has a few interesting characteristics, compared to previous `AsyncTask` objects shown in this book:

- It is a static inner class, following the safe threading pattern documented in the chapter on threads.

- It holds onto the `State`, obtained via the constructor.

- It does not reference the activity in `doInBackground()`, since that is not safe – it can only use the activity in methods executed on the main application thread.

- Since the `getForecast()` method from the `WeatherBinder` can raise an `Exception`, and since we cannot display an `Exception` to the user from `doInBackground()`, we hold onto it if it is raised. Then, in `onPostExecute()`, we can safely display the `Exception` information to the user, if an `Exception` was indeed raised.

```
static class FetchForecastTask extends AsyncTask<Location, Void, String> {
  Exception e=null;
  State state=null;

  FetchForecastTask(State state) {
    this.state=state;
  }

  @Override
  protected String doInBackground(Location... locs) {
    try {
      return(generatePage(state.weather.getForecast(locs[0])));
    }
    catch (Exception e) {
      this.e=e;
    }

    return(null);
```

```
  }

  @Override
  protected void onPostExecute(String page) {
    if (e==null) {
      state.lastForecast=page;
      state.activity.showForecast();
    }
    else {
      state.activity.goBlooey(e);
    }
  }
}
```

You may be wondering why we are not storing the `AsyncTask` in our `State`, to be passed between activity instances. In this case, that is not necessary. In the previous demonstration of an rotation-aware `AsyncTask`, the only "state" was the `AsyncTask`, and we needed to pass it to the new instance so the `AsyncTask` could be updated to reflect which activity instance was the one it should work with. `FetchForecastTask`, however, gets the activity via the `State` itself. So long as we are passing the `State` to the new instance, and so long as we are updating the `State` with the right activity, the `AsyncTask` will have access to the right activity. The `AsyncTask` will not be garbage-collected, simply because it will be strongly held either by a `Thread` (while `doInBackground()` is running) or by a `Message` (after `doInBackground()` ends, to pass control to the main application thread and trigger `onPostExecute()`).

Time to Unbind

We bind to the service when `onCreate()` is called, if it did not receive a `State` via `getLastNonConfigurationInstance()` (in which case, we are already bound). This begs the question: when do we unbind from the service?

We want to unbind when the activity is destroyed...but not if the activity is being destroyed because of a configuration change.

Unfortunately, there is no built-in way to make that determination from `onDestroy()`. There is an `isFinishing()` method you can call on an `Activity`, which will return `true` if the activity is going away for good or `false` otherwise. This does return `false` for a configuration change, but it will also

return `false` if the activity is being destroyed to free up RAM and the user might be able to return to it via the BACK button.

This is why `onRetainNonConfigurationInstance()` flips a `isConfigurationChanging` flag in `WeatherDemo` to `true`. That flag is initially `false`. We then check that flag to see if we should unbind from the service or not:

```
@Override
public void onDestroy() {
  super.onDestroy();

  if (mgr!=null) {
    mgr.removeUpdates(onLocationChange);
  }

  if (!isConfigurationChanging) {
    getApplicationContext().unbindService(state.svcConn);
  }
}
```

Simplification Strategies

On the surface, one might think it is easier to have the activities deal with the background thread – you are new to services, and services are scary!

However, generally speaking, services are much better at dealing with threads than are activities. Activities come and go, while services can remain more stable. Had we implemented `WeatherService` and `WeatherDemo` to have `WeatherService` use the `AsyncTask`, `WeatherDemo` would not have needed to deal with passing the `AsyncTask` in `onRetainNonConfigurationInstance()`.

That being said, it is difficult to design an activity->service interface that can completely avoid the issue of configuration changes. You have to pass the `ServiceConnection` between activity instances for binding, or you have to deal with challenges in the various asynchronous mechanisms for services to pass results back to the activity.

Alerting Users Via Notifications

Pop-up messages. Tray icons and their associated "bubble" messages. Bouncing dock icons. You are no doubt used to programs trying to get your attention, sometimes for good reason.

Your phone also probably chirps at you for more than just incoming calls: low battery, alarm clocks, appointment notifications, incoming text message or email, etc.

Not surprisingly, Android has a whole framework for dealing with these sorts of things, collectively called "notifications".

Notification Configuration

A service, running in the background, needs a way to let users know something of interest has occurred, such as when email has been received. Moreover, the service may need some way to steer the user to an activity where they can act upon the event – reading a received message, for example. For this, Android supplies status bar icons, flashing lights, and other indicators collectively known as "notifications".

Your current phone may well have such icons, to indicate battery life, signal strength, whether Bluetooth is enabled, and the like. With Android, applications can add their own status bar icons, with an eye towards having them appear only when needed (e.g., a message has arrived).

In Android, you can raise notifications via the `NotificationManager`. The `NotificationManager` is a system service. To use it, you need to get the service object via `getSystemService(NOTIFICATION_SERVICE)` from your activity.

The `NotificationManager` gives you three methods: one to raise a `Notification` (`notify()`) and two to get rid of an existing `Notification` (`cancel()` and `cancelAll()`).

The `notify()` method takes a `Notification`, which is a data structure that spells out what form your pestering should take – the capabilities of this object are described in the following sections.

Hardware Notifications

You can flash LEDs on the device by setting lights to true, also specifying the color (as an `#ARGB` value in `ledARGB`) and what pattern the light should blink in (by providing off/on durations in milliseconds for the light via `ledOnMS` and `ledOffMS`). Note, however, that Android devices will apply "best efforts" to meet your color request, meaning that different devices may give you different colors, or perhaps no control over color at all. For example, the Motorola CLIQ only has a white LED, so you can ask for any color you want, and you will get white. Note that you will have to OR (`|`) in the `Notification.FLAG_SHOW_LIGHTS` value into the public `flags` field on the `Notification` object for flashing the LED to work.

You can play a sound, using a `Uri` to a piece of content held, perhaps, by a `ContentManager` (`sound`). Think of this as a "ringtone" for your application.

You can vibrate the device, controlled via a `long[]` indicating the on/off patterns (in milliseconds) for the vibration (`vibrate`). You might do this by default, or you might make it an option the user can choose when circumstances require a more subtle notification than a ringtone. To use this, though, you will need to request the `VIBRATE` permission.

All of these, by default, happen once (e.g., one LED flash, one playback of the sound). If you want to have them persist until the `Notification` is canceled, you will need to set the `flags` public field in your `Notification` to include `FLAG_INSISTENT`.

Instead of manually specifying the hardware options, you can also use the `defaults` field in the `Notification`, setting it to `DEFAULT_LIGHTS`, `DEFAULT_SOUND`, `DEFAULT_VIBRATE`, or `DEFAULT_ALL`, which will use platform defaults for all hardware options.

Icons

While the flashing lights, sounds, and vibrations are aimed at getting somebody to look at the device, icons are designed to take them the next step and tell them what's so important.

To set up an icon for a `Notification`, you need to set two public fields: `icon`, where you provide the identifier of a `Drawable` resource representing the icon, and `contentIntent`, where you supply a `PendingIntent` to be raised when the icon is clicked. A `PendingIntent` is a wrapper around a regular `Intent` that allows the `Intent` to be invoked later, by another process, to start an activity or whatever. Typically, a `Notification` will trigger an activity, in which case you would create the `PendingIntent` via the static `getActivity()` method and give it an `Intent` that identifies one of your activities. That being said, you could have the `Notification` send a broadcast `Intent` instead by using a `getBroadcast()` version of a `PendingIntent`.

You can also supply a text blurb to appear when the icon is put on the status bar (`tickerText`).

If you want all three, the simpler approach is to call `setLatestEventInfo()`, which wraps all three of those in a single call.

You can also set a value in the `number` public field of your `Notification`. This will cause the number you supply to be drawn over top of the `icon` in one

corner. This is used, for example, to show the number of unread email messages, to save you from having to have a bunch of different icons, one for each possible number of unread messages. By default, the `number` will be ignored and not used.

Notifications in Action

Let us now take a peek at the `Notifications/Notify1` sample project, in particular the `NotifyDemo` class:

```
package com.commonsware.android.notify;

import android.app.Activity;
import android.app.Notification;
import android.app.NotificationManager;
import android.app.PendingIntent;
import android.content.Intent;
import android.os.Bundle;
import android.view.View;

public class NotifyDemo extends Activity {
  private static final int NOTIFY_ME_ID=1337;
  private int count=0;
  private NotificationManager mgr=null;

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    mgr=(NotificationManager)getSystemService(NOTIFICATION_SERVICE);
  }

  public void notifyMe(View v) {
    Notification note=new Notification(R.drawable.stat_notify_chat,
                                  "Status message!",
                                  System.currentTimeMillis());
    PendingIntent i=PendingIntent.getActivity(this, 0,
                       new Intent(this, NotifyMessage.class),
                                        0);

    note.setLatestEventInfo(this, "Notification Title",
                       "This is the notification message", i);
    note.number=++count;
    note.vibrate=new long[] {500L, 200L, 200L, 500L};
    note.flags|=Notification.FLAG_AUTO_CANCEL;

    mgr.notify(NOTIFY_ME_ID, note);
  }
```

```
  public void clearNotification(View v) {
    mgr.cancel(NOTIFY_ME_ID);
  }
}
```

This activity sports two large buttons, one to kick off a notification after a five-second delay, and one to cancel that notification (if it is active):
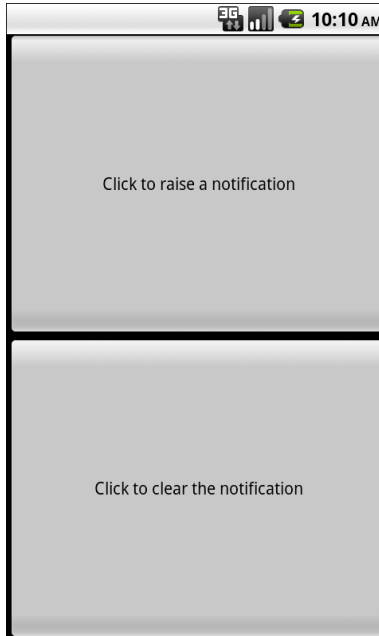
Figure 95. The NotifyDemo activity main view

Creating the notification, in notifyMe(), is accomplished in a handful of steps:

1. Create a Notification object with our icon, a message to flash on the status bar as the notification is raised, and the time associated with this event

2. Create a PendingIntent that will trigger the display of another activity (NotifyMessage)

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3. Use `setLatestEventInfo()` to specify that, when the notification is clicked on, we are to display a certain title and message, and if that is clicked on, we launch the `PendingIntent`

4. Update the "number" associated with the notification

5. Specify a vibration pattern – 500ms on, 200ms off, 200ms on, 500ms off

6. Include `FLAG_AUTO_CANCEL` in the `Notification` object's `flags` field

7. Tell the `NotificationManager` (obtained in `onCreate()`)to display the notification

Hence, if we click the top button, our icon will appear in the status bar, briefly along with our status message.
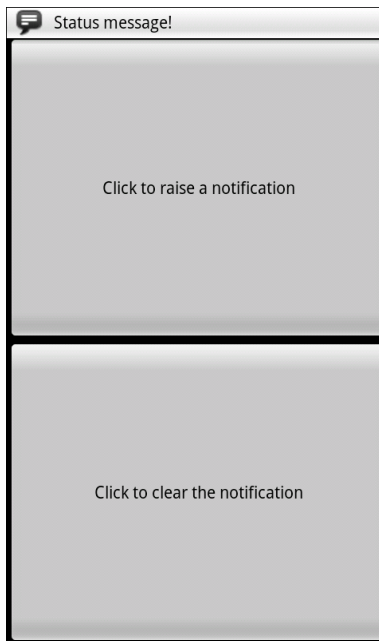
Figure 96. Our notification as it appears on the status bar, with our status message

After the status message goes away, the icon will have our number (initially 1) superimposed on the lower-right corner – you might use this to signify the number of unread messages.

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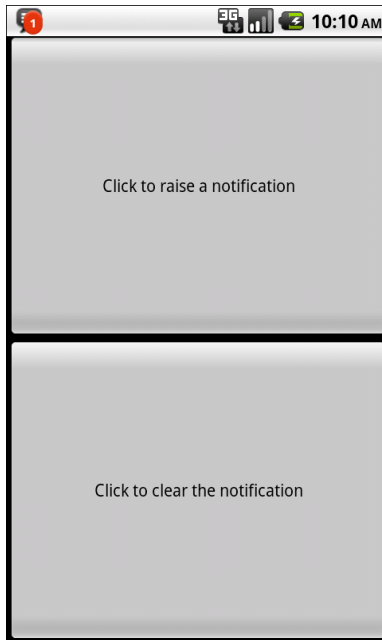
Figure 97. Our notification with the superimposed number

If you drag down the icon, a drawer will appear beneath the status bar. Drag that drawer all the way to the bottom of the screen to show the outstanding notifications, including our own:
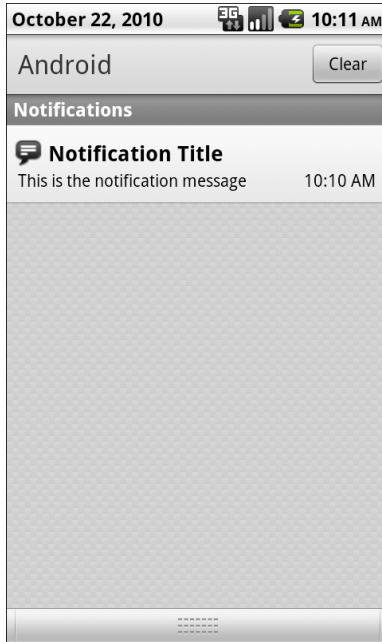
Figure 98. The notifications drawer, fully expanded, with our notification

If you click on the notification entry in the drawer, you'll be taken to a trivial activity displaying a message – though in a real application, this activity would do something useful based upon the event that occurred (e.g., take users to the newly-arrived mail messages).

Clicking on the cancel button, or clicking on the Clear button in the drawer, or clicking on the notification entry in the drawer, will remove the icon from the status bar. The latter is because we included FLAG_AUTO_CANCEL in the Notification, indicating that a tap on the drawer entry should cancel the Notification itself.

Staying in the Foreground

Notifications have another use: keeping select services around.

Services do not live forever. Android may terminate your application's process to free up memory in an emergency situation, or just because it

seems to have been hanging around memory too long. Ideally, you design your services to deal with the fact that they may not run indefinitely.

However, some services will be missed by the user if they mysteriously vanish. For example, the default music player application that ships with Android uses a service for the actual music playback. That way, the user can listen to music while continuing to use their phone for other purposes. The service only stops when the user goes in and presses the stop button in the music player activity. If that service were to be shut down unexpectedly, the user might wonder what is wrong.

Services like this can declare themselves as being part of the "foreground". This will cause their priority to rise and make them less likely to be bumped out of memory. The trade-off is that the service has to maintain a `Notification`, so the user knows that this service is claiming part of the foreground. And, ideally, that `Notification` provides an easy path back to some activity where the user can stop the service.

To do this, on `onCreate()` of your service (or wherever else in the service's life it would make sense), call `startForeground()`. This takes a `Notification` and a locally-unique integer, just like the `notify()` method on `NotificationManager`. It causes the `Notification` to appear and moves the service into foreground priority. Later on, you can call `stopForeground()` to return to normal priority.

Note that this method was added with Android 2.0 (API level 5). There was an earlier method, `setForeground()`, that performs a similar function in earlier versions of Android.

FakePlayer, Redux

In the chapter on service patterns, we showed a fake music player, implemented with an `Activity` (`FakePlayer`) and a `Service` (`PlayerService`). The `PlayerService` is actually what is playing the music, so the music can play even while the `FakePlayer` activity is gone.

However, Android may not consider `PlayerService` to be part of the user experience, since services normally interact very little directly with users. This means Android may run `PlayerService` in a way that caps CPU usage (not necessarily bad) and might elect to shut down the service if it thinks it has been running too long (probably bad).

The answer is to use `startForeground()` and `stopForeground()`. We can call `startForeground()` when we start the music playing in our `play()` method:

```java
private void play(String playlist, boolean useShuffle) {
  if (!isPlaying) {
    Log.w(getClass().getName(), "Got to play()!");
    isPlaying=true;

    Notification note=new Notification(R.drawable.stat_notify_chat,
                                "Can you hear the music?",
                                System.currentTimeMillis());
    Intent i=new Intent(this, FakePlayer.class);

    i.setFlags(Intent.FLAG_ACTIVITY_CLEAR_TOP|
            Intent.FLAG_ACTIVITY_SINGLE_TOP);

    PendingIntent pi=PendingIntent.getActivity(this, 0,
                                        i, 0);

    note.setLatestEventInfo(this, "Fake Player",
                        "Now Playing: \"Ummmm, Nothing\"",
                        pi);
    note.flags|=Notification.FLAG_NO_CLEAR;

    startForeground(1337, note);
  }
}
```

The plus side is that our service will have more CPU availability if needed and will be far less likely to be killed. The user will see an icon in the status bar, though. If they slide down the notification drawer and tap on our `Notification`'s entry, they will be taken back to `FakePlayer` – the existing instance if there is one, otherwise a fresh instance, courtesy of our Intent flags (`Intent.FLAG_ACTIVITY_CLEAR_TOP| Intent.FLAG_ACTIVITY_SINGLE_TOP`). For a music player, this UI pattern is a good thing, as it makes it easy for the user to quickly go back to stop the music when needed.

Stopping the music, via our `stop()` method, will call `stopForeground()`:

```
private void stop() {
  if (isPlaying) {
    Log.w(getClass().getName(), "Got to stop()!");
    isPlaying=false;
    stopForeground(true);
  }
}
```

The `true` value passed to `stopForeground()` tells Android to remove the `Notification`, which would be the typical approach for this pattern.

Requesting and Requiring Permissions

In the late 1990's, a wave of viruses spread through the Internet, delivered via email, using contact information culled from Microsoft Outlook. A virus would simply email copies of itself to each of the Outlook contacts that had an email address. This was possible because, at the time, Outlook did not take any steps to protect data from programs using the Outlook API, since that API was designed for ordinary developers, not virus authors.

Nowadays, many applications that hold onto contact data secure that data by requiring that a user explicitly grant rights for other programs to access the contact information. Those rights could be granted on a case-by-case basis or all at once at install time.

Android is no different, in that it requires permissions for applications to read or write contact data. Android's permission system is useful well beyond contact data, and for content providers and services beyond those supplied by the Android framework.

You, as an Android developer, will frequently need to ensure your applications have the appropriate permissions to do what you want to do with other applications' data. You may also elect to require permissions for other applications to use your data or services, if you make those available to other Android components. This chapter covers how to accomplish both these ends.

Mother, May I?

Requesting the use of other applications' data or services requires the `uses-permission` element to be added to your `AndroidManifest.xml` file. Your manifest may have zero or more `uses-permission` elements, all as direct children of the root `manifest` element.

The `uses-permission` element takes a single attribute, `android:name`, which is the name of the permission your application requires:

```
<uses-permission
  android:name="android.permission.ACCESS_LOCATION" />
```

The stock system permissions all begin with `android.permission` and are listed in the Android SDK documentation for `Manifest.permission`. Third-party applications may have their own permissions, which hopefully they have documented for you. Here are some of the permissions we will see in this book:

- `INTERNET`, if your application wishes to access the Internet through any means, from raw Java sockets through the `WebView` widget

- `WRITE_EXTERNAL_STORAGE`, for writing data to the SD card (or whatever the device has designated as "external storage")

- `ACCESS_COARSE_LOCATION` and `ACCESS_FINE_LOCATION`, for determining where the device is

- `CALL_PHONE`, to allow the application to place phone calls directly, without user intervention

Permissions are confirmed at the time the application is installed – the user will be prompted to confirm it is OK for your application to do what the permission calls for. Hence, it is important for you to ask for as few permissions as possible and to justify those you ask for, so users do not elect to skip installing your application because you ask for too many unnecessary permissions. This prompt will not appear when loading an application via USB, such as during development.

If you do not have the desired permission and try to do something that needs it, you should get a `SecurityException` informing you of the missing permission. Note that you will only fail on a permission check if you forgot to ask for the permission – it is impossible for your application to be running and *not* have been granted your requested permissions.

Halt! Who Goes There?

The other side of the coin, of course, is to secure your own application. If your application is mostly activities, security may be just an "outbound" thing, where you request the right to use resources of other applications. If, on the other hand, you put content providers or services in your application, you will want to implement "inbound" security to control which applications can do what with the data.

Note that the issue here is less about whether other applications might "mess up" your data, but rather about privacy of the user's information or use of services that might incur expense. That is where the stock permissions for built-in Android applications are focused – can you read or modify contacts, can you send SMS, etc. If your application does not store information that might be considered private, security is less an issue. If, on the other hand, your application stores private data, such as medical information, security is much more important.

The first step to securing your own application using permissions is to declare said permissions, once again in the `AndroidManifest.xml` file. In this case, instead of `uses-permission`, you add `permission` elements. Once again, you can have zero or more `permission` elements, all as direct children of the root `manifest` element.

Declaring a permission is slightly more complicated than using a permission. There are three pieces of information you need to supply:

1. The symbolic name of the permission. To keep your permissions from colliding with those from other applications, you should use your application's Java namespace as a prefix

2. A label for the permission: something short that would be understandable by users

3. A description for the permission: something a wee bit longer that is understandable by your users

```
<permission
  android:name="vnd.tlagency.sekrits.SEE_SEKRITS"
  android:label="@string/see_sekrits_label"
  android:description="@string/see_sekrits_description" />
```

This does not enforce the permission. Rather, it indicates that it is a possible permission; your application must still flag security violations as they occur.

Enforcing Permissions via the Manifest

There are two ways for your application to enforce permissions, dictating where and under what circumstances they are required. The easier one is to indicate in the manifest where permissions are required.

Activities, services, and receivers can all declare an attribute named `android:permission`, whose value is the name of the permission that is required to access those items:

```
<activity
  android:name=".SekritApp"
  android:label="Top Sekrit"
  android:permission="vnd.tlagency.sekrits.SEE_SEKRITS">
  <intent-filter>
    <action android:name="android.intent.action.MAIN" />
    <category
      android:name="android.intent.category.LAUNCHER" />
  </intent-filter>
</activity>
```

Only applications that have requested your indicated permission will be able to access the secured component. In this case, "access" means:

•   Activities cannot be started without the permission

- Services cannot be started, stopped, or bound to an activity without the permission

- Intent receivers ignore messages sent via `sendBroadcast()` unless the sender has the permission

Enforcing Permissions Elsewhere

In your code, you have two additional ways to enforce permissions.

Your services can check permissions on a per-call basis via `checkCallingPermission()`. This returns `PERMISSION_GRANTED` or `PERMISSION_DENIED` depending on whether the caller has the permission you specified. For example, if your service implements separate read and write methods, you could require separate read versus write permissions in code by checking those methods for the permissions you need from Java.

Also, you can include a permission when you call `sendBroadcast()`. This means that eligible broadcast receivers must hold that permission; those without the permission are ineligible to receive it. We will examine `sendBroadcast()` in greater detail elsewhere in this book.

May I See Your Documents?

There is no automatic discovery of permissions at compile time; all permission failures occur at runtime. Hence, it is important that you document the permissions required for your public APIs, including content providers, services, and activities intended for launching from other activities. Otherwise, the programmers attempting to interface with your application will have to find out the permission rules by trial and error.

Furthermore, you should expect that users of your application will be prompted to confirm any permissions your application says it needs. Hence, you need to document for your users what they should expect, lest they get confused by the question posed by the phone and elect to not install or use your application. You may wish to use string resources for this,

so you can internationalize your permission details the way you internationalize all the other messages and prompts in your application.

PART V – Other Android Capabilities and Tools

Accessing Location-Based Services

A popular feature on current-era mobile devices is GPS capability, so the device can tell you where you are at any point in time. While the most popular use of GPS service is mapping and directions, there are other things you can do if you know your location. For example, you might set up a dynamic chat application where the people you can chat with are based on physical location, so you are chatting with those you are nearest. Or, you could automatically "geotag" posts to Twitter or similar services.

GPS is not the only way a mobile device can identify your location. Alternatives include:

- The European equivalent to GPS, called Galileo, which is still under development at the time of this writing

- Cell tower triangulation, where your position is determined based on signal strength to nearby cell towers

- Proximity to public WiFi "hotspots" that have known geographic locations

Android devices may have one or more of these services available to them. You, as a developer, can ask the device for your location, plus details on what providers are available. There are even ways for you to simulate your location in the emulator, for use in testing your location-enabled applications.

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Location Providers: They Know Where You're Hiding

Android devices can have access to several different means of determining your location. Some will have better accuracy than others. Some may be free, while others may have a cost associated with them. Some may be able to tell you more than just your current position, such as your elevation over sea level, or your current speed.

Android, therefore, has abstracted all this out into a set of `LocationProvider` objects. Your Android environment will have zero or more `LocationProvider` instances, one for each distinct locating service that is available on the device. Providers know not only your location, but their own characteristics, in terms of accuracy, cost, etc.

You, as a developer, will use a `LocationManager`, which holds the `LocationProvider` set, to figure out which `LocationProvider` is right for your particular circumstance. You will also need a permission in your application, or the various location APIs will fail due to a security violation. Depending on which location providers you wish to use, you may need `ACCESS_COARSE_LOCATION`, `ACCESS_FINE_LOCATION`, or both.

Finding Yourself

The obvious thing to do with a location service is to figure out where you are right now.

To do that, you need to get a `LocationManager` – call `getSystemService(LOCATION_SERVICE)` from your activity or service and cast it to be a `LocationManager`.

The next step to find out where you are is to get the name of the `LocationProvider` you want to use. Here, you have two main options:

1. Ask the user to pick a provider
2. Find the best-match provider based on a set of criteria

If you want the user to pick a provider, calling `getProviders()` on the `LocationManager` will give you a `List` of providers, which you can then present to the user for selection.

Or, you can create and populate a `Criteria` object, stating the particulars of what you want out of a `LocationProvider`, such as:

- `setAltitudeRequired()` to indicate if you need the current altitude or not

- `setAccuracy()` to set a minimum level of accuracy, in meters, for the position

- `setCostAllowed()` to control if the provider must be free or if it can incur a cost on behalf of the device user

Given a filled-in `Criteria` object, call `getBestProvider()` on your `LocationManager`, and Android will sift through the criteria and give you the best answer. Note that not all of your criteria may be met – all but the monetary cost criterion might be relaxed if nothing matches.

You are also welcome to hard-wire in a `LocationProvider` name (e.g., `GPS_PROVIDER`), perhaps just for testing purposes.

Once you know the name of the `LocationProvider`, you can call `getLastKnownPosition()` to find out where you were recently. However, unless something else is causing the desired provider to collect fixes (e.g., unless the GPS radio is on), `getLastKnownPosition()` will return `null`, indicating that there is no known position. On the other hand, `getLastKnownPosition()` incurs no monetary or power cost, since the provider does not need to be activated to get the value.

These methods return a `Location` object, which can give you the latitude and longitude of the device in degrees as a Java `double`. If the particular location provider offers other data, you can get at that as well:

- For altitude, `hasAltitude()` will tell you if there is an altitude value, and `getAltitude()` will return the altitude in meters.

- For bearing (i.e., compass-style direction), `hasBearing()` will tell you if there is a bearing available, and `getBearing()` will return it as degrees east of true north.

- For speed, `hasSpeed()` will tell you if the speed is known and `getSpeed()` will return the speed in meters per second.

A more likely approach to getting the `Location` from a `LocationProvider`, though, is to register for updates, as described in the next section.

On the Move

Not all location providers are necessarily immediately responsive. GPS, for example, requires activating a radio and getting a fix from the satellites before you get a location. That is why Android does not offer a `getMeMyCurrentLocationNow()` method. Combine that with the fact that your users may well want their movements to be reflected in your application, and you are probably best off registering for location updates and using that as your means of getting the current location.

The `Internet/Weather` and `Service/WeatherAPI` sample applications show how to register for updates – call `requestLocationUpdates()` on your `LocationManager` instance. This takes four parameters:

1. The name of the location provider you wish to use

2. How long, in milliseconds, must have elapsed before we might get a location update

3. How far, in meters, must the device have moved before we might get a location update

4. A `LocationListener` that will be notified of key location-related events, as shown below:

```
LocationListener onLocationChange=new LocationListener() {
  public void onLocationChanged(Location location) {
    updateForecast(location);
  }

  public void onProviderDisabled(String provider) {
```

```
    // required for interface, not used
  }

  public void onProviderEnabled(String provider) {
    // required for interface, not used
  }

  public void onStatusChanged(String provider, int status,
                              Bundle extras) {
    // required for interface, not used
  }
};
```

Here, all we do is call `updateForecast()` with the `Location` supplied to the `onLocationChanged()` callback method. The `updateForecast()` implementation, as shown in the chapter on creating services, builds a Web page with the current forecast for the location and sends a broadcast so the activity knows an update is available.

When you no longer need the updates, call `removeUpdates()` with the `LocationListener` you registered. If you fail to do this, your application will continue receiving location updates even after all activities and such are closed up, which will also prevent Android from reclaiming your application's memory.

There is another version of `requestLocationUpdates()` that takes a `PendingIntent` rather than a `LocationListener`. This is useful if you want to be notified of changes in your position even when your code is not running. For example, if you are logging movements, you could use a `PendingIntent` that triggers a `BroadcastReceiver` (`getBroadcast()`) and have the `BroadcastReceiver` add the entry to the log. This way, your code is only in memory when the position changes, so you do not tie up system resources while the device is not moving.

Are We There Yet? Are We There Yet? Are We There Yet?

Sometimes, you want to know not where you are now, or even when you move, but when you get to where you are going. This could be an end destination, or it could be getting to the next step on a set of directions, so you can give the user the next turn.

To accomplish this, `LocationManager` offers `addProximityAlert()`. This registers an `PendingIntent`, which will be fired off when the device gets within a certain distance of a certain location. The `addProximityAlert()` method takes, as parameters:

- The latitude and longitude of the position that you are interested in

- A radius, specifying how close you should be to that position for the `Intent` to be raised

- A duration for the registration, in milliseconds – after this period, the registration automatically lapses. A value of `-1` means the registration lasts until you manually remove it via `removeProximityAlert()`.

- The `PendingIntent` to be raised when the device is within the "target zone" expressed by the position and radius

Note that it is not guaranteed that you will actually receive an `Intent`, if there is an interruption in location services, or if the device is not in the target zone during the period of time the proximity alert is active. For example, if the position is off by a bit, and the radius is a little too tight, the device might only skirt the edge of the target zone, or go by so quickly that the device's location isn't sampled while in the target zone.

It is up to you to arrange for an activity or receiver to respond to the `Intent` you register with the proximity alert. What you then do when the `Intent` arrives is up to you: set up a notification (e.g., vibrate the device), log the information to a content provider, post a message to a Web site, etc. Note that you will receive the `Intent` whenever the position is sampled and you are within the target zone – not just upon entering the zone. Hence, you

will get the `Intent` several times, perhaps quite a few times depending on the size of the target zone and the speed of the device's movement.

Testing...Testing...

The Android emulator does not have the ability to get a fix from GPS, triangulate your position from cell towers, or identify your location by some nearby WiFi signal. So, if you want to simulate a moving device, you will need to have some means of providing mock location data to the emulator.

For whatever reason, this particular area has undergone significant changes as Android itself has evolved. It used to be that you could provide mock location data within your application, which was very handy for demonstration purposes. Alas, those options have all been removed as of Android 1.0.

One likely option for supplying mock location data is the Dalvik Debug Monitor Service (DDMS). This is an external program, separate from the emulator, where you can feed it single location points or full routes to traverse, in a few different formats. DDMS is described in greater detail in the chapter on Android development tools.

Mapping with MapView and MapActivity

One of Google's most popular services – after search, of course – is Google Maps, where you can find everything from the nearest pizza parlor to directions from New York City to San Francisco (only 2,905 miles!) to street views and satellite imagery.

Most Android devices, not surprisingly, integrate Google Maps. For those that do, there is a mapping activity available to users straight off the main Android launcher. More relevant to you, as a developer, are `MapView` and `MapActivity`, which allow you to integrate maps into your own applications. Not only can you display maps, control the zoom level, and allow people to pan around, but you can tie in Android's location-based services to show where the device is and where it is going.

Fortunately, integrating basic mapping features into your Android project is fairly easy. However, there is a fair bit of power available to you, if you want to get sophisticated.

Terms, Not of Endearment

Google Maps, particularly when integrated into third party applications, requires agreeing to a fairly lengthy set of legal terms. These terms include clauses that you may find unpalatable.

If you are considering Google Maps, please review these terms closely to determine if your intended use will not run afoul of any clauses. You are strongly recommended to seek professional legal counsel if there are any potential areas of conflict.

Also, keep your eyes peeled for other mapping options, based off of other sources of map data, such as OpenStreetMap.

Piling On

As of Android 1.5, Google Maps are not strictly part of the Android SDK. Instead, they are part of the Google APIs Add-On, an extension of the stock SDK. The Android add-on system provides hooks for other subsystems that may be part of some devices but not others.

After all, Google Maps is not part of the Android open source project, and undoubtedly there will be some devices that lack Google Maps due to licensing issues. For example, at the time of this writing, the ARCHOS 5 Android tablet does not have Google Maps.

By and large, the fact that Google Maps is in an add-on does not affect your day-to-day development. However, bear in mind:

- You will need to create your project with an appropriate target to ensure the Google Maps APIs will be available

- To test your Google Maps integration, you will also need an AVD that uses an appropriate target

The Key To It All

If you download the source code for the book, compile the `Maps/NooYawk` project, install it in your emulator, and run it, you will probably see a screen with a grid and a couple of push-pins, but no actual maps.

That's because the API key in the source code is invalid for your development machine. Instead, you will need to generate your own API key(s) for use with your application. This also holds true for any map-enabled projects you create on your own from scratch.

Full instructions for generating API keys, for development and production use, can be found on the Android Web site. In the interest of brevity, let's focus on the narrow case of getting `NooYawk` running in your emulator. Doing this requires the following steps:

1. Visit the API key signup page and review the terms of service.

2. Re-read those terms of service and make really really sure you want to agree to them.

3. Find the MD5 digest of the certificate used for signing your debug-mode applications (described in detail below)

4. On the API key signup page, paste in that MD5 signature and submit the form

5. On the resulting page, copy the API key and paste it as the value of `apiKey` in your `MapView`-using layout

The trickiest part is finding the MD5 signature of the certificate used for signing your debug-mode applications...and much of the complexity is merely in making sense of the concept.

All Android applications are signed using a digital signature generated from a certificate. You are automatically given a debug certificate when you set up the SDK, and there is a separate process for creating a self-signed certificate for use in your production applications. This signature process involves the use of the Java `keytool` and `jarsigner` utilities. For the purposes of getting your API key, you only need to worry about `keytool`.

To get your MD5 digest of your debug certificate, if you are on OS X or Linux, use the following command:

```
keytool -list -alias androiddebugkey -keystore ~/.android/debug.keystore
-storepass android -keypass android
```

On other development platforms, you will need to replace the value of the `-keystore` switch with the location for your platform and user account:

- XP: `C:\Documents and Settings\<user>\.android\debug.keystore`

- Vista: `C:\Users\<user>\.android\debug.keystore`

(where `<user>` is your account name)

The second line of the output contains your MD5 digest, as a series of pairs of hex digits separated by colons.

The Bare Bones

To put a map into your application, you need to create your own subclass of `MapActivity`. Like `ListActivity`, which wraps up some of the smarts behind having an activity dominated by a `ListView`, `MapActivity` handles some of the nuances of setting up an activity dominated by a `MapView`. A `MapView` can only be used by a `MapActivity`, not any other type of `Activity`.

In your layout for the `MapActivity` subclass, you need to add an element named `com.google.android.maps.MapView`. This is the "longhand" way to spell out the names of widget classes, by including the full package name along with the class name. This is necessary because `MapView` is not in the `com.google.android.widget` namespace. You can give the `MapView` widget whatever `android:id` attribute value you want, plus handle all the layout details to have it render properly alongside your other widgets.

However, you do need to have:

- `android:apiKey`, which in production will need to be a Google Maps API key – more on this below

- `android:clickable = "true"`, if you want users to be able to click and pan through your map

For example, from the `Maps/NooYawk` sample application, here is the main layout:

```
<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent">
  <com.google.android.maps.MapView android:id="@+id/map"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:apiKey="00yHj0k7_7vzHbUFXzY2j94lYYCqW3NAIW8EEEw"
    android:clickable="true" />
</RelativeLayout>
```

We'll cover that mysterious apiKey in a later section.

In addition, you will need a couple of extra things in your AndroidManifest.xml file:

- The INTERNET and ACCESS_FINE_LOCATION permissions (the latter for use with the MyLocationOverlay class, described later in this chapter)

- Inside your <application>, a <uses-library> element with android:name = "com.google.android.maps", to indicate you are using one of the optional Android APIs

Here is the AndroidManifest.xml file for NooYawk:

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.commonsware.android.maps">
  <uses-permission android:name="android.permission.INTERNET" />
  <uses-permission android:name="android.permission.ACCESS_FINE_LOCATION" />

  <application android:label="@string/app_name"
    android:icon="@drawable/cw">
    <uses-library android:name="com.google.android.maps" />
    <activity android:name=".NooYawk" android:label="@string/app_name">
      <intent-filter>
        <action android:name="android.intent.action.MAIN" />
        <category android:name="android.intent.category.LAUNCHER" />
      </intent-filter>
    </activity>
  </application>
</manifest>
```

That is pretty much all you need for starters, plus to subclass your activity from MapActivity. If you were to do nothing else, and built that project and tossed it in the emulator, you'd get a nice map of the world. Note, however,

that `MapActivity` is abstract – you need to implement `isRouteDisplayed()` to indicate if you are supplying some sort of driving directions or not. Since displaying driving directions is not supported by the current edition of the terms of service, you should have `isRouteDisplayed()` return `false`.

Optional Maps

Not every Android device will have Google Maps, because they did not elect to license it from Google. While most mainstream devices will have Google Maps, a few percent of Android devices will be without it.

You need to decide if having Google Maps is essential for your application's operation, or not.

If it is, the `<uses-library>` element shown above is the right answer, as that will require any device running your app to have Google Maps.

If, however, you want Google Maps to be optional, there is an undocumented `android:required` attribute available on `<uses-library>`. Set that to `false`, and then Google Maps will be loaded into your application if it is available, but your application will run regardless. You will then need to use something like `Class.forName("com.google.android.maps.MapView")` to see if Google Maps is available to you. If it is not, you can disable the menu items or whatever would lead the user to your `MapActivity`. While this attribute is undocumented, Google has indicated that it is an available option, and hopefully it will be officially documented in a future Android release.

Exercising Your Control

You can find your `MapView` widget by `findViewById()`, no different than any other widget. The widget itself then offers a `getMapController()` method. Between the `MapView` and `MapController`, you have a fair bit of capability to determine what the map shows and how it behaves. Here are some likely features you will want to use:

Zoom

The map of the world you start with is rather broad. Usually, people looking at a map on a phone will be expecting something a bit narrower in scope, such as a few city blocks.

You can control the zoom level directly via the `setZoom()` method on the `MapController`. This takes an integer representing the level of zoom, where 1 is the world view and 21 is the tightest zoom you can get. Each level is a doubling of the effective resolution: 1 has the equator measuring 256 pixels wide, while 21 has the equator measuring 268,435,456 pixels wide. Since the phone's display probably does not have 268,435,456 pixels in either dimension, the user sees a small map focused on one tiny corner of the globe. A level of 17 will show you several city blocks in each dimension and is probably a reasonable starting point for you to experiment with.

If you wish to allow users to change the zoom level, call `setBuiltInZoomControls(true);`, and the user will be able to zoom in and out of the map via zoom controls found in the bottom center of the map.

Center

Typically, you will need to control what the map is showing, beyond the zoom level, such as the user's current location, or a location saved with some data in your activity. To change the map's position, call `setCenter()` on the `MapController`.

This takes a `GeoPoint` as a parameter. A `GeoPoint` represents a location, via latitude and longitude. The catch is that the `GeoPoint` stores latitude and longitude as integers representing the actual latitude and longitude in microdegrees (degrees multiplied by `1E6`). This saves a bit of memory versus storing a `float` or `double`, and it greatly speeds up some internal calculations Android needs to do to convert the `GeoPoint` into a map position. However, it does mean you have to remember to multiply the "real world" latitude and longitude by `1E6`.

Rugged Terrain

Just as the Google Maps you use on your full-size computer can display satellite imagery, so too can Android maps.

MapView offers toggleSatellite(), which, as the name suggests, toggles on and off this perspective on the area being viewed. You can have the user trigger these via an options menu or, in the case of NooYawk, via keypresses:

```
@Override
 public boolean onKeyDown(int keyCode, KeyEvent event) {
   if (keyCode == KeyEvent.KEYCODE_S) {
     map.setSatellite(!map.isSatellite());
     return(true);
   }
   else if (keyCode == KeyEvent.KEYCODE_Z) {
     map.displayZoomControls(true);
     return(true);
   }

   return(super.onKeyDown(keyCode, event));
 }
```

Layers Upon Layers

If you have ever used the full-size edition of Google Maps, you are probably used to seeing things overlaid atop the map itself, such as "push-pins" indicating businesses near the location being searched. In map parlance – and, for that matter, in many serious graphic editors – the push-pins are on a separate layer than the map itself, and what you are seeing is the composition of the push-pin layer atop the map layer.

Android's mapping allows you to create layers as well, so you can mark up the maps as you need to based on user input and your application's purpose. For example, NooYawk uses a layer to show where select buildings are located in the island of Manhattan.

Overlay Classes

Any overlay you want to add to your map needs to be implemented as a subclass of `Overlay`. There is an `ItemizedOverlay` subclass available if you are looking to add push-pins or the like; `ItemizedOverlay` simplifies this process.

To attach an overlay class to your map, just call `getOverlays()` on your `MapView` and `add()` your `Overlay` instance to it, as we do here with a custom `SitesOverlay`:

```
marker.setBounds(0, 0, marker.getIntrinsicWidth(),
                       marker.getIntrinsicHeight());

map.getOverlays().add(new SitesOverlay(marker));
```

We will explain that `marker` in just a bit.

Drawing the ItemizedOverlay

As the name suggests, `ItemizedOverlay` allows you to supply a list of points of interest to be displayed on the map – specifically, instances of `OverlayItem`. The overlay, then, handles much of the drawing logic for you. Here are the minimum steps to make this work:

- First, override `ItemizedOverlay<OverlayItem>` as your own subclass (in this example, `SitesOverlay`)

- In the constructor, build your roster of `OverlayItem` instances, and call `populate()` when they are ready for use by the overlay

- Implement `size()` to return the number of items to be handled by the overlay

- Override `createItem()` to return `OverlayItem` instances given an index

- When you instantiate your `ItemizedOverlay` subclass, provide it with a `Drawable` that represents the default icon (e.g., push-pin) to display for each item, on which you call `boundCenterBottom()` to enable the drop-shadow effect

The marker from the `NooYawk` constructor is the `Drawable` used for the last bullet above – it shows a push-pin.

For example, here is `SitesOverlay`:

```java
private class SitesOverlay extends ItemizedOverlay<OverlayItem> {
  private List<OverlayItem> items=new ArrayList<OverlayItem>();
  private Drawable marker=null;

  public SitesOverlay(Drawable marker) {
    super(marker);
    this.marker=marker;

    boundCenterBottom(marker);

    items.add(new OverlayItem(getPoint(40.748963847316034,
                                       -73.96807193756104),
                              "UN", "United Nations"));
    items.add(new OverlayItem(getPoint(40.76866299974387,
                                       -73.98268461227417),
                              "Lincoln Center",
                              "Home of Jazz at Lincoln Center"));
    items.add(new OverlayItem(getPoint(40.765136435316755,
                                       -73.97989511489868),
                              "Carnegie Hall",
                "Where you go with practice, practice, practice"));
    items.add(new OverlayItem(getPoint(40.70686417491799,
                                       -74.01572942733765),
                              "The Downtown Club",
                    "Original home of the Heisman Trophy"));

    populate();
  }

  @Override
  protected OverlayItem createItem(int i) {
    return(items.get(i));
  }

  @Override
  protected boolean onTap(int i) {
    Toast.makeText(NooYawk.this,
                   items.get(i).getSnippet(),
                   Toast.LENGTH_SHORT).show();

    return(true);
  }

  @Override
  public int size() {
    return(items.size());
```

```
  }
}
```

Handling Screen Taps

An `Overlay` subclass can also implement `onTap()`, to be notified when the user taps on the map, so the overlay can adjust what it draws. For example, in full-size Google Maps, clicking on a push-pin pops up a bubble with information about the business at that pin's location. With `onTap()`, you can do much the same in Android.

The `onTap()` method for `ItemizedOverlay` receives the index of the `OverlayItem` that was clicked. It is up to you to do something worthwhile with this event.

In the case of `SitesOverlay`, as shown above, `onTap()` looks like this:

```
@Override
protected boolean onTap(int i) {
  Toast.makeText(NooYawk.this,
                 items.get(i).getSnippet(),
                 Toast.LENGTH_SHORT).show();

  return(true);
}
```

Here, we just toss up a short `Toast` with the "snippet" from the `OverlayItem`, returning true to indicate we handled the tap.

My, Myself, and MyLocationOverlay

Android has a built-in overlay to handle two common scenarios:

1. Showing where you are on the map, based on GPS or other location-providing logic

2. Showing where you are pointed, based on the built-in compass sensor, where available

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All you need to do is create a `MyLocationOverlay` instance, add it to your `MapView`'s list of overlays, and enable and disable the desired features at appropriate times.

The "at appropriate times" notion is for maximizing battery life. There is no sense in updating locations or directions when the activity is paused, so it is recommended that you enable these features in `onResume()` and disable them in `onPause()`.

For example, `NooYawk` will display a compass rose using `MyLocationOverlay`. To do this, we first need to create the overlay and add it to the list of overlays:

```
me=new MyLocationOverlay(this, map);
map.getOverlays().add(me);
```

Then, we enable and disable the compass rose as appropriate:

```
@Override
public void onResume() {
  super.onResume();

  me.enableCompass();
}

@Override
public void onPause() {
  super.onPause();

  me.disableCompass();
}
```

This gives us a compass rose while the activity is on-screen:
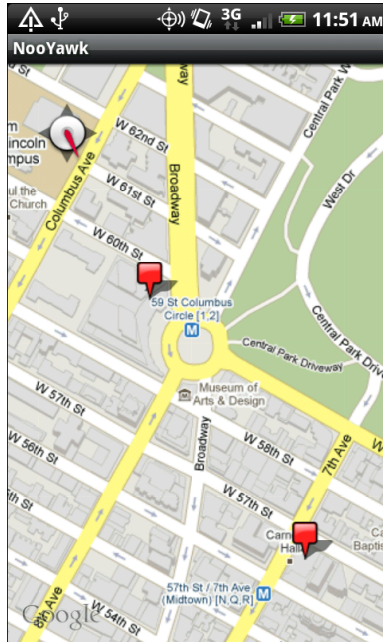
Figure 99. The NooYawk map, showing a compass rose and two OverlayItems

Rugged Terrain

Just as the Google Maps you use on your full-size computer can display satellite imagery, so too can Android maps.

MapView offers toggleSatellite(), which, as the name suggests, toggles on and off this perspective on the area being viewed. You can have the user trigger these via an options menu or, in the case of NooYawk, via keypresses:

```java
@Override
public boolean onKeyDown(int keyCode, KeyEvent event) {
  if (keyCode == KeyEvent.KEYCODE_S) {
    map.setSatellite(!map.isSatellite());
    return(true);
  }
  else if (keyCode == KeyEvent.KEYCODE_Z) {
    map.displayZoomControls(true);
    return(true);
  }
```

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```
    return(super.onKeyDown(keyCode, event));
}
```

So, for example, here is `NooYawk` showing a satellite view, courtesy of pressing the `s` key:
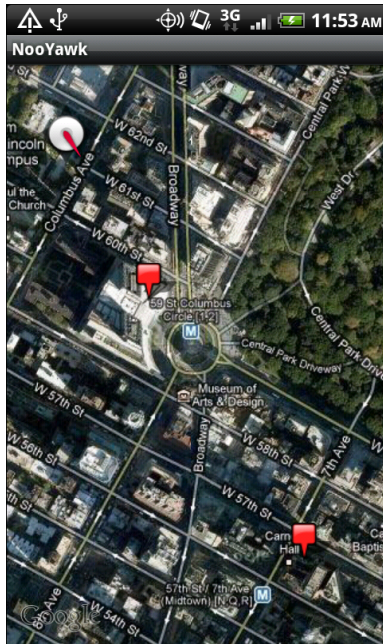
Figure 100. The NooYawk map, showing a compass rose and two OverlayItems, overlaid on the satellite view

Handling Telephone Calls

Many, if not most, Android devices will be phones. As such, not only will users be expecting to place and receive calls using Android, but you will have the opportunity to help them place calls, if you wish.

Why might you want to?

- Maybe you are writing an Android interface to a sales management application (a la Salesforce.com) and you want to offer users the ability to call prospects with a single button click, and without them having to keep those contacts both in your application and in the phone's contacts application

- Maybe you are writing a social networking application, and the roster of phone numbers that you can access shifts constantly, so rather than try to "sync" the social network contacts with the phone's contact database, you let people place calls directly from your application

- Maybe you are creating an alternative interface to the existing contacts system, perhaps for users with reduced motor control (e.g., the elderly), sporting big buttons and the like to make it easier for them to place calls

Whatever the reason, Android has the means to let you manipulate the phone just like any other piece of the Android system.

Report To The Manager

To get at much of the phone API, you use the `TelephonyManager`. That class lets you do things like:

- Determine if the phone is in use via `getCallState()`, with return values of `CALL_STATE_IDLE` (phone not in use), `CALL_STATE_RINGING` (call requested but still being connected), and `CALL_STATE_OFFHOOK` (call in progress)

- Find out the SIM ID (IMSI) via `getSubscriberId()`

- Find out the phone type (e.g., GSM) via `getPhoneType()` or find out the data connection type (e.g., GPRS, EDGE) via `getNetworkType()`

You Make the Call!

You can also initiate a call from your application, such as from a phone number you obtained through your own Web service. To do this, simply craft an `ACTION_DIAL` Intent with a `Uri` of the form `tel:NNNNN` (where `NNNNN` is the phone number to dial) and use that `Intent` with `startActivity()`. This will not actually dial the phone; rather, it activates the dialer activity, from which the user can then press a button to place the call.

For example, let's look at the `Phone/Dialer` sample application. Here's the crude-but-effective layout:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
  <LinearLayout
    android:orientation="horizontal"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    >
    <TextView
      android:layout_width="wrap_content"
      android:layout_height="wrap_content"
      android:text="Number to dial:"
      />
```

```
    <EditText android:id="@+id/number"
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      android:cursorVisible="true"
      android:editable="true"
      android:singleLine="true"
    />
  </LinearLayout>
  <Button android:id="@+id/dial"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:layout_weight="1"
    android:text="Dial It!"
    android:onClick="dial"
  />
</LinearLayout>
```

We have a labeled field for typing in a phone number, plus a button for dialing said number.

The Java code simply launches the dialer using the phone number from the field:

```
package com.commonsware.android.dialer;

import android.app.Activity;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.view.View;
import android.widget.EditText;

public class DialerDemo extends Activity {
  @Override
  public void onCreate(Bundle icicle) {
    super.onCreate(icicle);
    setContentView(R.layout.main);
  }

  public void dial(View v) {
    EditText number=(EditText)findViewById(R.id.number);
    String toDial="tel:"+number.getText().toString();

    startActivity(new Intent(Intent.ACTION_DIAL, Uri.parse(toDial)));
  }
}
```

The activity's own UI is not that impressive:
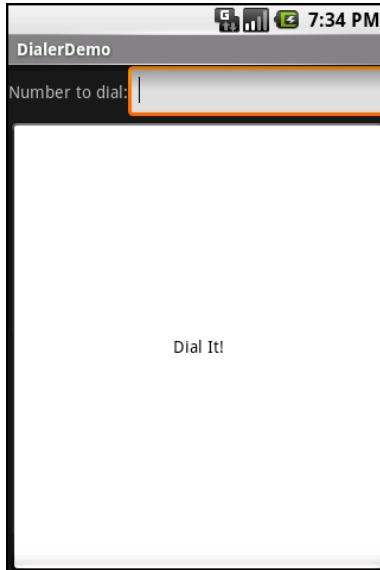
Figure 101. The DialerDemo sample application, as initially launched

However, the dialer you get from clicking the dial button is better, showing you the number you are about to dial:
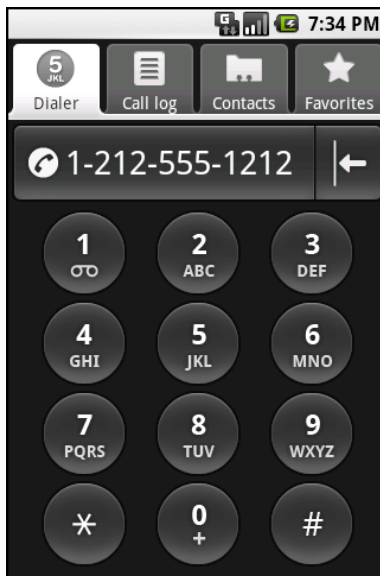
Figure 102. The Android Dialer activity, as launched from DialerDemo

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No, Really, You Make the Call!

The good news is that `ACTION_DIAL` works without any special permissions. The bad news is that it only takes the user to the Dialer – the user still has to take action (pressing the green call button) to actually place the phone call.

An alternative approach is to use `ACTION_CALL` instead of `ACTION_DIAL`. Calling `startActivity()` on an `ACTION_CALL Intent` will immediately place the phone call, without any other UI steps required. However, you need the `CALL_PHONE` permission in order to use `ACTION_CALL`.

Development Tools

The Android SDK is more than a library of Java classes and API calls. It also includes a number of tools to assist in application development.

Much of the focus has been on the Eclipse plug-in, to integrate Android development with that IDE. Secondary emphasis has been placed on the plug-in's equivalents for use in other IDEs or without an IDE, such as `adb` for communicating with a running emulator.

This chapter will cover other tools beyond those two groups.

Hierarchical Management

Android comes with a Hierarchy Viewer tool, designed to help you visualize your layouts as they are seen in a running activity in a running emulator. So, for example, you can determine how much space a certain widget is taking up, or try to find where a widget is hiding that does not appear on the screen.

To use the Hierarchy Viewer, you first need to fire up your emulator, install your application, launch your activity, and navigate to the spot you wish to examine. Note that you cannot use HierarchyViewer with a production Android device (e.g., T-Mobile G1). For illustration purposes, we'll use the `ReadWrite` demo application we introduced back in the chapter on file access:

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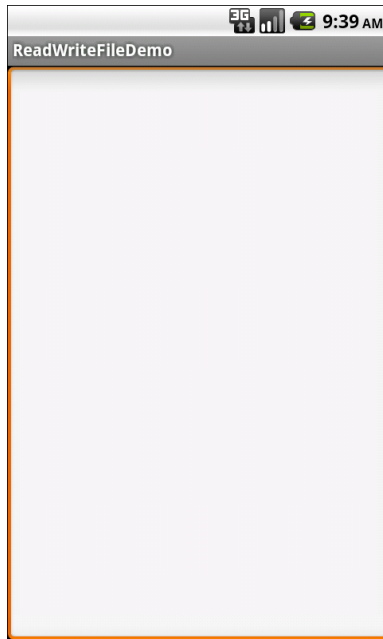
Figure 103. ReadWrite demo application

You can launch the Hierarchy Viewer via the `hierarchyviewer` program, found in the `tools/` directory in your Android SDK installation. This brings up the main Hierarchy Viewer window:
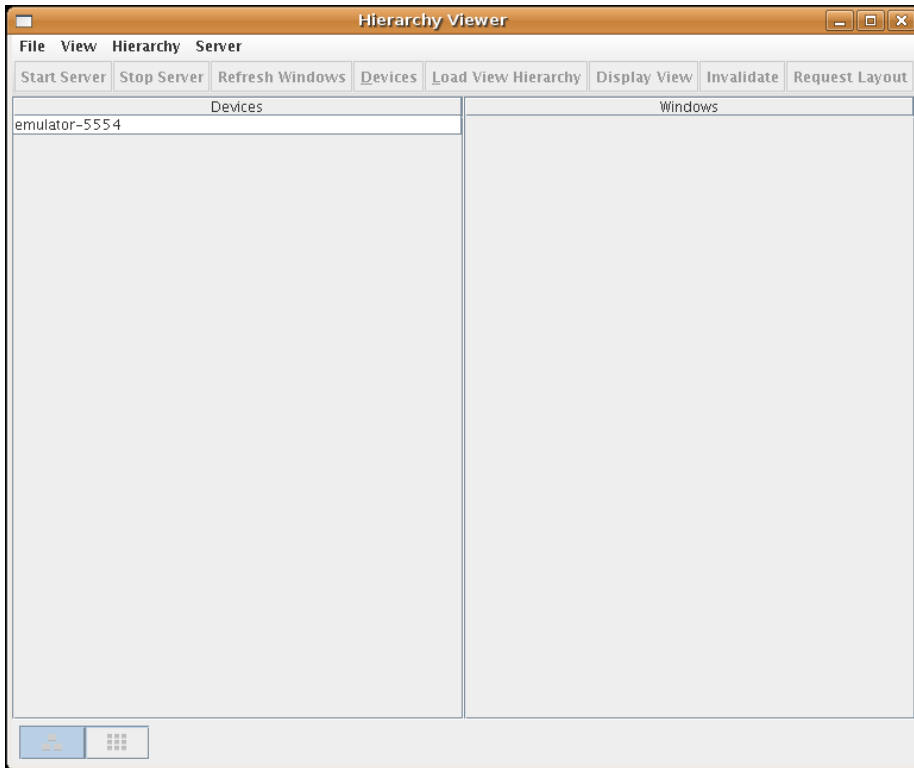
Figure 104. Hierarchy Viewer main window

The list on the left shows the various emulators you have opened. The number after the hyphen should line up with the number in parentheses in your emulator's title bar.

Clicking on an emulator shows, on the right, the list of "windows" available for examination:
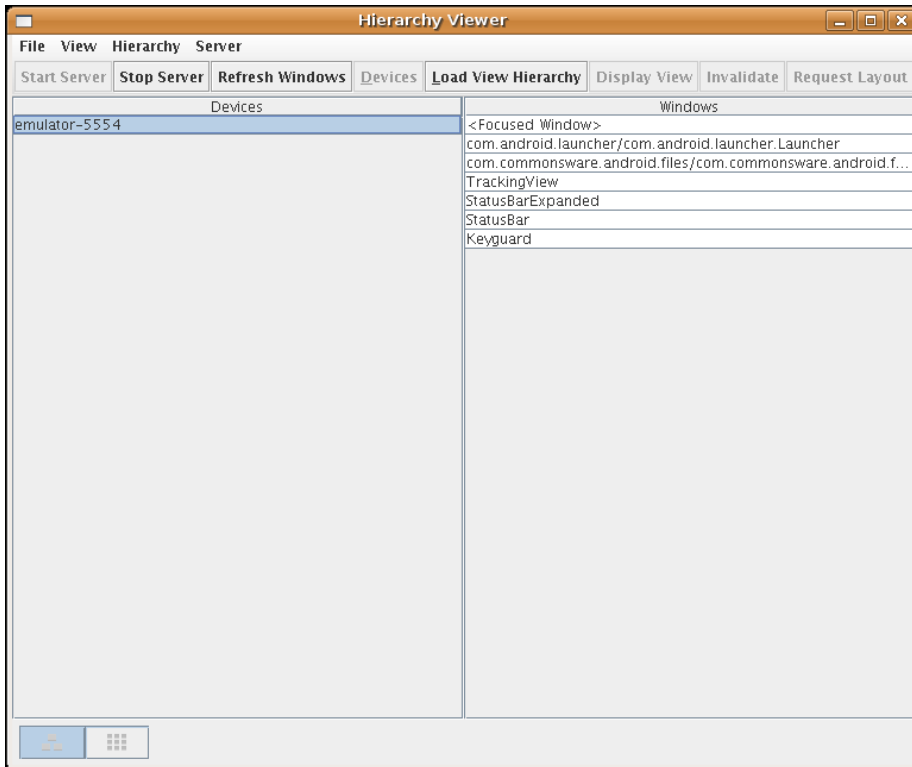
Figure 105. Hierarchy Viewer list of available windows

Note how there are many other windows besides our open activity, including the Launcher (i.e., the home screen), the Keyguard (i.e., the "Press Menu to Unlock" black screen you get when first opening the emulator), and so on. Your activity will be identified by application package and class (e.g., `com.commonsware.android.files/...`).

Where things get interesting, though, is when you choose a window and click Load View Hierarchy. After a few seconds, the details spring into view, in a perspective called the Layout View:
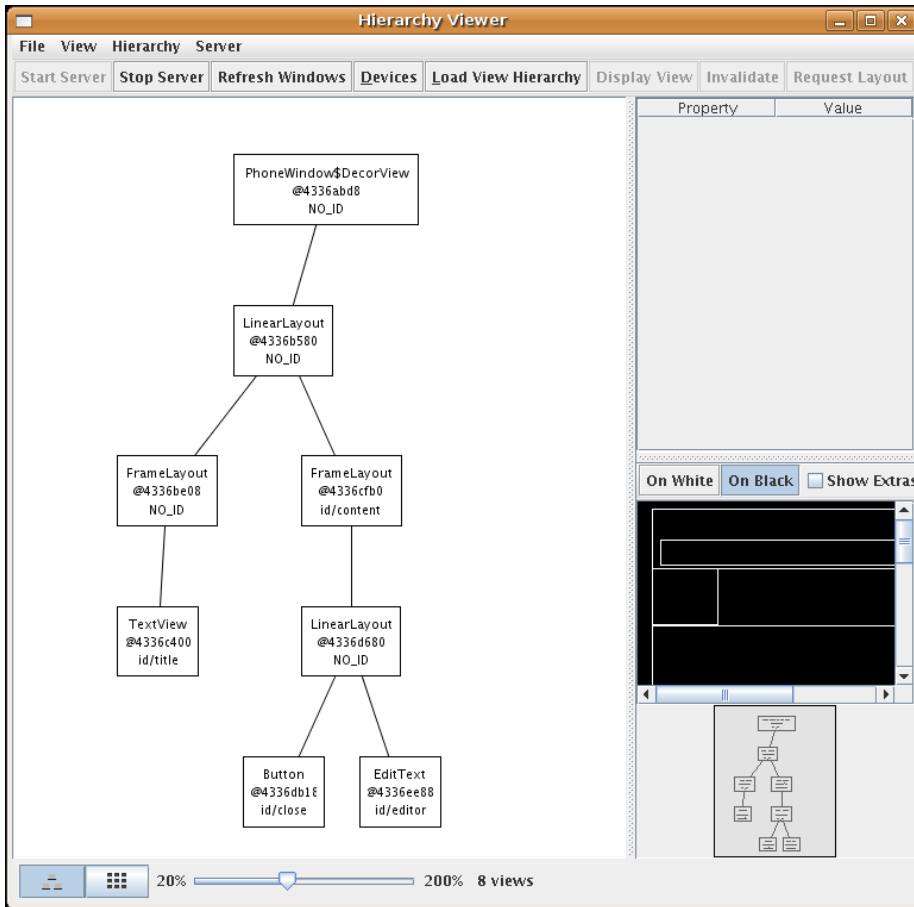
Figure 106. Hierarchy Viewer Layout View

The main area of the Layout View shows a tree of the various Views that make up your activity, starting from the overall system window and driving down into the individual UI widgets that users are supposed to interact with. You will see, on the lower-right branch of the tree, the `LinearLayout`, `Button`, and `EditText` shown in the above code listing. The remaining `Views` are all supplied by the system, including the title bar.

Clicking on one of the views adds more information to this perspective:
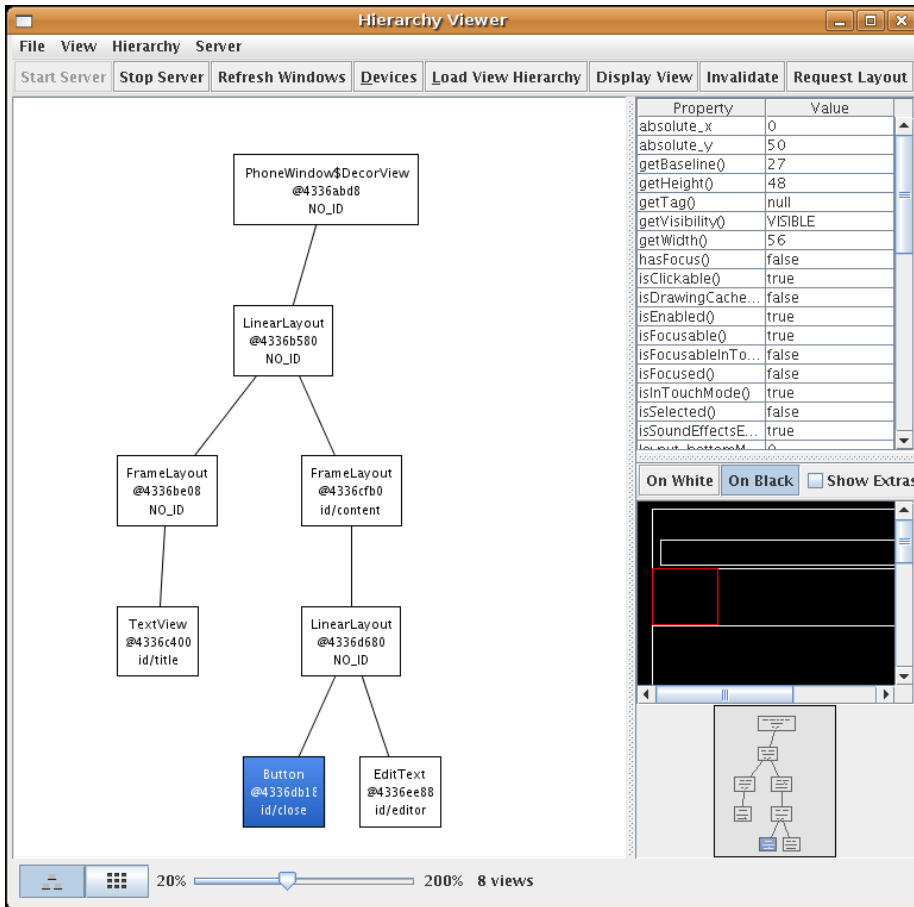
Figure 107. Hierarchy Viewer View properties

Now, in the upper-right region of the Viewer, we see properties of the selected widget — in this case, the `Button`. Alas, these properties do not appear to be editable.

Also, the widget is highlighted in red in the wireframe of the activity, shown beneath the properties (by default, views are shown as white outlines on a black background). This can help you ensure you have selected the right widget, if, say, you have several buttons and cannot readily tell from the tree what is what.

And, if you double-click on a `View` in the tree, you are given a pop-up pane showing just that `View` (and its children), isolated from the rest of your activity.

Down in the lower-left corner, you will see two toggle buttons, with the tree button initially selected. Clicking on the grid button changes puts the Viewer in a whole new perspective, called the Pixel Perfect View:
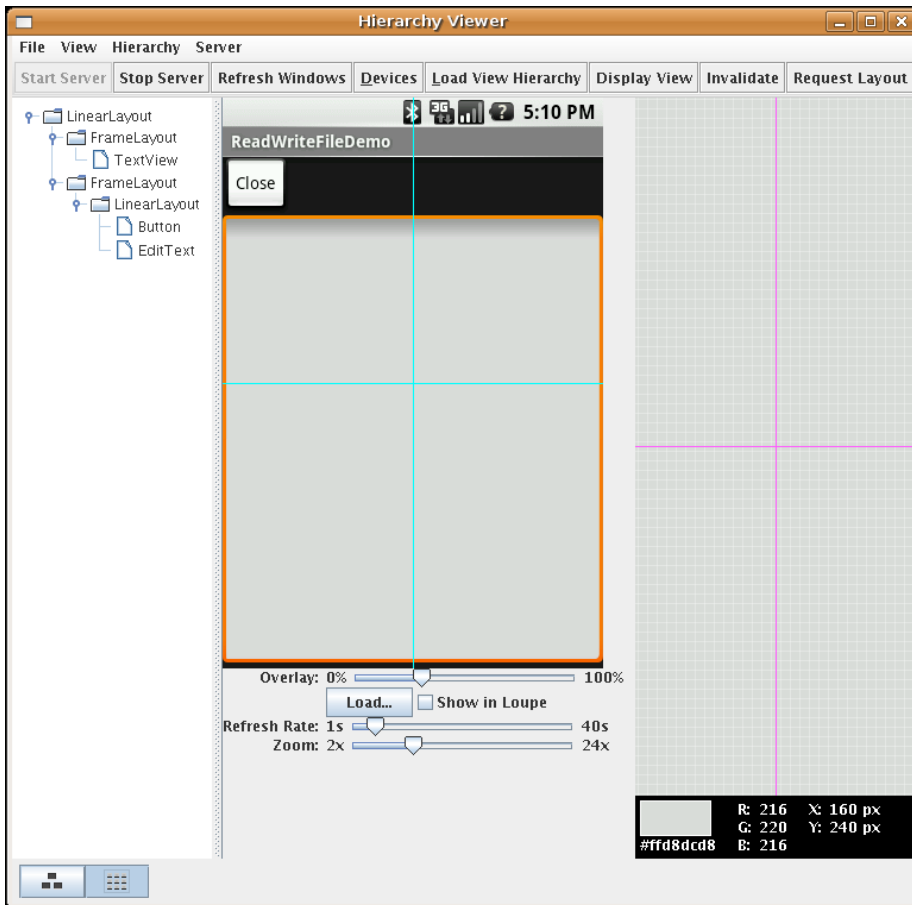
Figure 108. Hierarchy Viewer Pixel Perfect View

On the left, you see a tree representing the widgets and other `View`s in your activity. In the middle, you see your activity (the Normal View), and on the right, you see a zoomed edition of your activity (the Loupe View).

What may not be initially obvious is that this imagery is live. Your activity is polled every so often, controlled by the Refresh Rate slider. Anything you do in the activity will then be reflected in the Pixel Perfect View's Normal and Loupe Views.

The hairlines (cyan) overlaying the activity show the position being zoomed upon — just click on a new area to change where the Loupe View is inspecting. And, of course, there is another slider to adjust how much the Loupe View is zoomed.

Delightful Dalvik Debugging Detailed, Demoed

Another tool in the Android developer's arsenal is the Dalvik Debug Monitor Service (DDMS). This is a "Swiss army knife", allowing you to do everything from browse log files, update the GPS location provided by emulator, simulate incoming calls and messages, and browse the on-emulator storage to push and pull files.

Eventually, this section will contain a complete overview of DDMS. However, DDMS has a wide range of uses, so this section will gradually expand over time to try to cover them all.

To launch DDMS, run the `ddms` program inside the `tools/` directory in your Android SDK distribution. It will initially display just a tree of emulators and running programs on the left:
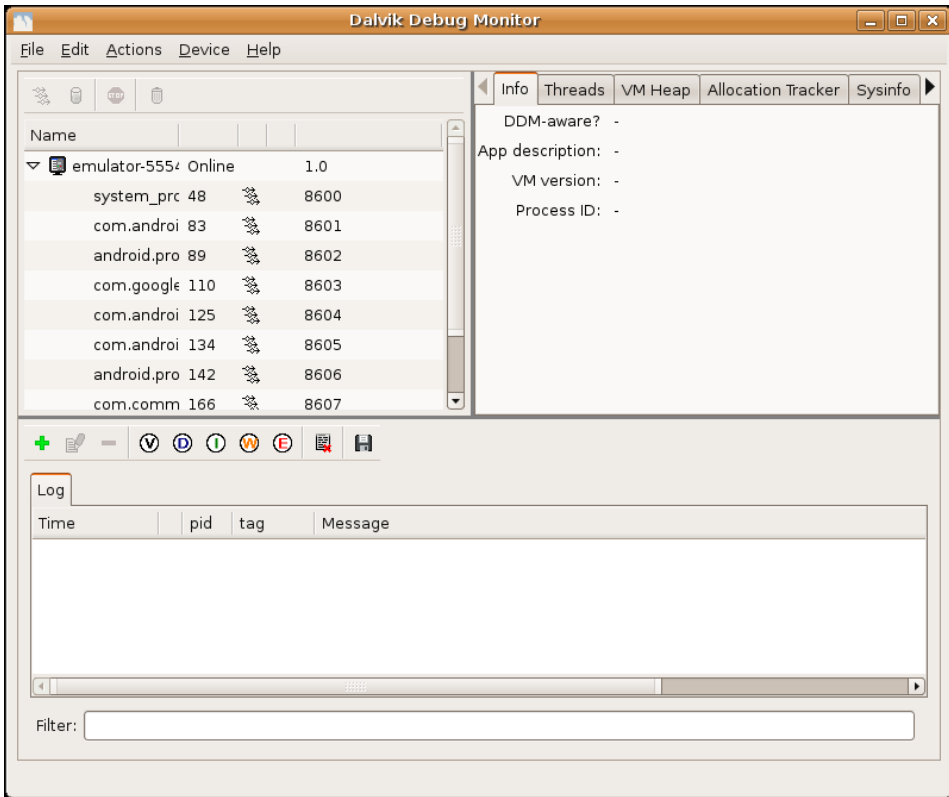
Figure 109. DDMS initial view

Clicking on an emulator allows you to browse the event log on the bottom and manipulate the emulator via the tabs on the right:
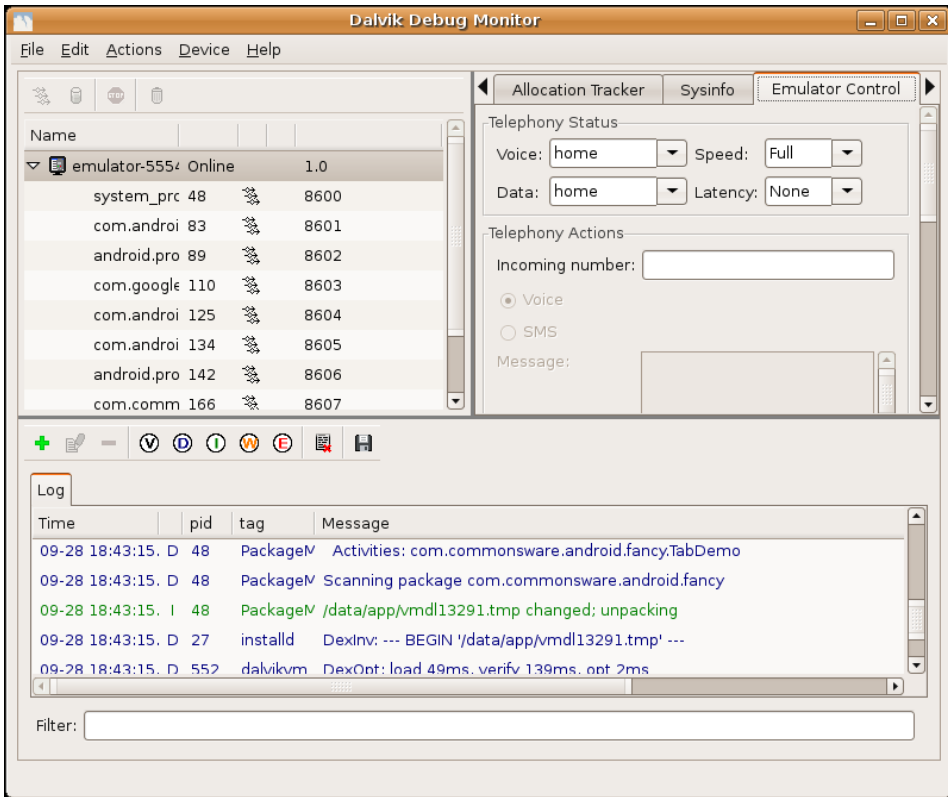
Figure 110. DDMS, with emulator selected

Logging

Rather than use `adb logcat`, DDMS lets you view your logging information in a scrollable table. Just highlight the emulator or device you want to monitor, and the bottom half of the screen shows the logs.

In addition, you can:

- Filter the Log tab by any of the five logging levels, shown as the V through E toolbar buttons.

- Create a custom filter, so you can view only those tagged with your application's tag, by pressing the + toolbar button and completing the form (shown below). The name you enter in the form will be

used as the name of another logging output tab in the bottom portion of the DDMS main window.

• Save the log information to a text file for later perusal, or for searching.
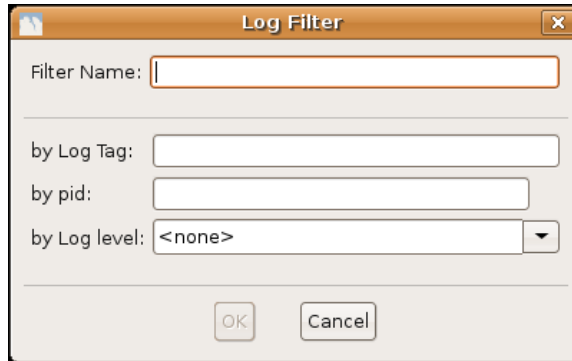
Figure 111. DDMS logging filter

File Push and Pull

While you can use `adb pull` and `adb push` to get files to and from an emulator or device, DDMS lets you do that visually. Just highlight the emulator or device you wish to work with, then choose **Device|File Explorer...** from the main menu. That will bring up your typical directory browser:
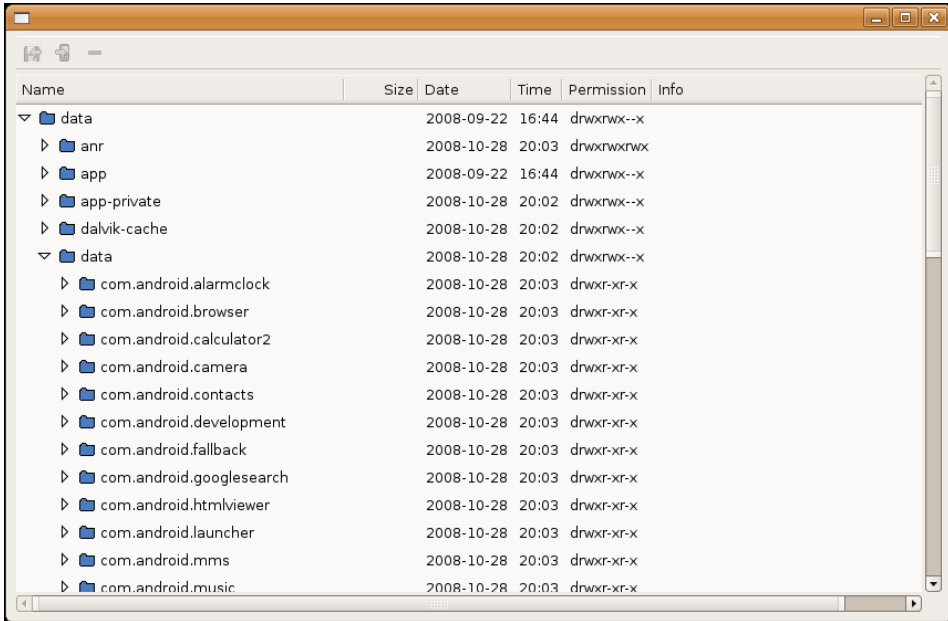
Figure 112. DDMS File Explorer

Just browse to the file you want and click either the pull (left-most) or push (middle) toolbar button to transfer the file to/from your development machine. Or, click the delete (right-most) toolbar button to delete the file.

There are a few caveats to this:

- You cannot create directories through this tool. You will either need to use `adb shell` or create them from within your application.

- While you can putter through most of the files on an emulator, you can access very little outside of `/sdcard` on an actual device, due to Android security restrictions.

Screenshots

To take a screenshot of the Android emulator or device, simply press `<Ctrl>-<S>` or choose **Device| Screen capture...** from the main menu. This will bring up a dialog box containing an image of the current screen:
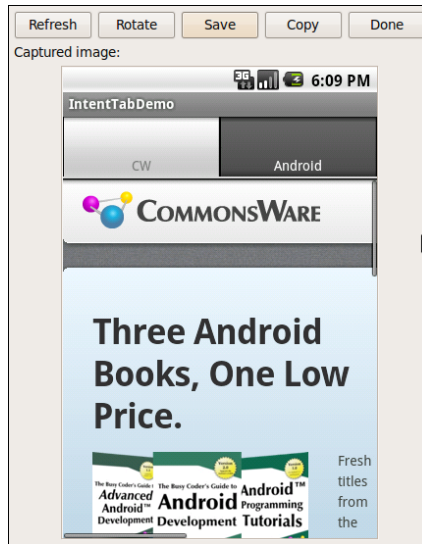
Figure 113. DDMS screen capture

From here, you can click **[Save]** to save the image as a PNG file somewhere on your development machine, **[Refresh]** to update the image based on the current state of the emulator or device, or **[Done]** to close the dialog.

Location Updates

To use DDMS to supply location updates to your application, the first thing you must do is have your application use the `gps LocationProvider`, as that is the one that DDMS is set to update.

Then, click on the Emulator Control tab and scroll down to the Location Controls section. Here, you will find a smaller tabbed pane with three options for specifying locations: Manual, GPX, and KML:
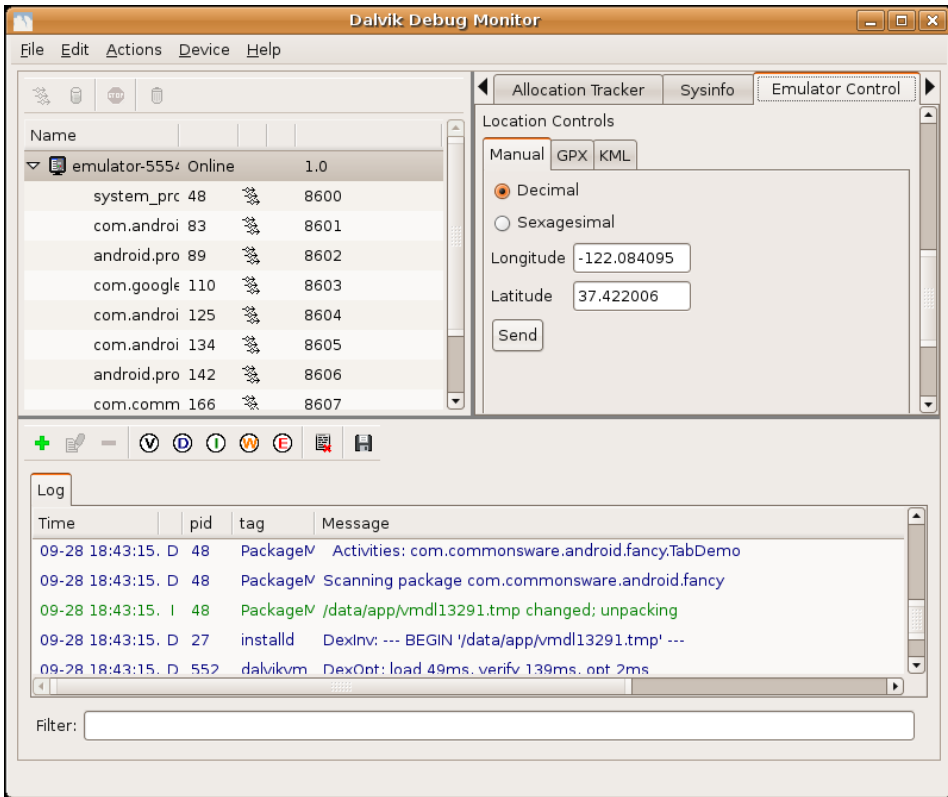
Figure 114. DDMS location controls

The Manual tab is fairly self-explanatory: provide a latitude and longitude and click the Send button to submit that location to the emulator. The emulator, in turn will notify any location listeners of the new position.

Discussion of the GPX and KML options is reserved for a future edition of this book.

Placing Calls and Messages

If you want to simulate incoming calls or SMS messages to the Android emulator, DDMS can handle that as well.

On the Emulator Control tab, above the Location Controls group, is the Telephony Actions group:
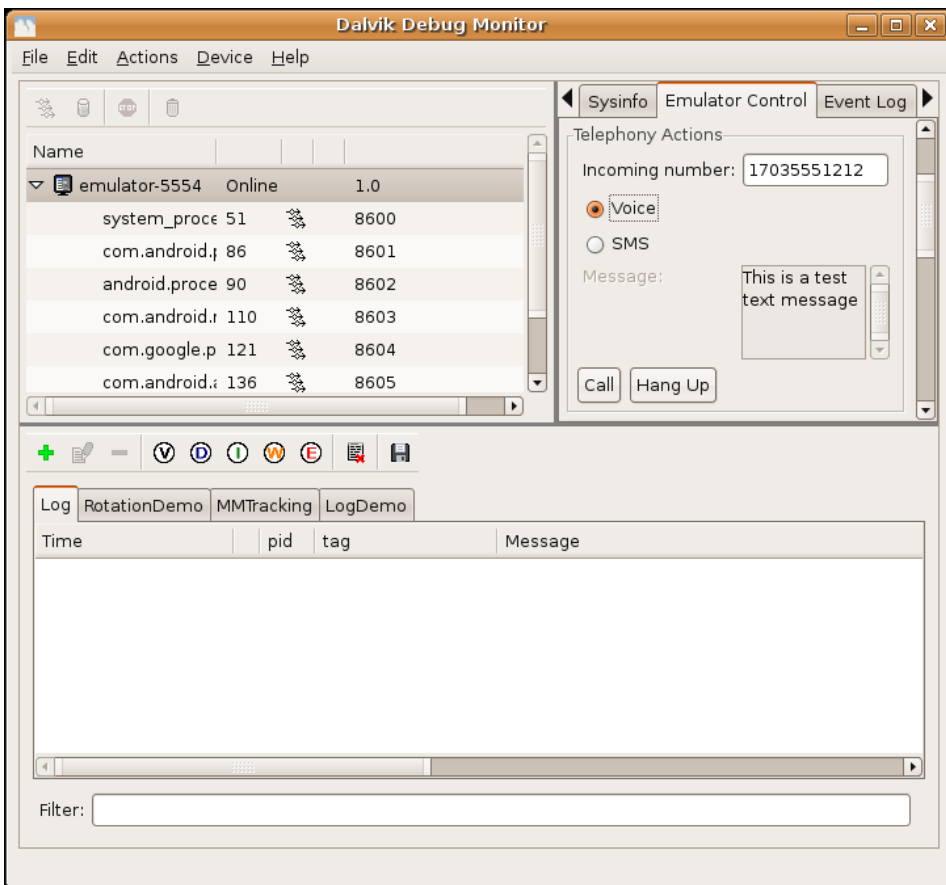
Figure 115. DDMS telephony controls

To simulate an incoming call, fill in a phone number, choose the Voice radio button, and click Call. At that point, the emulator will show the incoming call, allowing you to accept it (via the green phone button) or reject it (via the red phone button):
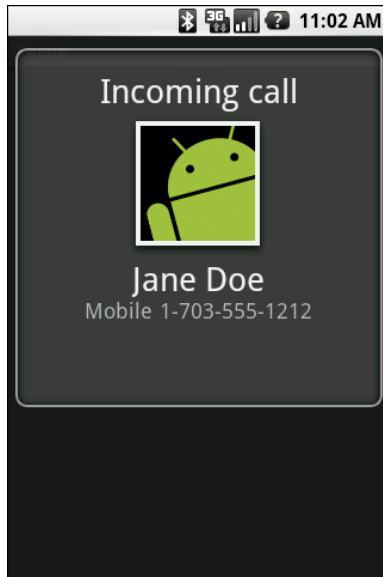
Figure 116. Simulated incoming call

To simulate in an incoming text message, fill in a phone number, choose the SMS radio button, enter a message in the provided text area, and click Send. The text message will then appear as a notification:
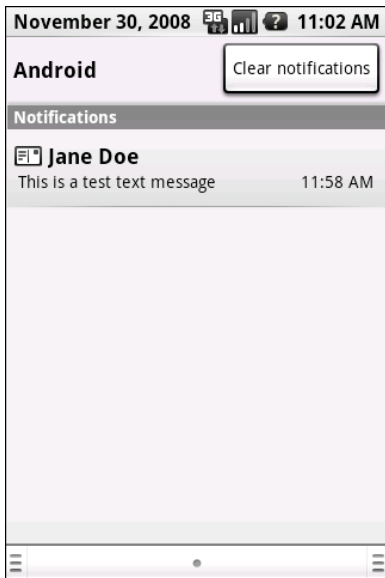
Figure 117. Simulated text message

And, of course, you can click on the notification to view the message in the full-fledged Messaging application:

Figure 118. Simulated text message, in Messaging application

Put It On My Card

The T-Mobile G1 has a microSD card slot. Many other Android devices are likely to have similar forms of removable storage, which the Android platform refers to generically as an "SD card".

SD cards are strongly recommended to be used by developers as the holding pen for large data sets: images, movie clips, audio files, etc. The T-Mobile G1, in particular, has a relatively paltry amount of on-board flash memory, so the more you can store on an SD card, the better.

Of course, the challenge is that, while the G1 has an SD card by default, the emulator does not. To make the emulator work like the G1, you need to create and "insert" an SD card into the emulator.

Creating a Card Image

Rather than require emulators to somehow have access to an actual SD card reader and use actual SD cards, Android is set up to use card images. An image is simply a file that the emulator will treat as if it were an SD card volume. If you are used to disk images used with virtualization tools (e.g., VirtualBox), the concept is the same: Android uses a disk image representing the SD card contents.

To create such an image, use the `mksdcard` utility, provided in the `tools/` directory of your SDK installation. This takes two main parameters:

1. The size of the image, and hence the size of the resulting "card". If you just supply a number, it is interpreted as a size in bytes. Alternatively, you can append `K` or `M` to the number to indicate a size in kilobytes or megabytes, respectively.

2. The filename under which to store the image.

So, for example, to create a 1GB SD card image, to simulate the G1's SD card in the emulator, you could run:

```
mksdcard 1024M sdcard.img
```

"Inserting" the Card

To have your emulator use this SD card image, start the emulator with the `-sdcard` switch, containing a fully-qualified path to the image file you created using `mksdcard`. While there will be no visible impact – there is no icon or anything in Android showing that you have a card mounted – the `/sdcard` path will now be available for reading and writing.

To put files on the `/sdcard`, either use the File Explorer in DDMS or `adb push` and `adb pull` from the console.

PART VI – The Ever-Evolving Android

Handling Multiple Screen Sizes

For the first year or so since Android 1.0 was released, all production Android devices had the same screen resolution (HVGA, 320x480) and size (around 3.5" / 9cm). Starting in the fall of 2009, though, devices started arriving with widely disparate screen sizes and resolutions, from tiny QVGA (240x320) screens to much larger WVGA (480x800) screens. And, in the fall of 2010, tablets and Google TV devices appeared, offering yet more screen sizes.

Of course, users will be expecting your application to be functional on all of these, and perhaps take advantage of larger screen sizes to add greater value. To that end, Android 1.6 added new capabilities to help better support these differing screen sizes and resolutions.

The Android documentation has extensive coverage of the mechanics of handling multiple screen sizes. You are encouraged to read that page along with this chapter, to get the best understanding of how best to cope with, and perhaps take advantage of, multiple screen sizes. After a number of sections discussing the options and theory, the chapter wraps with an in-depth look at making a fairly simple application handle multiple screen sizes well.

Taking the Default

Let's suppose, though, that you start off by totally ignoring the issue of screen sizes and resolutions. What happens?

If your application is compiled for Android 1.5 or lower, Android will assume your application was designed to look good on the classic screen size and resolution. Android will then automatically do the following:

- If your application is installed on a device with a larger screen, Android will run your application in "compatibility mode", scaling everything based on the actual screen size. So, suppose you have a 24px square PNG file, and Android install and runs your application on a device with the standard physical size but a WVGA resolution (a so-called "high-density" screen). Android might scale your PNG file to be 36px when it displays it, so it will take up the same visible space on the screen. On the plus side, Android handles this automatically; on the minus side, bitmap scaling algorithms tend to make the images a bit fuzzy.

- Android will block your application from running on a device with a smaller screen. Hence, QVGA devices, like the HTC Tattoo, will be unable to get your application, even if it is available on the Android Market.

As an example of how this affects your app, take a peek at the Containers/Table sample application as viewed on an HTC Tattoo, with its QVGA screen:
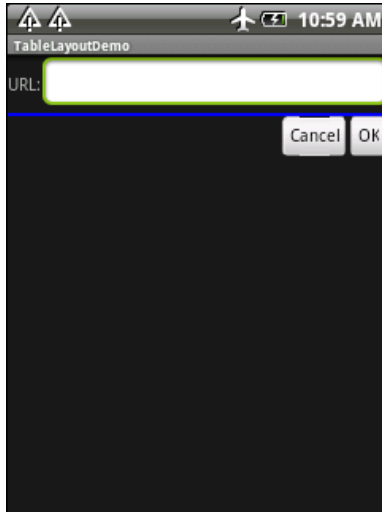
Figure 119. TableLayout sample in QVGA via compatibility mode

If your application is compiled for Android 1.6 or higher, Android assumes that you are properly handling all screen sizes, and therefore will not run your application in "compatibility mode". We will see how to tailor this in a later section.

Whole in One

The simplest approach to handling multiple screen sizes in Android is to design your user interfaces such that they automatically scale for the screen size, without any size-specific code or resources. In other words, "it just works".

This implies, though, that everything you use in your user interface can be gracefully scaled by Android and that everything will fit, even on a QVGA screen.

Here are some tips for achieving this "all in one" solution:

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Don't Think About Positions, Think About Rules

Some developers, perhaps those coming from the "drag-and-drop" school of UI development, think first and foremost about the positions of widgets. They think that they want certain widgets to be certain fixed sizes at certain fixed locations. They get frustrated with Android layout manager (containers) and may gravitate to the deprecated `AbsoluteLayout` as a way to design UIs they way they used to.

That rarely works well even on desktops, as can be seen by applications that do not handle window resizing very well. Similarly, it will not work on mobile devices, particularly Android, with its range of screen sizes and resolutions.

Instead of thinking about positions, think about rules. You need to teach Android the "business rules" about where widgets should be sized and placed, with Android then interpreting those rules based upon what the device's screen actually supports in terms of resolution.

The simplest rules are the `fill_parent` and `wrap_content` values for `android:layout_width` and `android:layout_height`. Those do not specify specific sizes, but rather adapt to the space available.

The richest environment for easily specifying rules is to use `RelativeLayout`. While complicated on the surface, `RelativeLayout` does an excellent job of letting you control your layout while still adapting it to other screen sizes. For example, you can:

- Explicitly anchor widgets to the bottom or right side of the screen, rather than hoping they will wind up there courtesy of some other layout

- Control the distances between widgets that are "connected" (e.g., a label for a field should be to the left of the field) without having to rely on padding or margins

The greatest control for specifying rules is to create your own layout class. For example, suppose you are creating a series of applications that

implement card games. You may want to have a layout class that knows about playing cards: how they overlap, which are face up versus face down, how big to be to handle varying number of cards, etc. While you could achieve the desired look with, say, a `RelativeLayout`, you may be better served implementing a `PlayingCardLayout` or a `HandOfCardsLayout` or something that is more explicitly tailored for your application. Unfortunately, creating custom layout classes is under-documented at this point in time.

Consider Physical Dimensions

Android offers a wide range of available units of measure for dimensions. The most popular has been the pixel (`px`), because it is easy to "wrap your head around" the concept. After all, all Android devices will have screens with such-and-so number of pixels in each direction.

However, pixels start to become troublesome as screen density changes. As the number of pixels in a given screen size increases, the pixels effectively shrink. A `32px` icon on a traditional Android device might be finger-friendly, but on a high-density device (say, WVGA in a mobile phone form factor), `32px` may be a bit small for use with a finger.

If you have something intrinsically scalable (e.g., a `Button`) where you had been specifying a size in pixels, you might consider switching to using millimeters (`mm`) or inches (`in`) as the unit of measure. `10mm` is `10mm` regardless of the screen resolution or the screen size. This way, you can ensure that your widget is sized to be finger-friendly, regardless of the number of pixels that might take.

Avoid "Real" Pixels

In some circumstance using millimeters for dimensions will not make sense. Then, you may wish to consider using other units of measure while still avoiding "real" pixels.

Android offers dimensions measured in density-independent pixels (`dip`). These map 1:1 to pixels for a 160dpi screen (e.g., a classic HVGA Android device) and scale from there. For example, on a 240dpi device (e.g., a phone-sized WVGA device), the ratio is 2:3, so `50dip` = 50px at 160dpi = `75px` at 240dpi. The advantage to the user of going with dip is that the actual size of the dimension stays the same, so visibly there is no difference between `50dip` at 160dpi and `50dip` at 240dpi.

Android also offers dimensions measured in scaled pixels (`sp`). Scaled pixels, in theory, are scaled based on the user's choice of font size (`FONT_SCALE` value in `System.Settings`).

Choose Scalable Drawables

Classic bitmaps – PNG, JPG, GIF – are not intrinsically scalable. If you are not running in "compatibility mode", Android will not even try to scale them for you based on screen resolution and size. Whatever size of bitmap you supply is the size it will be, even if that makes the image too large or too small on some screens.

One way to address this is to try to avoid static bitmaps, using nine-patch bitmaps and XML-defined drawables (e.g., `GradientDrawable`) as alternatives. A nine-patch bitmap is a PNG file specially encoded to have rules indicating how that image can be stretched to take up more space. XML-defined drawables use a quasi-SVG XML language to define shapes, their strokes and fills, and so on.

Tailor Made, Just For You (And You, And You, And...)

There will be times, though, when you want to have different looks or behaviors based upon screen size or density. Android has ways for you to switch out resources or code blocks based on the environment in which your application runs. When properly used in combination with the above techniques, achieving screen size- and density-independence is eminently possible, at least for devices running Android 1.6 and newer.

<supports-screens>

The first step to proactively supporting screen sizes is to add the `<supports-screens>` element to your `AndroidManifest.xml` file. This specifies which screen sizes you explicitly support and which you do not. Those that you do not will be handled by the automatic "compatibility mode" described previously.

Here is a manifest containing a `<supports-screens>` element:

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.commonsware.android.eu4you"
  android:versionCode="1"
  android:versionName="1.0">
  <supports-screens
    android:largeScreens="true"
    android:normalScreens="true"
    android:smallScreens="true"
    android:anyDensity="true"
  />
  <application android:label="@string/app_name"
    android:icon="@drawable/cw">
    <activity android:name=".EU4You"
              android:label="@string/app_name">
      <intent-filter>
        <action android:name="android.intent.action.MAIN" />
        <category android:name="android.intent.category.LAUNCHER" />
      </intent-filter>
    </activity>
  </application>
</manifest>
```

Three of these attributes are almost self-explanatory: `android:smallScreens`, `android:normalScreens`, and `android:largeScreens` each take a boolean value indicating if your application explicitly supports those screens (`true`) or requires "compatibility mode" assistance (`false`).

The `android:anyDensity` attribute indicates whether you are taking density into account in your calculations (`true`) or not (`false`). If `false`, Android will pretend as though all of your dimensions (e.g., `4px`) are for a normal-density (160dpi) screen. If your application is running on a screen with lower or higher density, Android will scale your dimensions accordingly. If you indicate that `android:anyDensity = "true"`, you are telling Android not to do

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that, putting the onus on you to use density-independent units, such as `dip`, `mm`, or `in`.

Resources and Resource Sets

The primary way to "toggle" different things based on screen size or density is to create resource sets. By creating resource sets that are specific to different device characteristics, you teach Android how to render each, with Android switching among those sets automatically.

Default Scaling

By default, Android will scale all drawable resources. Those that are intrinsically scalable, as described in the previous section, will scale nicely. Ordinary bitmaps will be scaled just using a normal scaling algorithm, which may or may not give you great results. It also may slow things down a bit. If you wish to avoid this, you will need to set up separate resource sets containing your non-scalable bitmaps.

Density-Based Sets

If you wish to have different layouts, dimensions, or the like based upon different screen densities, you can use the `-ldpi`, `-mdpi`, and `-hdpi` resource set labels. For example, `res/values-hdpi/dimens.xml` would contain dimensions used in high-density devices.

Note that there is a bug in Android 1.5 (API level 3) when it comes to working with these screen density resource sets. Even though all Android 1.5 devices are medium density, Android 1.5 might pick one of the other densities by accident. So long as you are aiming to support Android 1.5 and use screen density resource sets, you will need to clone the contents of your `-mdpi` set, with the clone named `-mdpi-v3`. This "version-based set" is described in greater detail a bit later in this section.

Size-Based Sets

Similarly, if you wish to have different resource sets based upon screen size, Android offers `-small`, `-normal`, and `-large` resource set labels. Creating `res/layout-large-land/` would indicate layouts to use on large screens (e.g., WVGA) in landscape orientation.

Version-Based Sets

There may be times when earlier versions of Android get confused by newer resource set labels. To help with that, you can include a version label to your resource set, of the form `-vN`, where `N` is an API level. Hence, `res/drawable-large-v4/` indicates these drawables should be used on large screens at API level 4 (Android 1.6) and newer.

So, if you find that Android 1.5 emulators or devices are grabbing the wrong resource sets, consider adding `-v4` to their resource set names to filter them out.

Finding Your Size

If you need to take different actions in your Java code based on screen size or density, you have a few options.

If there is something distinctive in your resource sets, you can "sniff" on that and branch accordingly in your code. For example, as will be seen in the code sample at the end of this chapter, you can have extra widgets in some layouts (e.g., `res/layout-large/main.xml`) – simply seeing if an extra widget exists will tell you if you are running a "large" screen or not.

You can also find out your screen size class via a `Configuration` object, typically obtained by an `Activity` via `getResources().getConfiguration()`. A `Configuration` object has a public field named `screenLayout` that is a bitmask indicating the type of screen the application is running on. You can test to see if your screen is small, normal, or large, or if it is "long" or not (where

"long" indicates a 16:9 or similar aspect ratio, compared to 4:3). For example, here we test to see if we are running on a large screen:

```
if (getResources().getConfiguration().screenLayout
      & Configuration.SCREENLAYOUT_SIZE_LARGE)
    ==Configuration.SCREENLAYOUT_SIZE_LARGE) {
 // yes, we are large
}
else {
 // no, we are not
}
```

Similarly, you can find out your screen density, or the exact number of pixels in your screen size, using the `DisplayMetrics` class.

Ain't Nothing Like the Real Thing

The Android emulators will help you test your application on different screen sizes. However, that will only get you so far, because mobile device LCDs have different characteristics than your desktop or notebook, such as:

- Mobile device LCDs may have a much higher density than does your development machine

- A mouse allows for much more precise "touchscreen" input than does an actual fingertip

Where possible, you are going to need to either use the emulator in new and exciting ways, or try to get your hands on actual devices with alternative screen resolutions.

Density Differs

The Motorola DROID has a 240dpi, 3.7-inch, 480x854 pixel screen.

To emulate a DROID screen, based on pixel count, takes up one third of a 19" 1280x1024 LCD monitor, because the LCD monitor's density is much lower than that of the DROID – around 96dpi. So, when you fire up your

Android emulator for an FWVGA display like that of the DROID, you will get a massive emulator window.

This is still perfectly fine for determining the overall look of your application in an FWVGA environment. Regardless of density, widgets will still align the same, sizes will have the same relationships (e.g., Widget A might be twice as tall as Widget B, and that will be true regardless of density), and so on.

However:

- Things that might appear to be a suitable size when viewed on a 19" LCD may be entirely too small on a mobile device screen of the same resolution
- Things that you can easily click upon in the emulator with a mouse may be much too small to pick out on a physically smaller and denser screen when used with a finger

Adjusting the Density

By default, the emulator will keep the pixel count accurate at the expense of density, which is why you get the really big emulator window. You do have an option, though, of having the emulator keep the density accurate at the expense of pixel count.

The easiest way to do this is to use the new Android AVD Manager, introduced in Android 1.6. The Android 2.0 edition of this tool has a "Launch Options" dialog that pops up when you go to start an emulator instance via the Start... button:
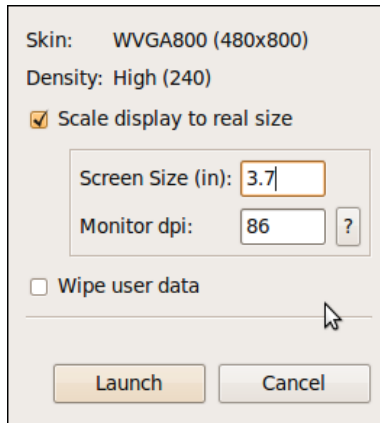
Figure 120. The Launch Options dialog

By default, the "Scale display to real size" checkbox is unchecked, and Android will open the emulator window normally. You can, however, check that checkbox and then provide two bits of scaling information:

1. The screen size of the device you wish to emulate, in inches (e.g., 3.7 inches for the Motorola DROID)

2. The dpi of your monitor – click the ? button to bring up a calculator to help you determine what your dpi value is

This will give you an emulator window that more accurately depicts what your user interface will look like on a physical device, at least in terms of sizes. However, since the emulator is using far fewer pixels than will a device, fonts may be difficult to read, images may be blocky, etc.

Accessing Actual Devices

Of course, the best possible way to see what your application looks like on different devices is to actually test it on different devices. You do not necessarily have to get every Android device ever made, but you may want to have access to ones with distinctive hardware that impacts your application...and screen size impacts just about everyone.

You can virtually test devices using services like DeviceAnywhere. This is an improvement over the emulator, but it is not free and certainly cannot test everything (e.g., changes in location).

You can purchase devices, perhaps through back channels like eBay. Unlocked GSM phones can readily share a SIM when you need to test telephony operations or go SIM-less otherwise.

If you live in or near a city, it may be you can set up some form of user group and use that group for testing applications on your collective set of hardware.

You can also always take the user-testing route, releasing your application as a free beta or something, then letting user feedback guide adjustments. You may wish to distribute this outside of the Android Market, lest beta test feedback harm your application's market rating.

Some device manufacturers, such as SonyEricsson, are starting to offer device loaner programs.

Ruthlessly Exploiting the Situation

So far, we have focused on how you can ensure your layouts look decent on other screen sizes. And, for smaller screens than the norm (e.g., QVGA), that is perhaps all you can ask for.

Once we get into larger screens, though, another possibility emerges: using different layouts designed to take advantage of the extra screen space. This is particularly useful when the physical screen size is larger (e.g., a 5" LCD like on the Dell Streak Android tablet, a 7" LCD like on the Samsung Galaxy Tab), rather than simply having more pixels in the same physical space.

Here are some ways you might take advantage of additional space:

Replace Menus with Buttons

An option menu selection requires two physical actions: press the MENU button, then tap on the appropriate menu choice. A context menu selection requires two physical actions as well: long-tap on the widget, then tap on the menu choice. Context menus have the additional problem of being effectively invisible – users may not realize that your `ListView`, for example, has a context menu.

You might consider augmenting your user interface to provide direct on-screen ways of accomplishing things that might otherwise be hidden away on a menu. Not only does this reduce the number of steps a user needs to take to do things, but it makes those options more obvious.

For example, let us suppose you are creating a media player application, and you want to offer manual playlist management. You have an activity that displays the songs in a playlist in a `ListView`. On an option menu, you have an "add" choice, to add a new song from the ones on the device to the playlist. On a context menu on the `ListView`, you have a "remove" choice, plus "move up" and "move down" choices to reorder the songs in the list. On a large screen, though, you might consider adding four `ImageButton` widgets to your UI for these four options, with the three from the context menu enabled only when a row is selected by the D-pad or trackball. On regular or small screens, you would stick with just using the menus.

Replace Tabs with a Simple Activity

You may have introduced a `TabHost` into your UI to allow you to display more widgets in the available screen space. So long as the widget space you "save" by moving them to a separate tab is more than the space taken up by the tabs themselves, you win. However, having multiple tabs means more user steps to navigate your UI, particularly if they need to flip back and forth between tabs frequently.

If you only have two tabs, consider changing your UI to offer a large-screen layout that removes the tabs and puts all the widgets on one screen. This

puts everything in front of the user, without having to switch tabs all the time.

If you have three or more tabs, you probably will lack screen space to put all those tabs' contents on one activity. However, you might consider going half-and-half: have popular widgets be on the activity all of the time, leaving your TabHost to handle the rest on (roughly) half of the screen.

Consolidate Multiple Activities

The most powerful technique is to use a larger screen to get rid of activity transitions outright. For example, if you have a ListActivity where clicking on an item brings up that item's details in a separate activity, consider supporting a large-screen layout where the details are on the same activity as the ListView (e.g., ListView on the left, details on the right, in a landscape layout). This eliminates the user having to constantly press the BACK button to leave one set of details before viewing another.

We will see this technique applied in the sample code presented in the following section.

Example: EU4You

To examine how to use some of these techniques, let us look at the ScreenSizes/EU4You sample application. This application has one activity (EU4You) that contains a ListView with the roster of European Union members and their respective flags. Clicking on one of the countries brings up the mobile Wikipedia page for that country.

In the source code to this book, you will find four versions of this application, as we start with an application that is ignorant of screen size and slowly add in more screen-related features.

The First Cut

First, here is our `AndroidManifest.xml` file, which looks distinctly like one shown earlier in this chapter:

```xml
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
  package="com.commonsware.android.eu4you"
  android:versionCode="1"
  android:versionName="1.0">
  <supports-screens
    android:largeScreens="true"
    android:normalScreens="true"
    android:smallScreens="true"
    android:anyDensity="true"
  />
  <application android:label="@string/app_name"
    android:icon="@drawable/cw">
    <activity android:name=".EU4You"
              android:label="@string/app_name">
      <intent-filter>
        <action android:name="android.intent.action.MAIN" />
        <category android:name="android.intent.category.LAUNCHER" />
      </intent-filter>
    </activity>
  </application>
</manifest>
```

You will note we have the `<supports-screens>` element, saying that we indeed do support all screen sizes. This blocks most of the automatic scaling that Android would do if we said we did not support certain screen sizes.

Our main layout is size-independent, as it is just a full-screen `ListView`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<ListView xmlns:android="http://schemas.android.com/apk/res/android"
  android:id="@android:id/list"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
/>
```

Our row, though, will eventually need some tweaking:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
```

```
  android:layout_width="fill_parent"
  android:layout_height="wrap_content"
  android:padding="2dip"
  android:minHeight="?android:attr/listPreferredItemHeight"
>
  <ImageView android:id="@+id/flag"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_gravity="center_vertical|left"
    android:paddingRight="4px"
  />
  <TextView android:id="@+id/name"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_gravity="center_vertical|right"
    android:textSize="20px"
  />
</LinearLayout>
```

For example, right now, our font size is set to be 20px, which will not vary by screen size or density.

Our EU4You activity is a bit verbose, mostly because there are a lot of EU members, and we have to have the smarts to display the flag and the text in the row:

```
package com.commonsware.android.eu4you;

import android.app.ListActivity;
import android.content.Intent;
import android.net.Uri;
import android.os.Bundle;
import android.view.View;
import android.view.ViewGroup;
import android.widget.ArrayAdapter;
import android.widget.ImageView;
import android.widget.ListView;
import android.widget.TextView;
import java.util.ArrayList;

public class EU4You extends ListActivity {
  static private ArrayList<Country> EU=new ArrayList<Country>();

  static {
    EU.add(new Country(R.string.austria, R.drawable.austria,
                       R.string.austria_url));
    EU.add(new Country(R.string.belgium, R.drawable.belgium,
                       R.string.belgium_url));
    EU.add(new Country(R.string.bulgaria, R.drawable.bulgaria,
                       R.string.bulgaria_url));
```

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```
    EU.add(new Country(R.string.cyprus, R.drawable.cyprus,
                   R.string.cyprus_url));
    EU.add(new Country(R.string.czech_republic,
                   R.drawable.czech_republic,
                   R.string.czech_republic_url));
    EU.add(new Country(R.string.denmark, R.drawable.denmark,
                   R.string.denmark_url));
    EU.add(new Country(R.string.estonia, R.drawable.estonia,
                   R.string.estonia_url));
    EU.add(new Country(R.string.finland, R.drawable.finland,
                   R.string.finland_url));
    EU.add(new Country(R.string.france, R.drawable.france,
                   R.string.france_url));
    EU.add(new Country(R.string.germany, R.drawable.germany,
                   R.string.germany_url));
    EU.add(new Country(R.string.greece, R.drawable.greece,
                   R.string.greece_url));
    EU.add(new Country(R.string.hungary, R.drawable.hungary,
                   R.string.hungary_url));
    EU.add(new Country(R.string.ireland, R.drawable.ireland,
                   R.string.ireland_url));
    EU.add(new Country(R.string.italy, R.drawable.italy,
                   R.string.italy_url));
    EU.add(new Country(R.string.latvia, R.drawable.latvia,
                   R.string.latvia_url));
    EU.add(new Country(R.string.lithuania, R.drawable.lithuania,
                   R.string.lithuania_url));
    EU.add(new Country(R.string.luxembourg, R.drawable.luxembourg,
                   R.string.luxembourg_url));
    EU.add(new Country(R.string.malta, R.drawable.malta,
                   R.string.malta_url));
    EU.add(new Country(R.string.netherlands, R.drawable.netherlands,
                   R.string.netherlands_url));
    EU.add(new Country(R.string.poland, R.drawable.poland,
                   R.string.poland_url));
    EU.add(new Country(R.string.portugal, R.drawable.portugal,
                   R.string.portugal_url));
    EU.add(new Country(R.string.romania, R.drawable.romania,
                   R.string.romania_url));
    EU.add(new Country(R.string.slovakia, R.drawable.slovakia,
                   R.string.slovakia_url));
    EU.add(new Country(R.string.slovenia, R.drawable.slovenia,
                   R.string.slovenia_url));
    EU.add(new Country(R.string.spain, R.drawable.spain,
                   R.string.spain_url));
    EU.add(new Country(R.string.sweden, R.drawable.sweden,
                   R.string.sweden_url));
    EU.add(new Country(R.string.united_kingdom,
                   R.drawable.united_kingdom,
                   R.string.united_kingdom_url));
  }

  @Override
  public void onCreate(Bundle savedInstanceState) {
```

```
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);
    setListAdapter(new CountryAdapter());
}

@Override
protected void onListItemClick(ListView l, View v,
                               int position, long id) {
    startActivity(new Intent(Intent.ACTION_VIEW,
                        Uri.parse(getString(EU.get(position).url))));
}

static class Country {
    int name;
    int flag;
    int url;

    Country(int name, int flag, int url) {
        this.name=name;
        this.flag=flag;
        this.url=url;
    }
}

class CountryAdapter extends ArrayAdapter<Country> {
    CountryAdapter() {
        super(EU4You.this, R.layout.row, R.id.name, EU);
    }

    @Override
    public View getView(int position, View convertView,
                        ViewGroup parent) {
        CountryWrapper wrapper=null;

        if (convertView==null) {
            convertView=getLayoutInflater().inflate(R.layout.row, null);
            wrapper=new CountryWrapper(convertView);
            convertView.setTag(wrapper);
        }
        else {
            wrapper=(CountryWrapper)convertView.getTag();
        }

        wrapper.populateFrom(getItem(position));

        return(convertView);
    }
}

class CountryWrapper {
    private TextView name=null;
    private ImageView flag=null;
    private View row=null;
```

```
    CountryWrapper(View row) {
      this.row=row;
    }

    TextView getName() {
      if (name==null) {
        name=(TextView)row.findViewById(R.id.name);
      }

      return(name);
    }

    ImageView getFlag() {
      if (flag==null) {
        flag=(ImageView)row.findViewById(R.id.flag);
      }

      return(flag);
    }

    void populateFrom(Country nation) {
      getName().setText(nation.name);
      getFlag().setImageResource(nation.flag);
    }
  }
}
```

Here is what the activity looks like in an ordinary HVGA emulator:
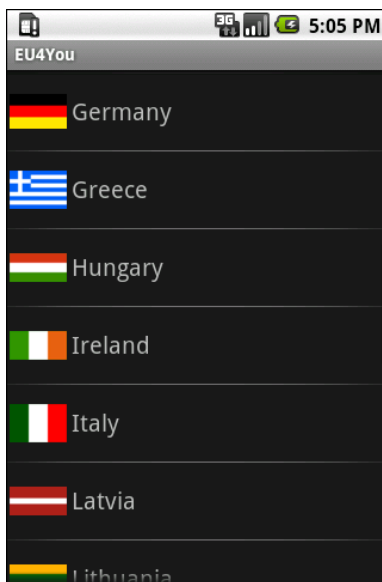
Figure 121. EU4You, original version, HVGA

Here is what the activity looks like in a WVGA emulator:
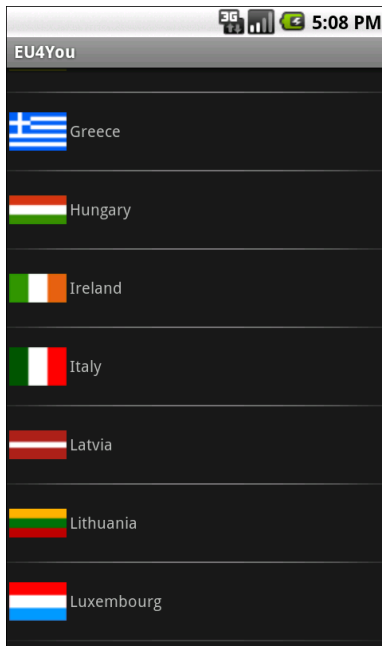
Figure 122. EU4You, original version, WVGA (800x480 pixels)

And, here is what it looks like in a QVGA screen:
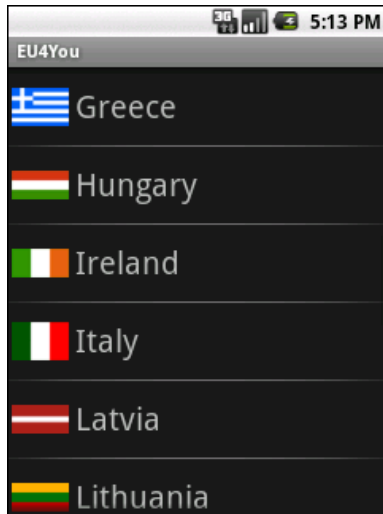
Figure 123. EU4You, original version, QVGA

Fixing the Fonts

The first problem that should be fixed is the font size. As you can see, with a fixed 20px size, the font ranges from big to tiny, depending on screen size and density. For a WVGA screen, the font may be rather difficult to read.

We could put the dimension as a resource (res/values/dimens.xml) and have different versions of that resource based upon screen size or density. However, it is simpler to just specify a density-independent size, such as 5mm, as seen in the ScreenSizes/EU4You_2 project:

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="wrap_content"
  android:padding="2dip"
  android:minHeight="?android:attr/listPreferredItemHeight"
>
  <ImageView android:id="@+id/flag"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_gravity="center_vertical|left"
    android:paddingRight="4px"
  />
  <TextView android:id="@+id/name"
    android:layout_width="wrap_content"
```

```
    android:layout_height="wrap_content"
    android:layout_gravity="center_vertical|right"
    android:textSize="5mm"
  />
</LinearLayout>
```

Here is what the new activity looks like in HVGA:
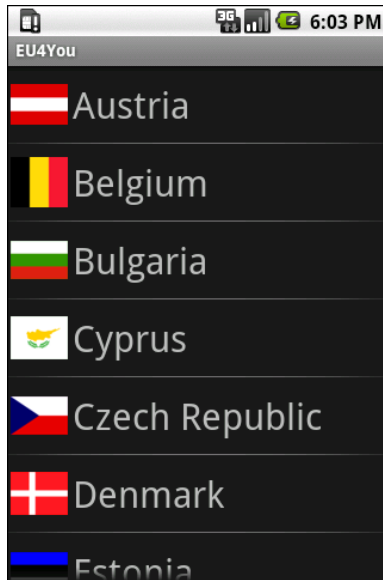
Figure 124. EU4You, 5mm font version, HVGA

...and WVGA:
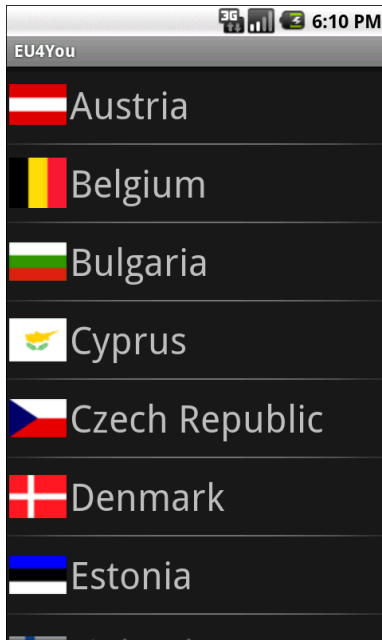
Figure 125. EU4You, 5mm font version, WVGA (800x480 pixels)

....and QVGA:
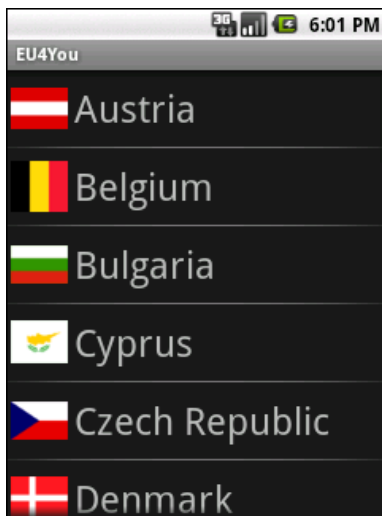
Figure 126. EU4You, 5mm font version, QVGA

Now our font is a consistent size, and large enough to match the flags.

Fixing the Icons

So, what about those icons? By rights, they should be varying in size as well, since they are the same for all three emulators.

However, Android automatically scales bitmap resources, even with `<supports-screens>` and its attributes set to `true`. On the plus side, this means you may not have to do anything with these bitmaps. However, you are relying upon a device to do the scaling, which definitely costs CPU time (and, hence, battery life). Also, the scaling algorithms that the device uses may not be optimal, compared to what you can do with graphics tools on your development machine.

The `ScreenSizes/EU4You_3` project creates `res/drawable-ldpi` and `res/drawable-hdpi`, putting in smaller and larger renditions of the flags, respectively. This project also renames `res/drawable` to `res/drawable-mdpi`. Android will use the flags for the appropriate screen density, depending on what the device or emulator needs.

This effect is subtle in this case and will not really show up well in this book.

Using the Space

While the activity looks fine on WVGA in portrait mode, it really wastes a lot of space in landscape mode:
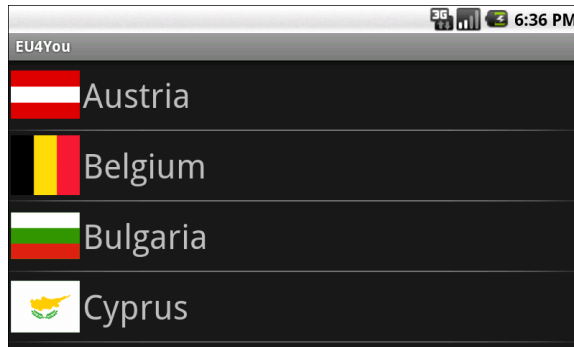
Figure 127. EU4You, landscape WVGA (800x480 pixels)

We can put that to better use by having the Wikipedia content appear right on the main activity when in large-screen landscape mode, instead of having to spawn a separate Browser activity.

To do this, we first must clone the `main.xml` layout into a `res/layout-large-land` rendition that incorporates a `WebView` widget, as seen in ScreenSizes/EU4You_4:

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
  android:layout_width="fill_parent"
  android:layout_height="fill_parent"
>
  <ListView
    android:id="@android:id/list"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_weight="1"
  />
  <WebView
    android:id="@+id/browser"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:layout_weight="1"
  />
</LinearLayout>
```

Then, we need to adjust our activity to look for that `WebView` and use it when found, defaulting to launching a Browser activity otherwise:

```
@Override
public void onCreate(Bundle savedInstanceState) {
```

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```
  super.onCreate(savedInstanceState);
  setContentView(R.layout.main);

  browser=(WebView)findViewById(R.id.browser);

  setListAdapter(new CountryAdapter());
}

@Override
protected void onListItemClick(ListView l, View v,
                               int position, long id) {
  String url=getString(EU.get(position).url);

  if (browser==null) {
    startActivity(new Intent(Intent.ACTION_VIEW,
                             Uri.parse(url)));
  }
  else {
    browser.loadUrl(url);
  }
}
```

This gives us a more space-efficient edition of the activity:
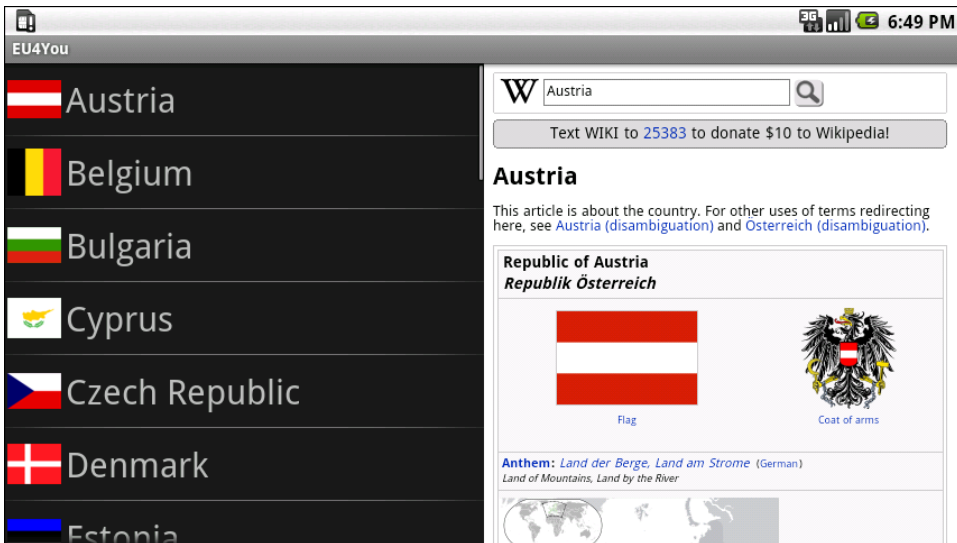
Figure 128. EU4You, landscape WVGA (800x480 pixels), set for normal density, and showing the embedded WebView

Of course, if the user clicks a link in the Wikipedia page, that will open up the full Browser, for easier surfing.

Note that testing this version of the activity, to see this behavior, requires a bit of extra emulator work. By default, Android sets up WVGA devices as being high-density, meaning WVGA is not large in terms of resource sets, but rather `normal`. You will need to create a different emulator AVD that is set for normal (`medium`) density, which will result in a `large` screen size.

What If It Is Not a Browser?

Of course, EU4You does cheat a bit. The second activity is a Browser (or `WebView` in the embedded form), not some activity of your own creation. Things get slightly more complicated if the second activity is some activity of yours, with many widgets in a layout, and you want to use it both as an activity (for smaller screens) and have it embedded in your main activity UI (for larger screens).

Here is one pattern to deal with this scenario:

1. Initially develop and test the second activity as an activity

2. Have all of the second activity's lifecycle methods delegate their logic to an inner class, and move all data members of the activity that are only needed by the inner class to that inner class, and ensure that still works

3. Pull the inner class out into a separate public class, and ensure that still works

4. For your first (or main) activity, create a separate layout for large screens and use the <include> directive to blend in the contents of your second activity's layout into the proper spot in the large-screen first activity's layout

5. In the first activity, if it finds the second activity's layout has been inflated as part of its own (e.g., by checking for the existence of some widget via `findViewById()`), create an instance of the public class you created in step #3 above and have it deal with all of those widgets, and adjust your code to reference that class directly rather than start the second activity as shown in the previous section above

In short, use a public class and reusable layout to keep your code and resources in one place, yet use them from both a standalone activity and as part of a large-screen version of the main activity.

Dealing With Devices

Android is "free as in beer" for device manufacturers, as it is an open source project. Hence, device manufacturers have *carte blanche* to do what they want with Android as they put it on their devices. This means a breadth of choices for device users, who will be able to have Android devices in all shapes, sizes, and colors. This also means developers will have some device differences and idiosyncrasies to take into account.

This chapter will give you some tips and advice for dealing with these device-specific issues, to go along with the screen size material from the previous chapter.

This App Contains Explicit...Instructions

Originally, the only Android device was the T-Mobile G1. Hence, if you were writing an Android application, you could assume the existence of a hardware QWERTY keyboard, a trackball for navigation, and so on. Now, though, other devices exist with different hardware capabilities (e.g., no keyboard).

Ideally, your application can work regardless of the existence of various types of hardware. Some applications, though, will be unusable without certain hardware characteristics. For example, a full-screen game may rely upon a hardware keyboard or trackball to indicate player actions – soft keyboards and touchscreens may be insufficient.

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Fortunately, starting with Android 1.5, you can now add explicit instructions, telling Android what you need, so your application is not installed on devices lacking such hardware.

In addition to using the target ID system to indicate what level of device your project is targeting, you can use a new `AndroidManifest.xml` element to specify hardware that is required for your application to run properly. You can add one or more `<uses-configuration>` elements inside the `<manifest>` element. Each `<uses-configuration>` element specifies one valid configuration of hardware that your application will work with. At the present time, there are five possible hardware requirements you can specify this way:

- `android:reqFiveWayNav` to indicate you need a 5-way navigation pointing device of some form (e.g, `android:reqFiveWayNav = "true"`)

- `android:reqNavigation` to restrict the 5-way navigation pointing device to a specific type (e.g, `android:reqNavigation = "trackball"`)

- `android:reqHardKeyboard` to specify if a hardware (physical) keyboard is required (e.g, `android:reqHardKeyboard = "true"`)

- `android:reqKeyboardType`, probably used in conjunction with `android:reqHardKeyboard`, to indicate a specific type of hardware keyboard that is required (e.g, `android:reqKeyboardType = "qwerty"`)

- `android:reqTouchScreen` to indicate what type of touchscreen is required, if any (e.g, `android:reqTouchScreen = "finger"`)

Starting in Android 1.6, there is a similar manifest element, `<uses-feature>`, which is designed to document requirements an application has of other optional features on Android devices. Specifically, the following attributes can be placed in a `<uses-feature>` element:

- `android:glEsVersion` indicates that your application requires OpenGL, where the value of the attribute indicates what level of OpenGL support (e.g., `0x00010002` for OpenGL 1.2 or higher)

- `android:name = "android.hardware.camera"` indicates that your application needs a camera, while `android:name =`

`"android.hardware.camera.autofocus"` indicates that your application specifically needs an auto-focus camera

Button, Button, Who's Got the Button?

There are few, if any, requirements on device manufacturers as to what buttons are available as physical buttons, versus on-screen "soft keys", versus simply not being available on a given Android device.

For example, the HTC Dream (a.k.a., T-Mobile G1) has call, end-call, home, back, menu, and camera buttons, along with a volume control and a dedicated search button on its QWERTY keyboard. The HTC Magic (a.k.a., T-Mobile myTouch 3G) lacks the camera button, putting the search button in its place. The ARCHOS 5 Android Internet Tablet has no hardware buttons at all beyond the volume control, with soft keys for home, back, and menu.

As such, you should be careful about assuming the existence or placement of hardware buttons. Provide alternative means of performing operations that you tie to buttons. For example, if you override the volume control to serve as page-up/page-down keys, make sure there is some other way for the user to move between pages.

A Guaranteed Market

As mentioned in the introduction to the chapter, Android is open source. Specifically, it is mostly available under the Apache Software License 2.0. This license places few restrictions on device manufacturers. Therefore, it is very possible for a device manufacturer to create a device that, frankly, does not run Android very well. It might work fine for standard applications shipped on the device but do a poor job of handling third-party applications, like the ones you might write.

To help address this, Google has some applications, such as the Android Market, that it has not released as open source. While these applications are available to device manufacturers, the devices that run the Android

Market are tested first, to help ensure that a user's experience with the device will be reasonable.

A Google engineer cited one case where a device manufacturer was readying a phone that had a QVGA screen, before the release of Android 1.6 where QVGA support was officially added to the platform. While that manufacturer had arranged for the built-in applications to work acceptably on the smaller-resolution screen, third party applications were a mess. Google apparently declined to provide the Android Market to the manufacturer for this device.

Hence, the existence of the Android Market on a device, beyond providing a distribution means for your applications, also serves as a bit of a "seal of approval" that the device should support well-written third-party applications.

The Down and Dirty Details

Unfortunately, the Android Market neither guarantees problem-free deployment on Market-enabled devices, nor does it prevent manufacturers from shipping Android devices sans the Market. Inevitably, devices will have some quirks or idiosyncrasies that might impact your applications. Here is a selection of some Android devices, in the order of their public availability, and ways that they differ from more standard devices.

ARCHOS 5 Android Internet Tablet

The ARCHOS 5 Android Internet Tablet is the first mainstream device to be built purely off of the Android open source project. Unlike the phones from HTC, Motorola, and others, the ARCHOS 5 is not a "Google Experience" device and does not have the Android Market, Google Maps, or other proprietary Google applications

The ARCHOS 5 is a WVGA device, but shipped with Android 1.5. Hence, an original ARCHOS 5 will not honor the new `-large` resource set designation as documented previously. Given that this device is not selling in major

quantities, you may wind up with it simply having an unoptimized UI until the ARCHOS 5 has Android 1.6 support.

The ARCHOS 5's touchscreen is resistive, not capacitive. This means users will be using fingernails or styli to manipulate the screen, more so than fingertips. Bear this in mind when designing "finger-friendly" user interfaces.

The ARCHOS 5, as of firmware 1.1.01, returned a somewhat invalid value for ANDROID_ID (a unique ID assigned to each Android device). ANDROID_ID is null in the emulator and is supposed to be a hex string in devices. On the ARCHOS 5, ANDROID_ID is a non-null but non-hex string. If all you care about is null versus non-null, then the ARCHOS 5 is fine; if you need a hex value for ANDROID_ID, you will experience some problems.

Since the ARCHOS 5 is not a phone, all telephony related features, such as dialing via ACTION_DIAL, are unavailable. Similarly, since the ARCHOS 5 lacks a camera, all camera-related features are unavailable. Also, the ARCHOS 5 lacks Google Maps, the Android Market, and other proprietary Google applications.

Also, the ARCHOS IMEI value is fake, since it is not a phone.

Motorola CLIQ/DEXT

The Motorola CLIQ (or DEXT, as it is known outside of the United States) is an HVGA device, originally shipping with Android 1.5.

The CLIQ has a directional pad (D-pad) for non-touchscreen navigation. However, the D-pad is on a side-slider QWERTY keyboard, and as such, the D-pad is not available to users when the device is in portrait mode, unless you force portrait mode for your activity via the manifest and force users to use their CLIQ with the keyboard slid out. Do not write applications that assume the D-pad is always available!

The CLIQ also ships with MOTOBLUR, Motorola's social media presentation layer. This means that the home application, contacts, and select other features that Android normally ships with have been replaced by MOTOBLUR-specific replacements. This should not cause too many problems if you stick to the SDK. The one area that does get a bit interesting is that not all MOTOBLUR contacts will be available to you via the Android Contacts content provider. For example, Facebook contacts are available to MOTOBLUR but not to third-party applications, perhaps for licensing reasons. This situation may change when the CLIQ is updated to the new `ContactsContract` system with Android 2.0.1 and beyond.

Motorola DROID/Milestone

The Motorola DROID (or Milestone, as it is known outside of the United States) is a WVGA854 device, originally shipping with Android 2.0, though most of these devices will now be running Android 2.0.1.

The DROID, like the CLIQ, has a D-pad on the side-slider keyboard, meaning the D-pad is not readily available to users when the device is in portrait mode.

Because the DROID has a WVGA854 screen on a normal phone-sized device, Android will consider the DROID to have a high-density screen, so `-hdpi` resource sets will be used.

Google/HTC Nexus One

The Nexus One – built by HTC, sold by Google – is a WVGA800 device, originally shipping with Android 2.1.

Like the DROID, the Nexus One will be a high-density (`-hdpi`) device.

Motorola BACKFLIP

The not-yet-released Motorola BACKFLIP has yet another take on pointing devices. Rather than a trackball or a D-pad, the BACKFLIP has two non-touchscreen navigation options:

1. The QWERTY keyboard has PC-style arrow keys, which should generate standard DPAD key events

2. The BACKFLIP touchpad on the reverse side of the touchscreen, which will generate trackball events (or DPAD key events, if the trackball events are not consumed)

Handling Platform Changes

Android is going to undergo rapid evolution over the next few years. Perhaps, in time, the rate of change will decline some. However, for the here and now, you have to assume significant Android releases every 6-12 months, and changes to the lineup of possible Android hardware on an ongoing basis. So, while right now, the focus of Android is phones, soon you will see Android netbooks, Android tablets, Android media players, and so on.

Many of these changes will have little impact on your existing code. Some, though, will necessitate at least new rounds of testing for your applications, and perhaps changes to those applications based upon the test results.

In this chapter, we cover a number of the areas which may cause you trouble in the future as Android evolves, and how to deal with them.

Brand Management

As of the time of this writing, the Android devices that have been released have been "Google experience" phones. This means they get the standard Android interface – the things you find in the emulator – along with the standard roster of add-on applications like Google Maps and GMail. In turn, manufacturers are allowed to put the "with Google" brand on the device.

Not all devices will be this way.

Some manufacturers will take Android as a base and change up what is included, adding some of their own applications, perhaps even changing the look-and-feel (menu icons, home screen structure, etc.).

Others may use Android solely from the open source repository, and while they may ship with the standard look-and-feel, they will lack the commercial add-on applications.

Even today, some devices have a different mix of applications based upon where they are distributed. US recipients of the T-Mobile G1 have an Amazon MP3 store application; not all international recipients do.

If your application is independent of all of this, then it should run anywhere. However, if your application code or documentation assumes the existence of Google Maps, GMail, Amazon MP3 store, etc., you may run into trouble. Be certain to test your application thoroughly in environments where these applications are not available.

More Things That Make You Go "Boom"

Most of the above was focused on hardware changes. Now, let us examine some ways in which Android can cause difficulty to you when the operating system itself changes.

View Hierarchy

Android is not designed to handle arbitrarily-complicated view hierarchies. Here, "view hierarchy" means containers holding containers holding containers holding widgets. The `hierarchyviewer` program, described in an earlier chapter, depicts such view hierarchies well:
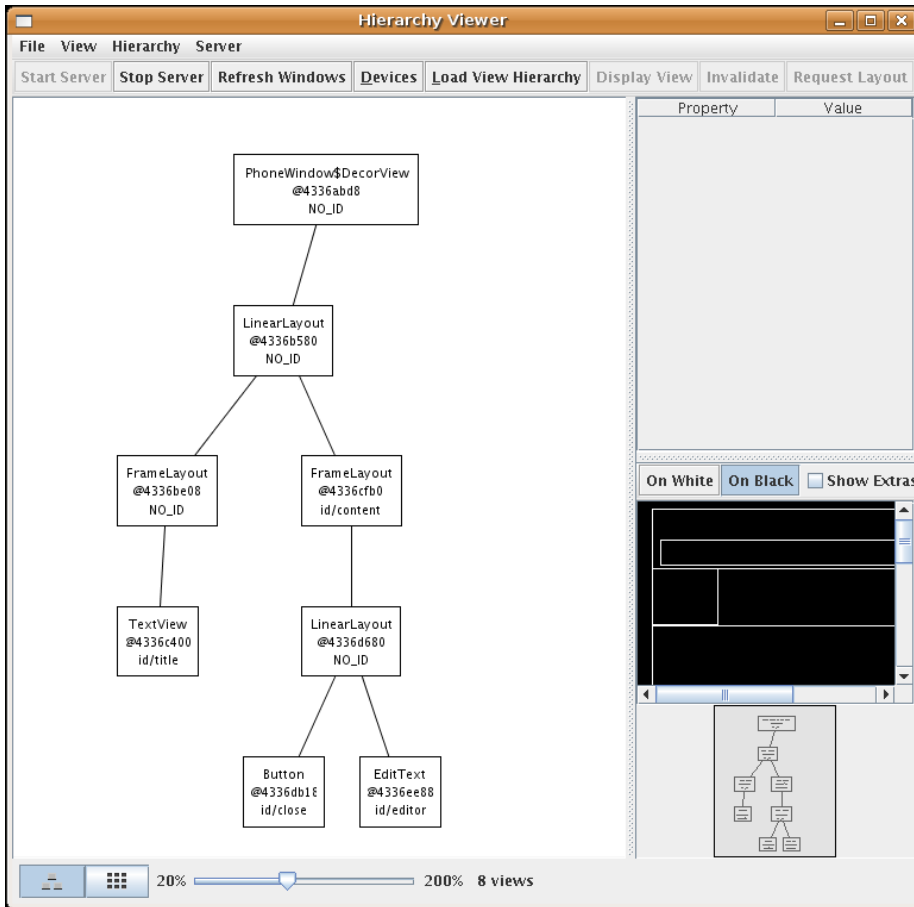
Figure 129. Hierarchy Viewer Layout View

Here, we see a five-layer-deep hierarchy, because the longest chain of containers and widgets is five (from `PhoneWindow$DecorView` through to `Button`).

Android has always had limits as to how deep the view hierarchy can be. In Android 1.5, though, the limit was reduced, so some applications that worked fine on Android 1.1 would crash with a `StackOverflowException` in the newer Android. This, of course, was frustrating to developers who never realized there was an issue with view hierarchy depth and then got caught by this change.

The lessons to take from this:

- Keep your view hierarchies shallow – once you drift into double-digit depth, you are increasingly likely to run out of stack space

- If you encounter a `StackOverflowException`, and the stack trace looks like it is somewhere in the middle of drawing your widgets, your view hierarchy is probably too complex

Changing Resources

The core Android team may change resources with an Android upgrade, and those may have unexpected effects in your application. For example, in Android 1.5, they changed the stock `Button` background, to allow for smaller buttons. However, applications that implicitly relied upon the former larger minimum size wound up "breaking" and needing some UI adjustment.

Similarly, applications can reuse public resources, such as icons, available inside of Android proper. While doing so saves some storage space, many of these resources are public by necessity and are not considered part of the SDK. For example, hardware manufacturers may change the icons to fit some alternative UI look-and-feel. Relying upon the existing ones to always look as they do is a bit dangerous. You are better served copying those resources out of the Android open source project into your own code base.

Handling API Changes

The core Android team has generally done a good job of keeping APIs stable, and supporting a deprecation model where they change APIs. In Android, being deprecated does not mean it is going away, just that its continued use is discouraged. And, of course, new APIs are released with every new Android update. Changes to the APIs are well-documented with each release via an API differences report.

Unfortunately, the Android Market – the primary distribution channel for Android applications – only allows you to upload one APK for each application. Hence, you need that one APK to deal with as many Android

versions as possible. Many times, your code will "just work" and not require changing. Other times, though, you will need to make adjustments, particularly if you want to support new APIs on new versions while not breaking on old versions. Let us examine some techniques for handling these cases.

Minimum, Maximum, Target, and Build Versions

Android goes to great lengths to help you deal with the fact that at any point in time, there will be many Android OS versions out on the market. Unfortunately, the tools supplied by Android have given us a somewhat confusing set of overlapping concepts, such as targets and SDK versions. This section will attempt to explain a bit more about what is all going on here.

Targets versus SDK Versions versus OS Versions

Way back towards the beginning of this book, we introduced the concept of targets. Targets are used when defining AVDs, to determine what sort of device those AVDs support. Targets are also used when creating new projects, primarily to determine what version of the SDK build tools will be used to build your project.

A target combines an API version with an indicator of whether or not the target includes Google APIs (e.g., Google Maps support).

An API version is an integer representing...well...a version of the Android API. Each Android OS release that makes changes to the Android API triggers a new API version. So, we have:

- Android 1.5r1, 1.5r2, and 1.5r3 all using API version 3

- Android 1.6r1 and 1.6r2 using API version 4

- Android 2.0 using API version 5

- Android 2.0.1 using API version 6

- Android 2.1 using API version 7

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• Android 2.2 using API version 8

Note that "Android 2.0" was used only on early versions of the Motorola DROID and Milestone and was replaced by 2.0.1 on those devices by the end of 2009. Hence, you should not see anything "in the wild" that uses API version 5 – it will either be 3, 4, or 6.

Google maintains a Web page outlining which versions of Android are in use today, based on requests made to the Android Market. At the time of this writing, only Android 1.5, 1.6, and 2.1 are being used significantly, though Android 2.2 will start to become a bit more prevalent in the next few months.

Minimum SDK Version

In your `AndroidManifest.xml` file, you should add a `<uses-sdk>` element. This element will describe how your application relates to the various SDK versions.

The most critical attribute to have in `<uses-sdk>` is `android:minSdkVersion`. This indicates what the lowest API level is that you will support. Devices running Android OS versions associated with lower API levels will not be able to install your application. Your application may not even appear to those devices in the Android Market listings, should you elect to publish via that distributor.

If you skip this attribute, Android assumes you work on *all* Android API versions. That may be true, but it is rather dangerous to assume if you have not tested it. Hence, set `android:minSdkVersion` to the lowest level you are testing and are willing to support.

Target SDK Version

Another `<uses-sdk>` attribute is `android:targetSdkVersion`. This represents the version of the Android API that you are primarily developing for. Any Android device running a newer version of the OS may elect to apply some

"compatibility settings" that will help apps like yours, targeting an older API, run on the newer version.

Most of the time, you should set this to be the then-current Android API version, as of the time you are publishing your application.

Maximum SDK Version

The third `<uses-sdk>` attribute is `android:maxSdkVersion`. Any Android device running a newer Android OS than is indicated by this API level will be prohibited from running your application.

On the plus side, this ensures that your application will not be used on API levels you have not tested, particularly if you set this to be the then-current Android API version as of your publication date.

However, bear in mind that your application may be spontaneously removed from users' devices, once they upgrade their devices to an Android OS release newer than your max level. Users may be confused and frustrated if your app vanishes. Hence, if you are going to specify `android:maxSdkVersion`, you are effectively committing yourself to quickly testing and publishing new versions for new API levels, before the newer Android OS is available to the public at large. Since Android is not known for giving much warning between SDK update and Android OS upgrade rollout, this is a dangerous proposition.

The core Android team recommends not using this option and relying upon Android's intrinsic backwards compatibility – particularly leveraging your `android:targetSdkVersion` value – to allow your application to continue to run on new Android OS versions.

Detecting the Version

If all you need to do is take different branches in your code based upon version, the easiest thing to do is inspect `android.os.Build.VERSION.SDK_INT`. This public static integer value will reflect the same API level as you use

when creating AVDs and specifying API levels in the manifest. So, you can compare that value to, say, `android.os.Build.VERSION_CODES.DONUT` to see whether you are running on Android 1.6 or newer.

Wrapping the API

So long as the APIs you try to use exist across all Android versions you are supporting, just branching may be sufficient. Where things get troublesome is when the APIs change: new parameters to methods, new methods, or even new classes. You need code that will work regardless of Android version, yet lets you take advantage of new APIs where available.

However, there is a recommended trick for dealing with this: reflection, plus a wee bit of caching.

For example, back in the chapter on fancy lists, we used `getTag()` and `setTag()` to associate an arbitrary object with a `View`. Specifically, we used this to associate a wrapper object that would lazy-find all necessary widgets. We also noted the new version of `getTag()` and `setTag()` that are "indexed", taking a resource ID as a parameter.

However, these new indexed methods do not exist on Android 1.5. If you want to use this new technique, you either need to wait until you are willing to support only Android 1.6 and beyond...or you will need to use reflection. Specifically, on Android 1.5, you could associate an `ArrayList<Object>` as the "tag" and have your own `getTag()`/`setTag()` pair that takes the index.

This seems straightforward enough, so let us look at `APIVersions/Tagger`. Our activity has a simple layout, just a `TextView`:

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:orientation="vertical"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    >
<TextView android:id="@+id/test"
```

```
      android:layout_width="fill_parent"
      android:layout_height="wrap_content"
      />
</LinearLayout>
```

The source code to our Tagger activity looks at the API version we are running and routes our getTag() and setTag() operations to either the native indexed one (for Android 1.6 and above) or to the original non-indexed getTag() and setTag(), where we use a HashMap to track all of the individual indexed objects:

```java
package com.commonsware.android.api.tag;

import android.app.Activity;
import android.os.Build;
import android.os.Bundle;
import android.util.Log;
import android.view.View;
import android.widget.TextView;
import java.util.HashMap;
import java.util.Date;

public class Tagger extends Activity {
  private static final String LOG_KEY="Tagger";

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    TextView view=(TextView)findViewById(R.id.test);

    setTag(view, R.id.test, new Date());

    view.setText(getTag(view, R.id.test).toString());
  }

  public void setTag(View v, int key, Object value) {
    if (Build.VERSION.SDK_INT>=Build.VERSION_CODES.DONUT) {
      v.setTag(key, value);
    }
    else {
      HashMap<Integer, Object> meta=(HashMap<Integer, Object>)v.getTag();

      if (meta==null) {
        meta=new HashMap<Integer, Object>();
      }

      meta.put(key, value);
    }
  }
```

```
public Object getTag(View v, int key) {
  Object result=null;

  if (Build.VERSION.SDK_INT>=Build.VERSION_CODES.DONUT) {
    result=v.getTag(key);
  }
  else {
    HashMap<Integer, Object> meta=(HashMap<Integer, Object>)v.getTag();

    if (meta==null) {
      meta=new HashMap<Integer, Object>();
    }

    result=meta.get(key);
  }

  return(result);
}
}
```

This looks great, and if we build it and deploy it on a 1.6 or greater emulator or device, it runs like a champ, showing the current time in the activity.

If we build it and deploy it on an Android 1.5 emulator or device, and try to run it, it blows up with a VerifyError. VerifyError, in this case, basically means we are referring to things that do not exist in our version of Android. Specifically:

- We are referring to SDK_INT, which was not introduced until Android 1.6

- We are referring to the indexed versions of getTag() and setTag() – even though we will not execute that code, the classloader still wants to resolve those methods and fails

So, we need to use some reflection.

Take a look at APIVersions/Tagger2. This is the same project with the same layout, but we have a more elaborate version of the Java source:

```
package com.commonsware.android.api.tag;

import android.app.Activity;
import android.os.Build;
```

```
import android.os.Bundle;
import android.util.Log;
import android.view.View;
import android.widget.TextView;
import java.lang.reflect.Method;
import java.util.HashMap;
import java.util.Date;

public class Tagger extends Activity {
  private static final String LOG_KEY="Tagger";
  private static Method _setTag=null;
  private static Method _getTag=null;

  static {
    int sdk=new Integer(Build.VERSION.SDK).intValue();

    if (sdk>=4) {
      try {
        _setTag=View.class.getMethod("setTag",
                                new Class[] {Integer.TYPE,
                                             Object.class});
        _getTag=View.class.getMethod("getTag",
                                new Class[] {Integer.TYPE});
      }
      catch (Throwable t) {
        Log.e(LOG_KEY, "Could not initialize 1.6 accessors", t);
      }
    }
  };

  @Override
  public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    TextView view=(TextView)findViewById(R.id.test);

    setTag(view, R.id.test, new Date());

    view.setText(getTag(view, R.id.test).toString());
  }

  public void setTag(View v, int key, Object value) {
    if (_setTag!=null) {
      try {
        _setTag.invoke(v, key, value);
      }
      catch (Throwable t) {
        Log.e(LOG_KEY, "Could not use 1.6 setTag()", t);
      }
    }
    else {
      HashMap<Integer, Object> meta=(HashMap<Integer, Object>)v.getTag();
```

```
    if (meta==null) {
      meta=new HashMap<Integer, Object>();
      v.setTag(meta);
    }

    meta.put(key, value);
  }
}

public Object getTag(View v, int key) {
  Object result=null;

  if (_getTag!=null) {
    try {
      result=_getTag.invoke(v, key);
    }
    catch (Throwable t) {
      Log.e(LOG_KEY, "Could not use 1.6 getTag()", t);
    }
  }
  else {
    HashMap<Integer, Object> meta=(HashMap<Integer, Object>)v.getTag();

    if (meta==null) {
      meta=new HashMap<Integer, Object>();
      v.setTag(meta);
    }

    result=meta.get(key);
  }

  return(result);
  }
}
```

First, when the class is initially loaded, the static initialization routines run. Here, we see what version of Android we are running, using the old SDK String instead of the new SDK_INT integer. If we are on Android 1.6 or newer, we use reflection to attempt to find the indexed getTag() and setTag() methods, and we cache those results. Since those methods should not change during the lifetime of our application, it is safe to cache them in static variables.

Then, when it comes time to actually use getTag() or setTag(), we look to see if the cached Method objects exist or are null. If they are null, we assume we need to use the old versions of those methods. If the Method objects exist, though, we use them instead, to take advantage of the native indexed versions.

This version of the application works fine on Android 1.5 and above – Android 1.6 and above using the built-in indexed methods, Android 1.5 using our "fake" version of the indexed methods.

There is a little extra overhead for going through the `Method`-based reflection, but it may be worth it in some cases to access APIs that exist in newer versions of Android than all the ones we want running our application. There are even ways to use this technique for cases where entire classes are new to newer Android versions.

Where Do We Go From Here?

Obviously, this book does not cover everything. And while your #1 resource (besides the book) is going to be the Android SDK documentation, you are likely to need information beyond what's covered in either of those places.

Searching online for "android" and a class name is a good way to turn up tutorials that reference a given Android class. However, bear in mind that tutorials written before late August 2008 are probably written for the M5 SDK and, as such, will require considerable adjustment to work properly in current SDKs.

Beyond randomly hunting around for tutorials, though, this chapter outlines some other resources to keep in mind.

Questions. Sometimes, With Answers.

The "official" places to get assistance with Android are the Android Google Groups. With respect to the SDK, there are three to consider following:

- StackOverflow's android tag

- android-developers, for SDK questions and answers

- android-discuss, designed for free-form discussion of anything Android-related, not necessarily for programming questions and answers

You might also consider:

- The Android tutorials and programming forums over at anddev.org

- The AndMob wiki

- The `#android-dev` IRC channel on freenode (irc.freenode.net)

- The Android board on JavaRanch

It is important, particularly for StackOverflow and the Google Groups, to write well-written questions:

- Include relevant portions of the source code (e.g., the method in which you are getting an exception)

- The stack trace from LogCat, if the problem is an unhandled exception

- On StackOverflow, make sure you source code and stack trace are formatted as source code; on Google Groups, consider posting long listings on gist.github.com or a similar sort of code-paste site

- Explain thoroughly what you are trying to do, how you are trying to do it, and why you are doing it this way (if you think your goal or approach may be a little offbeat)

- On StackOverflow, respond to answers and comments with your own comments, addressing the person using the @ syntax (e.g., @CommonsWare), to maximize the odds you will get a reply

- On the Google Groups, do not "ping" or reply to your own message to try to elicit a response until a reasonable amount of time has gone by (e.g., 24 hours)

Heading to the Source

The source code to Android is now available. Mostly this is for people looking to enhance, improve, or otherwise fuss with the insides of the Android operating system. But, it is possible that you will find the answers you seek in that code, particularly if you want to see how some built-in Android component "does it's thing".

The source code and related resources can be found at http://source.android.com. Here, you can:

- Download or browse the source code

- File bug reports against the operating system itself

- Submit patches and learn about the process for how such patches get evaluated and approved

- Join a separate set of Google Groups for Android platform development

Rather than download the multi-gigabyte Android source code snapshot, you may wish to use Google Code Search instead. Just add the `android:package` constraint to your search query, and it will only search in Android and related projects.

Getting Your News Fix

Ed Burnette, a nice guy who happened to write his own Android book, is also the manager of Planet Android, a feed aggregator for a number of Android-related blogs. Subscribing to the planet's feed will let you monitor quite a bit of Android-related blog posts, though not exclusively related to programming.

To try to focus more on programming-related Android-referencing blog posts, you can search DZone for "android" and subscribe to a feed based off that search.

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