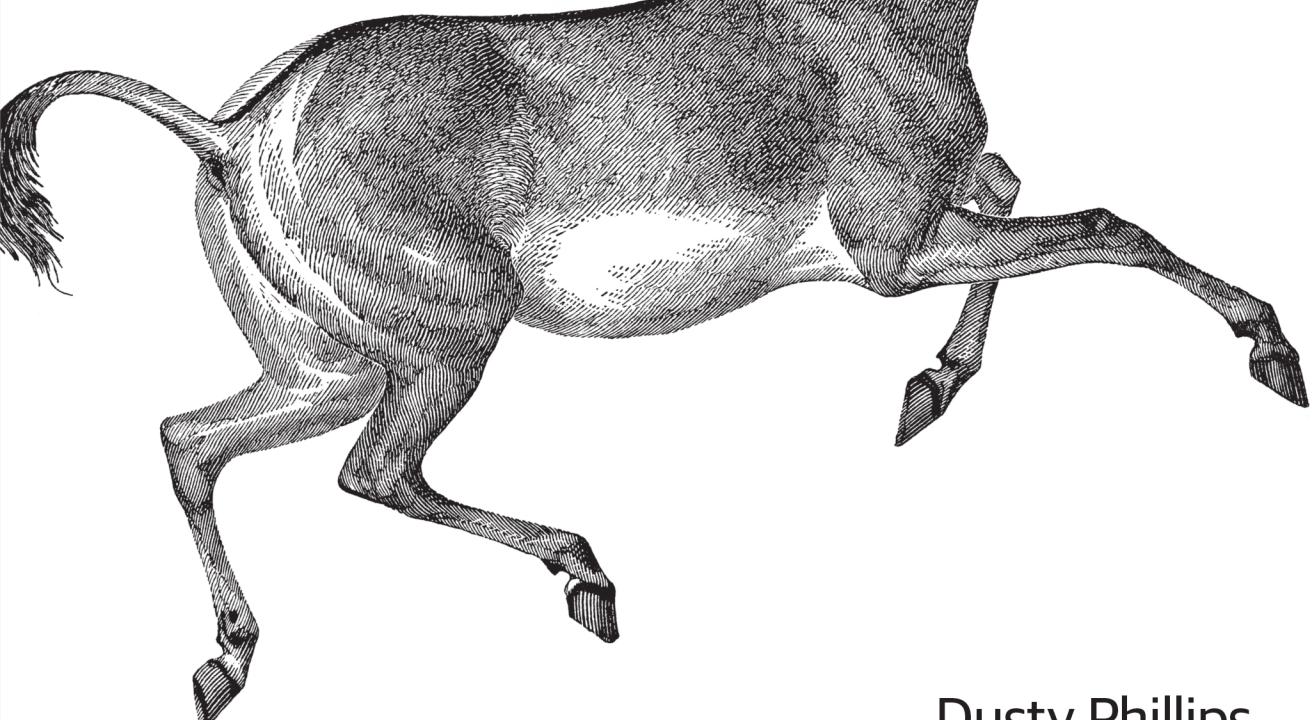


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Creating Apps in Kivy

MOBILE WITH PYTHON



Dusty Phillips

Creating Apps in Kivy

Build mobile apps efficiently with Kivy, the Python-powered graphical toolkit for creating natural user interfaces with elegant multitouch support. With this hands-on guide, you'll learn step-by-step how to build and deploy a complete Kivy app for iOS and Android devices. If you're just beginning to work with Python, but are reasonably familiar with its syntax, you're ready to go.

Each chapter includes exercises, using examples that run on Python 3 and Python 2.7. Learn how Kivy simplifies mobile development with its cross-platform API and domain-specific Kv language, and why this free and open source toolkit is ideal for commercial products.

- Design custom widgets with the Kv language
- Delve into Kivy events, event handlers, and properties
- Dynamically change which Kivy widgets are displayed
- Understand and apply iterative development principles
- Create basic animations using Canvas and graphics primitives
- Store local data with Kivy's powerful key value store
- Add basic gestures to switch between app views
- Improve your app's usability with Kivy's built-in widgets
- Deploy the app to your Android or iOS device using Buildozer

“Dusty has been a valuable contributor to the Kivy project, creating the awesome `kivy-catalog` example... in this book, he puts his great teaching skills to use, and will make you feel the Zen of Kivy development.”

— Gabriel Pettier
Core Kivy Developer

Dusty Phillips is a Canadian software engineer, blogger, and author. He holds a master's degree in computer science and has actively contributed to various open source communities, most notably Python and Arch Linux. He has written two previous books, including *Python 3 Object Oriented Programming* (Packt Publishing).

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Creating Apps in Kivy

Dusty Phillips

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Creating Apps in Kivy

by Dusty Phillips

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Editors: Meghan Blanchette and Rachel Roumeliotis

Indexer: Judy McConville

Production Editor: Nicole Shelby

Cover Designer: Randy Comer

Copyeditor: Rachel Monaghan

Interior Designer: David Futato

Proofreader: Rachel Head

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Preface

This book introduces Kivy, an exciting new graphical user interface library that finally allows Python to be used to code cross-platform applications on most traditional and mobile operating systems. I'm happy you're here to study Kivy with me and hope that you'll enjoy reading it as much as I have enjoyed writing it. I am confident that you will be happy with the App you develop and deploy in this book and that it will lead you to develop many new applications of your own design. I look forward to seeing your Kivy Apps on the Android and iTunes market in the near future!

Who Should Read This Book

This book is primarily targeted to fairly new programmers who have read the Python tutorial, but haven't done a lot of real-world coding. In addition to instructing you in Kivy, this book introduces you to the programming workflow. Each chapter builds on the previous chapter to help you create a fully functional mobile application. You will learn the steps you need to follow to design and implement your own apps.

It will also be applicable to programmers who have not worked with Python before but want to use Kivy for its amazing API, integrated multitouch support, or cross-platform deployment. You will probably want to review the Python tutorial to get a leg up on the language's syntax before reading this book. You may be able to skim some sections of the text if you already understand the culture of coding.

Technology Used in This Book

The examples in this book all target Python 3. All but three of them also run seamlessly on Python 2.7. Those three examples have been highlighted in sidebars that include simple workarounds you can use to make the code run on both Python 2.7 and Python 3. Then, any future examples that use the same code will always use the version that works on both Pythons.

I encourage you to use Python 3 if possible, as it is a more enjoyable language to work with, provides nicer APIs, and is slowly being adopted by the entire Python community. That said, depending on what operating system you use, Python 2 may be easier to deploy and develop against at this time. You will have no trouble using Python 2.7 with the examples in this book if you prefer it.

This book was written entirely against Kivy 1.8, which is the first version of Kivy to support Python 3. The examples have been tested somewhat against Kivy 1.7, and it works with all the chapters except [Chapter 6](#). Please use Kivy 1.8 or later if you can. The Kivy developers move very fast, and the newest version is always far better than the previous one in all dimensions: speed, stability, and features.

Conventions Used in This Book

The following typographical conventions are used in this book:

Italic

Indicates new terms, URLs, email addresses, filenames, and file extensions.

Constant width

Used for program listings, as well as within paragraphs to refer to program elements such as variable or function names, databases, data types, environment variables, statements, and keywords. Also used for commands and command-line options.

Constant width bold

Shows commands or other text that should be typed literally by the user.

Constant width italic

Shows text that should be replaced with user-supplied values or by values determined by context.



This element signifies a tip or suggestion.



This element signifies a general note.



This element indicates a warning or caution.

Using Code Examples

Supplemental material (code examples, exercises, etc.) is available for download at https://github.com/oreillymedia/creating_apps_in_kivy.

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Please heap gratitude on the entire Kivy development team. I've been doing GUI programming for years and have touched many toolkits in Python and other languages. Kivy is the first of the many user interface toolkits I have used that I truly enjoy. Designing a good UI API is extremely challenging (or someone would have got it right before now), and the Kivy developers deserve many, many accolades for their amazing work. Please tip them profusely using [Gittip!](#)

I want to especially thank Gabriel Pettier (tshirtman) not only for developing and maintaining Kivy, but also for his technical review of this book. He pointed out many flaws, omissions, and inconsistencies, which helped me refine the end product into what

it is. Jennifer Pierce also tech-reviewed the book from a beginner's perspective and highlighted the areas where I was confusing my readers.

Finally, I want to thank every person who has ever spoken publicly about dealing with mental illness. The wall of silence around all mental illnesses is doing society a huge disservice. Every time someone speaks about this topic, the mentally ill are perceived as somewhat more acceptable and contributing members of society. I've done many incredible things since dealing with a near-terminal form of my illness three years ago. Others have not been so fortunate. We need to talk so that brilliant minds can discover that treatment is available before they succumb to their illness, as Aaron Swartz and Ilya Zhitomirskiy did.

CHAPTER 1

Introducing Kivy

Kivy is a modern graphical user interface toolkit. It allows you to easily develop natural interfaces for a wide selection of devices. It is attractive to a variety of developers for a few key reasons:

- Kivy has elegant built-in support for multitouch devices.
- Kivy is the only viable way to code in Python on mobile devices.
- Kivy replaces the horrible APIs of earlier graphical interfaces like HTML and CSS.
- Kivy allows you to maintain a single application for numerous operating systems.

Whatever your reasons for studying Kivy, I'm glad you found this book. You'll be going step by step through Kivy basics to create and deploy a fully functional application. Each chapter presents a working program that you will expand on in subsequent chapters. I've chosen to develop a weather application with you, partially because it's at the right complexity level, but mostly because there aren't any decent open source weather applications in the F-Droid open source Android market!

While I hope this book appeals to a diverse array of developers, I have a specific audience in mind as I write it. As with any job description, you don't have to completely fit this profile, but it will help you to understand who I'm thinking about and how you might differ. My intended audience:

- Has beginner to intermediate programming skills and has read the Python tutorial
- Is not intimately acquainted with advanced Python concepts, but is eager to learn
- Wants to learn about programming workflow, not just Kivy
- Has a good sense of humor
- Owns an Android or iOS device

Regardless of who you are, if you’re interested in creating a working application in Kivy, you’re in the right place! I’ll be showing you how to develop a weather application step by step. You’ll start with setting up a Kivy development environment and end up with an application running on your Android device or iPhone.

Dependencies: The Hard Part

It’s an unfortunate truth in the programming world that the fun part has to come after a lot of work. Getting Kivy up and running is not a terribly complicated process, but I wouldn’t call it enjoyable. “I got a programming library installed after half an hour of effort” just doesn’t have the same ring as, “I made a program window pop up after 20 seconds!” So, to boost your excitement, let me tell you that 20 seconds after you get all these dependencies set up, you’ll have written and run a small Kivy application. Ready? Let’s go!

Python 2 Versus Python 3

There are currently two active versions of Python: Python 2 and Python 3. The syntax and standard library have changed between the two versions, and both are quite popular. You may be wondering which one you should use.

As of version 1.8, which is used for the examples in this book, Kivy supports both Python 2 and Python 3 interpreters. From a developer’s point of view, I recommend using Python 3, as it is a simpler syntax, has a cleaner standard library, and will be more useful knowledge going into the future.

However, from an ease-of-use perspective, you are more likely to find that Python 2 is already installed on your computer and ready to go. Further, the tools used to deploy to both Android and iOS currently run only on Python 2.

I wrote the examples in this book to run in Python 3. However, most of them can be run unmodified on Python 2, and I have noted any differences in sidebars.

Regardless of which version of Python you choose, make sure you’re using Kivy version 1.8 or later.

Frankly, writing about dependency setup is frustrating for me as well. I don’t know what operating system you’re using. I don’t know what libraries you already have installed or how they conflict with each other. I can’t predict the myriad ways that things might go wrong for you.

Luckily, Kivy has great installers for most operating systems. You can use these to get up and running quickly. Quick installers have their downsides, though. A major one is that you, as the developer, don’t know exactly what they are doing. This can cause head-

aches later when things break and you don't know what's going on. However, Kivy takes good care of its users, so it will probably be quite a long time before you have to work out the details.

While I use and recommend the Linux operating system (all the code in this book was first written and tested on Linux), I don't provide Linux installation instructions. Installing dependencies in Linux tends to be much more straightforward than on other operating systems. However, the instructions for doing so vary completely depending on which Linux distribution you are using, and as a Linux user, you probably know better than I how to go about getting them for your distribution of choice (unless you use Arch Linux, for which I've written a ton of documentation). Kivy has terrific instructions for most popular Linux distributions on its [downloads page](#).

Installing on Mac OS

You can download an all-inclusive *.dmg* file that includes a compiled version of Kivy, all the libraries it depends on, a shell command to run it from a terminal window (this is necessary to see debugging output), and all the examples that Kivy supplies in case you get stuck.

To install it, simply download the latest (version 1.8 or higher) *.dmg* file from [Kivy's download page](#). Double-click the file in your downloads folder or stack to open it. Then drag and drop the *Kivy.app* file into the *Applications* folder shortcut inside the volume.

Before you close the *.dmg* volume, also double-click the *Make Symlinks* file. This will allow you to run Kivy as a script on the terminal. This script is kind of a wrapper for the Python executable. After you've run *Make Symlinks*, you can open a terminal and type **kivy**. You'll be presented with a standard Python prompt as if you had run the *python* command directly.



In Mac OS Mavericks (10.9), Apple introduced a new antideveloper feature to prevent running “unlicensed” programs. It will pop up a warning that you can't run the script downloaded from the Internet and doesn't provide an obvious way for you to get in on the debate.

There is a hidden workaround, though (I guess Apple just wants you to prove you know what you are doing). In Finder, open the folder containing the script. Then Control-click the icon and click Open in the shortcut menu. This will override the security settings and allow the script to run.

This prompt is your system Python with some paths modified to ensure that all the libraries it requires are installed. If you're an experienced Python coder, you're likely wondering why you wouldn't just use a *virtualenv*. Virtual environments are great when your dependencies are Python libraries that you can install from *pypi* or Git reposi-

ries. However, many of Kivy's dependencies are C libraries that have complicated interdependencies. These have been bundled into *Kivy.app* as a bunch of dynamic libraries that are loaded when you run the `kivy` script.

Note that *Kivy.app* uses the default Python that comes with Mac OS. That means you'll be using Python 2 instead of Python 3. You will have to adapt a couple of the examples in this book to make them work, but I've highlighted those so you won't have any trouble.

For the most part, you will be using Kivy from the terminal in this book. Your file will be named `main.py`. I may tell you to run `python main.py`, but if you're using the Mac OS *Kivy.app*, you'll want to run `kivy main.py` instead.

Installing on Windows

Windows can be pretty quirky for software development. It doesn't have a terrific command-line interface, and there can be bizarre conflicts between software libraries or software and the heterogeneous collection of hardware that Windows supports.

That said, the Kivy developers have done a great job of bundling the dependencies into a single ZIP file. The archive contains the minimum dependencies you need to run Kivy. This portable package should integrate well with the operating system and isolate you from conflicting libraries on the same system.

Download the Kivy for Windows ZIP file from [Kivy's download page](#). Extract (right-click the file and click "Extract all") the ZIP file to a known directory on your system; I recommend the folder `C:\utils\kivy`.

Now you can open a Windows command prompt. Type the command `cd C:\utils\kivy` and then just `kivy`. This will activate the Kivy environment, which includes the libraries you need. It also bundles a Python executable (you can choose between Python 2 and Python 3 from the downloads page). You will have to perform this activation step each time you open a new terminal.

Note that you can also install `msysgit` to get a programmer-friendly command-line interface (the same command shell used by default on Linux and Mac OS). If you are using this package, you'll need to run `source kivyenv.sh` instead of the `kivy` script. I recommend using this installer, as you will also have access to the Git version control system to manage your source code, and it will install some of the dependencies you'll need in [Chapter 9](#).

Writing Code: The Easy Part

Now create a directory somewhere to host your project and open a new file called `main.py` in your preferred text editor.

Program Editors

I'm assuming you've done some basic Python development before diving into Kivy. That probably means you've explored the world of Python editors already. All Python programs are simple text that is organized into the structure expected by the Python interpreter. There are numerous tools for editing Python programs, and even more opinions on which one is best.

If you already have such an opinion, then stick with it, by all means. However, if you're feeling confused by the array of program editing choices, I can recommend [Sublime Text](#). It is very easy for novices, with no more of a learning curve than the basic Microsoft Notepad. However, it is also an advanced editor that professionals, including myself, use for their daily programming. The best part is that if Sublime doesn't do something that you need it to do, you can easily extend it using plug-ins written in Python!

The starting Python module for all Kivy applications should be named `main.py`, as the build tools you'll use later to automate deployment to mobile devices will look for that file. Now add a couple of lines of code to this new file, as shown in [Example 1-1](#).

Example 1-1. The most basic Kivy app

```
from kivy.app import App

App().run()
```

That is it: the most basic Kivy code you could possibly write. It imports an `App` class, instantiates it, and then calls the `run` method. Run this code by activating your Kivy environment in a terminal and typing `python main.py` (or `kivy main.py` on Mac OS). It will pop up a blank window with a black background. Close it.

The Kivy `App` object does an impressive amount of work on your behalf. That is the beauty of object-oriented programming. This object does something, and all you have to do is tell it to do its job by invoking the `run` method. It takes care of all sorts of stuff: interacting with the screen hardware; talking to input devices such as multitouch displays, keyboards, and accelerometers; scheduling tasks; and more. We'll get into some of that later, but for now, just know that if you don't have an `App` object, you don't get a window.

If you aren't familiar with the basics of object-oriented programming, you might want to review the [relevant section of the Python Tutorial](#). If you'd like in-depth coverage of the topic, see my book *Python 3 Object Oriented Programming* (Packt, 2010).

In Kivy, your use of object-oriented principles is largely to extend Kivy's built-in objects through inheritance. This is a fairly easy paradigm to understand, so you don't need to be well versed in classes to get there.

If a blank window with a black background is exactly the kind of application you were looking to write, then you're done! Congratulations. Perhaps you can skip to the chapter on deploying so you can get that black background onto your mobile device (or just use the power button; black goes with anything).

Personally, I'd like something a little more interesting. So let's try again. Edit the file to look like [Example 1-2](#).

Example 1-2. A slightly less basic Kivy app

```
from kivy.app import App

class WeatherApp(App):
    pass

if __name__ == '__main__':
    WeatherApp().run()
```

This version uses inheritance to create a new subclass of `App` called `WeatherApp`. This is the application you'll be developing in this book. You didn't actually add anything to the new class, so it behaves exactly the same as the previous version. However, you'll be extending it a lot in subsequent chapters. It also wraps the call to `App.run` in an `if` statement to make sure that this file can be imported from inside other files later in the book. More importantly, you can now use the KV language to add some real user interface elements to that black window.

Introducing the KV Language

The KV language, often referred to as *kvlang*, is a simple markup syntax that I think of as "what HTML would look like if HTML looked like Python." It's a very clean syntax and makes Kivy interface design much more enjoyable than any other toolkit I've worked with, including the Web. ,

You'll be creating a new file to store the KV language in. Call it `weather.kv` and save it in the same directory as `main.py`. Your `.kv` file should always have the same name as your app class, but with the word `App` stripped from the end, and converted to lowercase. Thus, `WeatherApp` will always look for its layout information in a file called `weather.kv`.

I'll be explaining more about the KV language throughout the book. Start by putting [Example 1-3](#) in your `weather.kv` file.

Example 1-3. Simple KV language file

Label:

```
text: "Hello World"
```

This is a very simple KV language file that creates a new `Label` object and sets its text to the infamous `Hello World` string. If you now run the `python main.py` command, you will see the window pop up, still with a black background, but also with the text displayed in its center, as shown in [Figure 1-1](#).

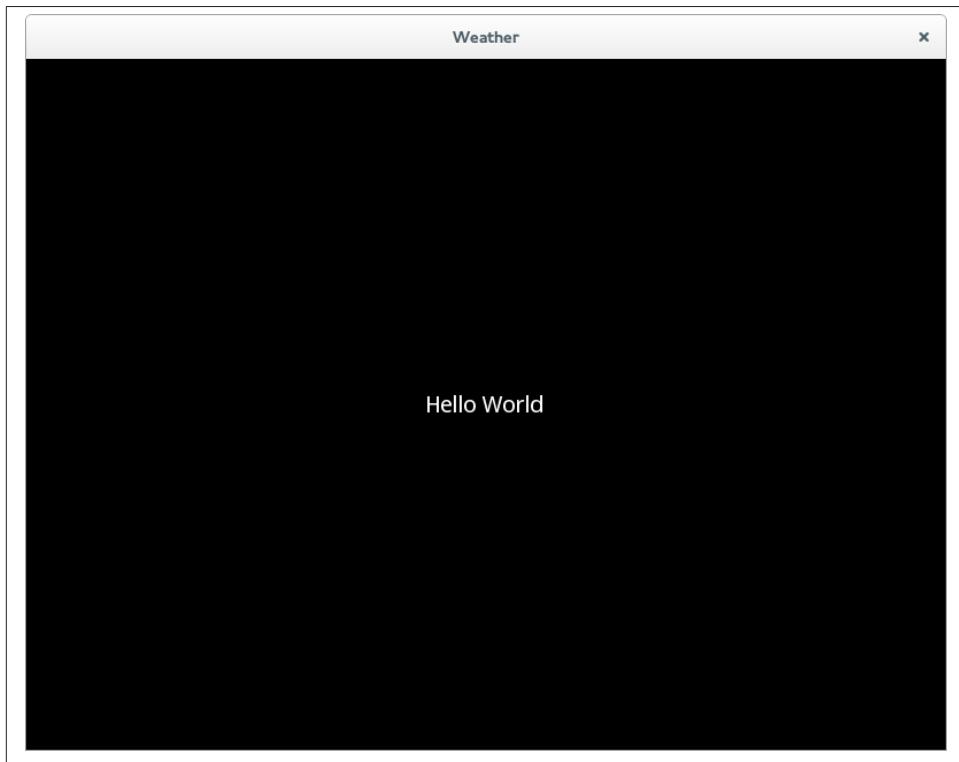


Figure 1-1. Hello World label

User Interface Design

Each chapter in this book builds on the results of the chapter preceding it. At the end of the book, you will have created a weather application that runs on your desktop computer, Android, and iOS. It's a good idea, before you write an application, to know

what kind of application you want to write. Therefore, let's spend a few minutes discussing what features the app will support and how it will look.

Weather apps tend to have the same set of features. Here are some capabilities I want to cover in this project:

- Render weather for multiple locations, with a selector to switch between them.
- Store the list of locations between App invocations so they don't have to be searched again.
- Switch between current conditions and long-term forecast.
- Include settings for users to choose metric or imperial units.
- Incorporate gestures for users to switch between screens.

Given these features, it's fairly easy to imagine the set of views the application will require:

- A form for adding new locations
- A list of previously searched locations
- The current conditions screen
- The forecast screen
- The settings screen

These will, of course, be composed of other interface components. I'll introduce the widgets you require as they come up. The remainder of this chapter will focus on the form for adding a new location. This form is pretty simple, requiring only a text entry field in which to type a city name, and a button to search for that location (see [Figure 1-2](#) for a mockup).

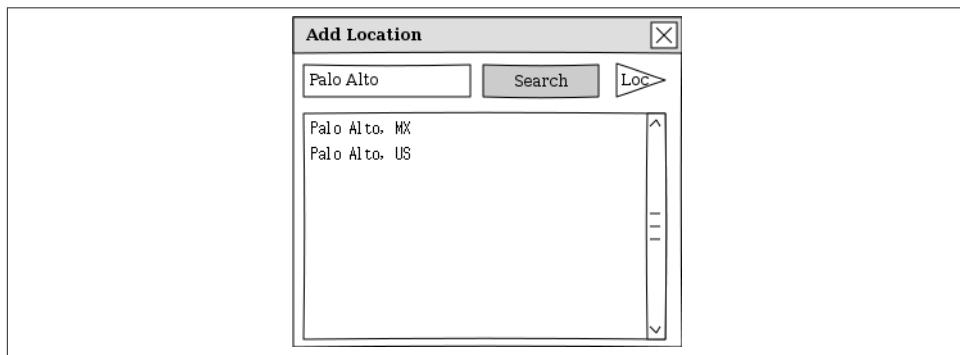


Figure 1-2. Mockup of Add Location form

I'll also add a button to search for the current location, assuming the device has a GPS. Finally, there needs to be a list of results so users can choose which of multiple matching cities is the one they want.

Mockups

Mockups are an essential component of user interface design. They give quick insights into how to lay out visual application components. Normally, the first mockup you create will indicate flaws in the design (especially if you show it to an experienced user interface designer... or your client) that you can address before putting any effort into actually coding an inappropriate interface.

I personally tend to do my mockups using a pencil and plain paper. One of my far too many hobbies is sketching, and paper puts me into a more creative frame of mind than the computer screen, which I spend too much time staring at as it is.

However, my sketches are not professional enough to show to clients (or render in a book). There are plenty of online and desktop applications for creating mockups. I enjoyed the closed source [Balsamiq](#) when my company provided a license for it. I am loath to pay for software, though, so the mockups in this book were all done using the open source [Pencil](#).

Whatever you choose, you should have, at the very least, a mental picture of what you want your interface to look like. The KV language is awesome for implementation and prototyping, but for the initial design phase, you'll want more freedom and feedback.

Widgets

Kivy uses the word *widget* to describe any user interface element. Just a few examples of widgets include:

- The label you rendered in [Example 1-3](#)
- The text input field and buttons you'll render shortly
- Layout classes that comprise other widgets and determine where they should be displayed
- Complicated tree views such as file pickers
- Movie and photo renderers
- Tabbed boxes that display different widgets depending on the selected tab

I find it convenient to think of a widget as a sort of box that has behaviors and can contain other boxes. The `Widget` class is the most basic such box. It is empty. However, all other widgets extend this class in a beautiful inheritance hierarchy. The `Label` widget

is a very simple widget that displays text. The `Button` widget is more interactive and responds to touch or click events. The `TextInput` widget knows how to deal with keyboard events.

The more advanced widgets, such as `TabbedPanel` or `FileChooser`, are composed of multiple other widgets. There is really no conceptual difference between an advanced and a primitive widget other than the difficulty of drawing them on the screen. Advanced widgets are normally composed of `Layout` widgets, which are essentially boxes that know enough about the widgets inside them to determine how they should be sized and positioned relative to one another. There are several different `Layout` subclasses. I personally use `BoxLayout` unless I have very specific needs that require a `GridLayout` or `FloatLayout`. `BoxLayout`, which renders widgets in a vertical or horizontal line, tends to be better suited to adapting its size to the display on which it is currently rendering.

Finally, you can make custom widgets of your own by extending the `Widget` class (or, often, a `Layout` subclass) and applying KV language rules to describe how the widget should look. There are two ways to do this. One is to create custom drawing commands to render graphics directly to the widget canvas. The other is to compose multiple primitive widgets into something more complicated; that's what you'll be doing in this chapter.

The KV Language Root Widget

The KV language is a special domain-specific language that is ideal for laying out user interfaces. It has a Pythonesque syntax and borrows heavily from Python's notions of simplicity and elegance. The KV language file uses indentation to indicate which "boxes" go inside other boxes.

The outermost box in a KV language file is called the *root widget*. There can only be one root widget per KV language file. In [Example 1-3](#), there was only one widget, a `Label`, and it is the root widget. You can tell it is the root widget because it is the leftmost indented line, and doesn't have any funny brackets or angle brackets around it to indicate that it is something else.

There is an indented block below the root widget's `Label:` specifier. Inside this block, you can define other child widgets (except `Label` doesn't typically have children), and you can specify properties about that widget. I'll tell you more about properties in [Chapter 2](#), including how to create your own custom properties on custom widgets. For now, understand that the `Label` widget has a `text` property. That property takes a string value. Like a string value in Python, it is embedded in quotes. A colon separates the property name from the value, much like a key/value specifier in a Python dictionary.

You've probably guessed that the root widget is attached directly to the Kivy window and rendered. If it were a container widget that held multiple child widgets, it would render them as well. Try changing your `weather.kv` file to look like [Example 1-4](#).

Example 1-4. Basic container widget

```
BoxLayout:  
    Label:  
        text: "Hello"  
    Label:  
        text: "Beautiful"  
    Label:  
        text: "World"
```

The root widget, in this case, is a `BoxLayout` object. As I mentioned before, Layout widgets are essentially containers that know how to hold other widgets and position them in some way. There are three labels supplied, indented, as children of the `BoxLayout`. Each of these `Label`s has an indented block of its own where that widget's properties are configured; in this example, a different value for `text` is supplied for each.

KV Syntax Errors

If your KV language file doesn't compile correctly, you'll get a Python traceback. Debugging syntax errors is a common task in programming, as it is rare to type code correctly the first time. You will probably even make mistakes and omissions as you type the examples from this book.

The KV parser will typically give you a `ParseException` if it encounters a line it doesn't like. It will mention the line number in the KV language file that is at fault and normally includes a short description of what's wrong in the file.

You will eventually encounter these regularly (at least, if you type like I do). I suggest you force one now so you know what to look for. Try deleting the colon after `text` in one of the labels in [Example 1-4](#) and see what happens when you try to run the app.

By default, the `BoxLayout` places each of its child widgets side by side, from left to right, giving each one an equal amount of space. Since you haven't done anything to change the defaults, this is what happens when you render the KV file. If you now run `python main.py`, it will render three labels, as shown in [Figure 1-3](#).

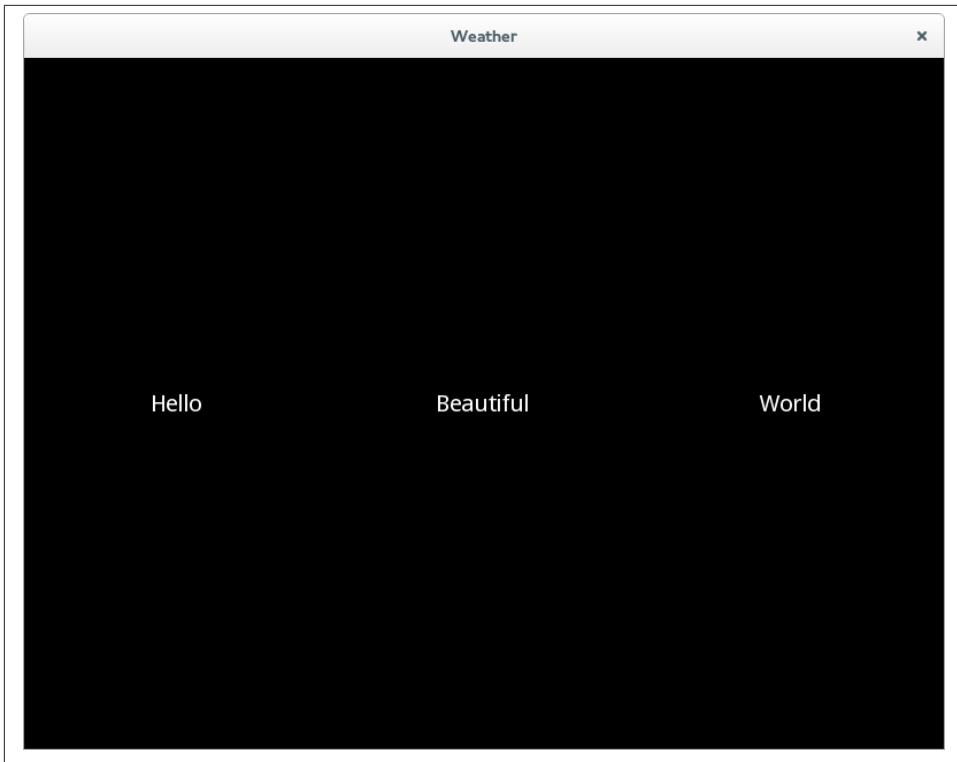


Figure 1-3. Rendering of basic container widget

Creating a Custom Widget

It would not be difficult to change the labels in the root widget to some buttons and text boxes to create the Add Location form I have in mind. But that would make things rather complicated later, when you need to remove all those widgets from the view to put other data (for example, a forecast) on display. Further, if the user later wanted to add another location, it would be tricky to restore all the Add Location widgets.

Instead, create a custom `AddLocationForm` widget that encapsulates the text entry, search button, location button, and search results into a single widget. Then set the root widget to be an instance of that custom widget instead. [Example 1-5](#) does all of this.

Example 1-5. Custom AddLocationForm widget

```
AddLocationForm: #①
<AddLocationForm@BoxLayout>: #②
    orientation: "vertical" #③
    BoxLayout:
        TextInput:
```

```

    Button:
        text: "Search"
    Button:
        text: "Current Location"
ListView:
    item_strings: ["Palo Alto, MX", "Palo Alto, US"] # ④

```

- ➊ The root widget is now a custom widget named `AddLocationForm`. It doesn't have an indented block below it, so there are no properties or child widgets defined.
- ➋ The new custom class is defined here. The @ symbol in the KV language indicates that the class is extending `BoxLayout` using inheritance. This means that the new widget is a `BoxLayout` and can do all the things a `BoxLayout` can do, such as lay out its children. The angle brackets tell the KV language that this is a new class rule, not a root widget.
- ➌ `AddLocationForm` is a `BoxLayout` like in the previous example, but you are setting its `orientation` property to vertical. This will force its child elements to appear one above the other. The child elements in this case are another `BoxLayout` (this one is horizontal), and a `ListView`.
- ➍ I'll tell you a lot more about the `ListView` widget later. For now, because search isn't implemented yet, just hardcode a couple of values so you can see what the rendered `ListView` looks like.

The rendering of this code is shown in [Figure 1-4](#). It's already looking a lot like I want it to look, but the widget proportions are all wonky.

Adjusting Widget Size

There are a couple of proportion problems with the rendering in [Figure 1-4](#). First, the text box and two buttons are way too tall. And second, the text box doesn't take enough of the available width. This is fairly easy to take care of in terms of lines of code. However, I find setting proportions on Kivy widgets to be confusing. I hope to spare you that frustration by giving a thorough explanation in this section!

It is up to the `Layout` object to determine what size its child widgets should be. It is allowed to take two types of advice from its children, should the children choose to provide it, but it is also free to ignore that advice. For example, a horizontal `BoxLayout` will always make its children the same height as itself, no matter what the child requests (this can cause extensive problems if the child widget is in its teens).

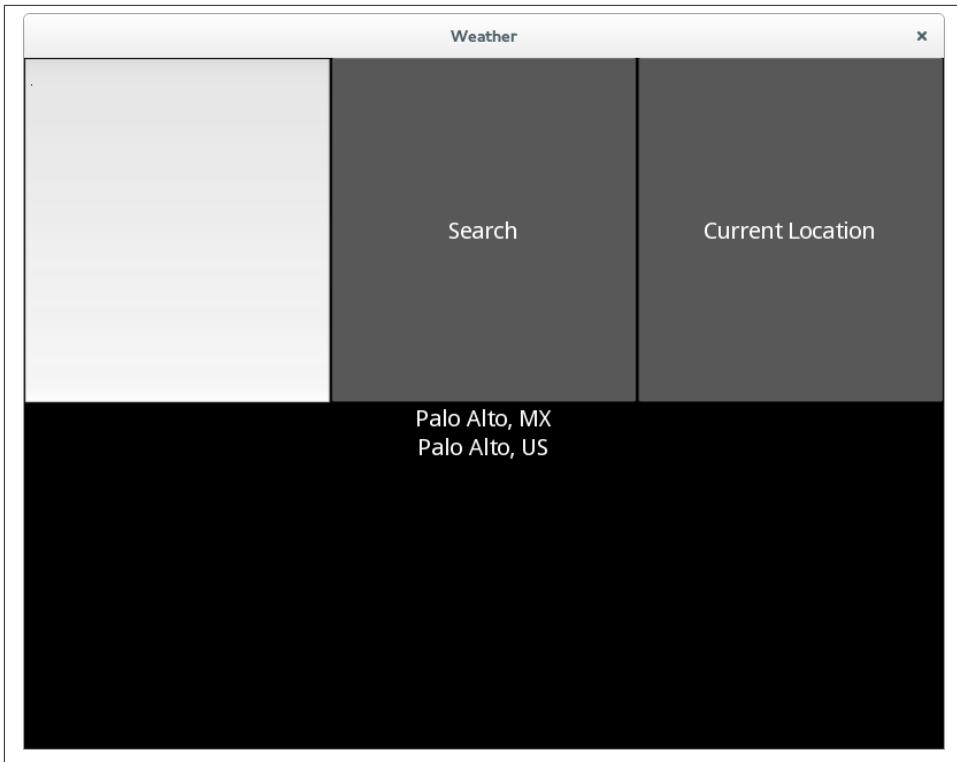


Figure 1-4. Rendering of `AddLocationForm`

The two types of advice the child can give its parent layout are size hints and absolute sizes. For each type of advice, the child widget can set properties in the `x` dimension (horizontally) and the `y` dimension (vertically). In addition, it is possible to combine the horizontal and vertical settings in the case where you need to explicitly set both of them. This is unnecessary with `BoxLayout`, since it always uses maximum space in one direction, but can be useful with other layouts. Thus, there are technically six different proportion advice properties that you can set on any given widget class:

- `size_hint_x`
- `size_hint_y`
- `size_hint` (tuple of `size_hint_x`, `size_hint_y`)
- `width`
- `height`
- `size` (tuple of `width`, `height`)

Of course, if you use the tuple version, you shouldn't use the individual dimension version.

Size hint advice

The `size_hint` is a proportional measure. If three widgets have the same `size_hint` (and the layout chooses not to ignore that information), they will all be the same size. If one widget's `size_hint` is twice as big as another widget's, then it will be rendered at double the size.

The main thing to bear in mind is that the size of a widget is calculated based on the sum of the `size_hint` values for all the widgets. A single widget having a `size_hint` of 1 has no meaning unless you also know that its sibling widget has a `size_hint` of 2 (the first widget will be smaller than the second) or 0.5 (the first widget will be larger). Have a look at [Example 1-6](#), rendered in [Figure 1-5](#).

Example 1-6. Size hints

```
BoxLayout:  
    orientation: "vertical"  
    BoxLayout:  
        Button:  
            size_hint_x: 1  
        Button:  
            size_hint_x: 1  
        Button:  
            size_hint_x: 1  
    BoxLayout:  
        Button:  
            size_hint_x: 1  
        Button:  
            size_hint_x: 2  
        Button:  
            size_hint_x: 3  
    BoxLayout:  
        Button:  
            size_hint_x: 1  
        Button:  
            size_hint_x: 0.75  
        Button:  
            size_hint_x: 0.25
```

The first button in each row has a `size_hint_x` value of 1. However, its size is different in each row because the sibling buttons in each row have `size_hint_x` values that are bigger or smaller.

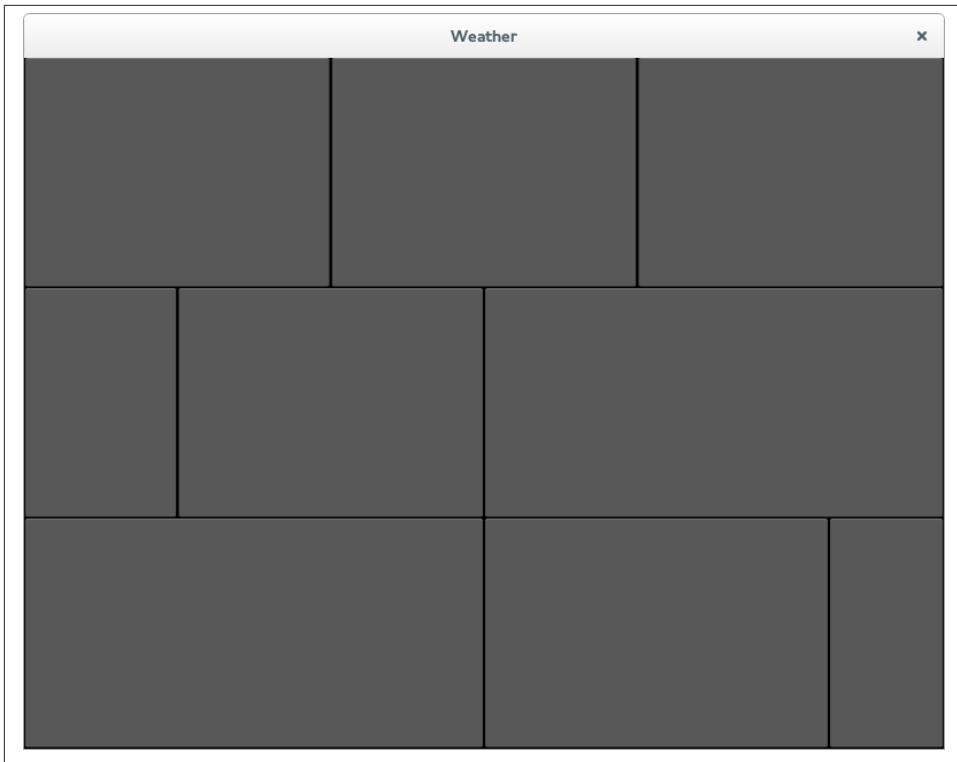


Figure 1-5. Size hints

Size advice

Sometimes having widget sizes calculated relative to the sizes of other widgets is exactly what you need. Other times, you need to control the size in one or both dimensions a little more accurately. This is where the `width` and `height` properties come in.



One of the most frustrating layout issues for Kivy newbies is that size properties (including `width` and `height`) are ignored unless the relevant `size_hint` properties are set to `None`. The default value for a `size_hint` is `1.0`.

Thus, as a rule of thumb, any time you choose to set a `height` on a widget, you must also set `size_hint_y` to `None`. Similarly, any time you set a `width`, you must set `size_hint_x` to `None` if you want to get the expected results. And, of course, if you set the `size` property instead, you should set `size_hint` to `(None, None)`.

The `width` and `height` values themselves are pretty easy to interpret. They can be integer values, in which case they refer to the pixel size of the widget on the screen. However, you can also pass string values such as "1cm", "0.75in", or "100dp" to render the widget relative to the resolution of the display. This is almost always a good idea, because modern devices can have an extremely wide variety of pixel densities. A pixel on a cheap laptop might be three times the size of a pixel on a high-end smartphone, and the disparity is even larger for so-called retina displays.

Personally, unless I have a good reason to do otherwise, I always use Kivy's concept of *display pixels* by passing a suffix of `dp` to my `height` and `width` properties. A display pixel is a resolution-independent value that roughly maps to "the size of a pixel on a typical laptop at 72 dots per inch." On a lower-end screen, 1 display pixel is equivalent to 1 pixel. On top-end displays, a display pixel might be 3 or 4 real pixels wide. The display pixel will be roughly the same size on all the devices; it's the pixels themselves that are smaller. It's not guaranteed, but I find that a display pixel on mobile devices is a bit bigger than on desktops and laptops. This is useful, since touch interfaces need to provide a bit more room for widgets to accommodate the clumsy size of the human finger.

Remember that a given layout is free to ignore the `width` and `height` properties if it so chooses. Also remember that most Layouts will ignore those properties no matter what, if the `size_hint` has not been set to `None` in that dimension. Keep this knowledge close to hand, and you should (I hope) never have to go through the trauma that I did to figure out Kivy sizing! It's really quite elegant; I don't know why I once found it so difficult.

See it in action

After all that reading, you're probably eager to see some KV language code. Hopefully [Example 1-7](#) will satisfy you.

Example 1-7. Setting widget sizes on AddLocationForm

`AddLocationForm:`

```
<AddLocationForm@BoxLayout>:
    orientation: "vertical"
    BoxLayout:
        height: "40dp" # ❶
        size_hint_y: None
        TextInput:
            size_hint_x: 50 # ❷
        Button:
            text: "Search"
            size_hint_x: 25 # ❸
        Button:
            text: "Current Location"
            size_hint_x: 25 # ❹
```

```
ListView: # 5  
    item_strings: ["Palo Alto, MX", "Palo Alto, US"]
```

- ➊ Pay close attention to the indentation so you can tell what size property has been set on which widget. Remember, there are two `BoxLayout` objects. The outer `AddLocationForm`, a type of `BoxLayout`, is vertical. You are setting the inner (by default, horizontal) `BoxLayout` to have an explicit height of 40 display pixels. This means the `TextInput` and two button widgets inside will be constrained to that height, since they expand to fill the full height of the parent. Note the explicit setting of `size_hint_y` to `None`!
- ➋ The `TextInput` is given a `size_hint_x` of 50 to make it take up half the width of the window, since the parent widget takes up the full window size.
- ➌ ➍ The two `Button` objects are assigned a `size_hint_x` of 25 so they each take up a quarter of the width. The `size_hint_x` values for the three widgets total 100, making it easy for us to think of them as percentages.
- ➎ The `ListView` has not been given any additional size information. Its `size_hint` defaults to (1, 1). It's in a vertical `BoxLayout`, so its width will be the full width of the parent. The only other widget in that `BoxLayout` has a `size_hint_y` of `None`, so the `ListView` will take up all remaining vertical space after the 40dp for the other `BoxLayout` is deducted.

The result is rendered in [Figure 1-6](#). It was clearly coded by a programmer, not a user interaction designer, but it does the job and beautifully illustrates the concepts you've learned in this chapter.

File It All Away

Programming is a task that is best learned by doing, not reading, studying, watching, or listening. Take some time to try things and mess up. I close each chapter with a set of explorations you can use to guide your study. Don't think of them as exercises. Think of them as topics. Programming is best facilitated by a sense of wonder. Never be afraid to ask, "What happens if I do this?" (unless you are testing on live code deployed to a nuclear facility, moving vehicle, or my personal mobile phone). Here are a few ideas to get you started:

- Check out Kivy's extensive [API documentation](#), focusing on the `kivy.uix` modules, which describe the widgets shipped with Kivy. Pay special attention to the different types of `Layout` classes. `BoxLayout` is usually the best choice unless you're doing something specific.
- Clone the Kivy repository and check out the `examples` directory. Pay particular attention to the `showcase` and `kivycatalog` examples in the `demo` folder. The latter

even allows you to interactively change KV language code to see what happens. It's pretty awesome (I wrote it).

- Try coming up with several toy layout projects using the widgets you encountered in this chapter and any others that tickle your fancy. If you're having trouble coming up with ideas, try a basic login form (`TextInput` has a Boolean `password` property) or a web browser toolbar.
- Experiment *a lot* with different `size_hint` and `size` combinations on a `BoxLayout` until you understand what works and what doesn't.
- Experiment with the other built-in Layout classes that come with Kivy. `FloatLayout` and `GridLayout` are popular for certain specific tasks. `AnchorLayout` and `StackLayout` have, in my opinion, less common utility. Figure out how each interprets `size_hint` and `size`.

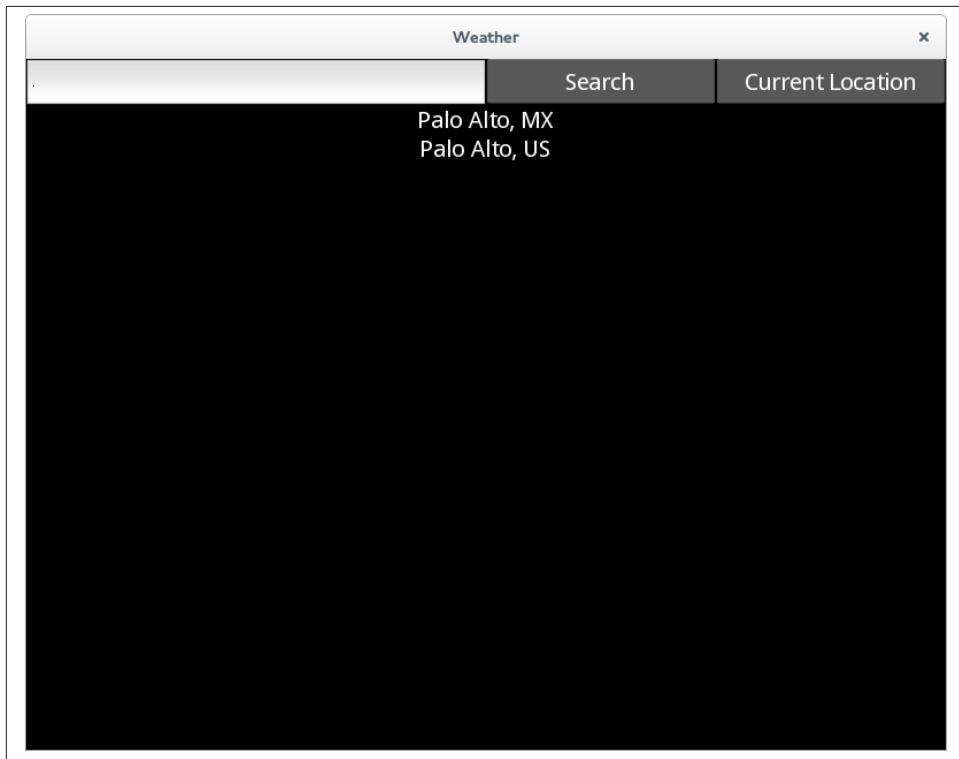


Figure 1-6. *AddLocationForm* with reasonable widget proportions

Events and Properties

In this chapter, you'll learn what Kivy means, specifically, by the words *event* and *property*. You'll also learn how to respond to events using event handlers and how changing properties automatically fires events on those properties. I'll include a digression on choosing client libraries. By the end of the chapter, you will be able to search for weather locations anywhere in the world.

What Is an Event?

Dictionary.com defines an event as “something that happens, especially something important.” That’s a perfect description of events in Kivy. Kivy is firing events all the time, but you only have to pay attention to those that you consider important. Every graphical toolkit has some concept of events. The difference between Kivy and those other toolkits is that in Kivy, event dispatch and handling are sane and uncomplicated.

Like most user interface toolkits, Kivy provides an *event loop*. This is executed by your Python code when you call the `run` method on `WeatherApp`. Underneath the hood, this method is constantly cycling through events such as touch or mouse motion, clock ticks, keyboard entry, accelerometer input, and more. When something interesting happens, it does the necessary processing to make sure that your code knows the event has happened and has a chance to respond.

So if an event is something that happens, an event handler is something that responds to something that happens. In Kivy, an event handler is just a function or method. By the end of this chapter, your event handler is going to search for potential locations to retrieve weather for and add them to the `ListView`. But you can start a bit smaller: how about just printing a message to the console from which your Kivy app is running?

Adding Logic to a Custom Widget

I have a guideline. It's a strict guideline—you might call it a rule—but there are legitimate reasons to break it. The guideline is this: layout and graphical information should always go in the KV language file. Logic (the calculations and activities that make up a program) should always go in a Python file. Keeping these two types of information separate will save hours in the long-term maintenance of your app.

You may have noticed in the previous chapter that I didn't touch the Python file at all. All the changes happened in the KV language file. This is because that chapter was entirely related to the user interface. This chapter is going to do some logic. Granted, that logic is going to change the user interface (for example, by updating the values in the `ListView`), but such activity still belongs in the Python file.

The Python file, therefore, needs to know about the `AddLocationForm` custom widget that you defined in [Chapter 1](#). I kind of cheated in that chapter by allowing the KV language file to create a class dynamically using the `@BoxLayout` syntax. Take that out first, as shown in [Example 2-1](#).

Example 2-1. Making AddLocationForm into a normal, rather than dynamic, class

`AddLocationForm:`

```
<AddLocationForm>: # ❶
    orientation: "vertical"
    BoxLayout:
        height: "40dp"
        size_hint_y: None
        TextInput:
            size_hint_x: 50
        Button:
            text: "Search"
            size_hint_x: 25
        Button:
            text: "Current Location"
            size_hint_x: 25
    ListView:
        item_strings: ["Palo Alto, MX", "Palo Alto, US"]
```

- ❶ The `@BoxLayout` was removed, changing this into a normal class.

You won't be able to run this KV language file because you took out the Kivy magic that allows it to know what kind of class it's supposed to be. Dynamic classes are a shortcut in Kivy that are most often useful if you want to reuse the same widget layout settings—with no logic—in multiple locations. For example, if you had a group of buttons that all needed to be styled similarly, you could create a dynamic class that extends `Button` and set the relevant properties on them. Then you could use instances of that class in multiple locations, instead of having a bunch of duplicate code for all the buttons.

However, `AddLocationForm` is a rather normal class that needs logic attached to it. Start by adding a class definition to the `main.py` file, as shown in [Example 2-2](#).

Example 2-2. Adding a class to main.py

```
from kivy.app import App
from kivy.uix.boxlayout import BoxLayout # ❶

class AddLocationForm(BoxLayout): # ❷
    pass

class WeatherApp(App):
    pass

if __name__ == '__main__':
    WeatherApp().run()
```

- ❶ Remember to import the class you are extending.
- ❷ Inheritance is used to create a new subclass of `BoxLayout` with no extra logic just yet. The rule in the KV language file, which matches this class based on the class name, will apply all the additional styling for this form. This styled class is then set as the root class in the KV language file.

If you now run `python main.py`, it will behave exactly the same as at the end of [Chapter 1](#). Not much gain, since all you've done is make the code more verbose, but you'll be adding logic to this class right away.

Responding to Events

Quickly add a method to the new class that prints a short maxim to the console when it is called, as shown in [Example 2-3](#).

Example 2-3. Adding some very simple logic

```
class AddLocationForm(BoxLayout):
    def search_location(self): ❶
        print("Explicit is better than implicit.")
```

- ❶ The method doesn't accept any arguments. This is just a normal method; it's not an event handler.

You'll be adding an event handler to the KV language file now. It's just one line of code. The boundary between user interface and logic should, in my opinion, always be one line of code in the KV language file. That single line of code can, and should, call a

method in the Python file that does as much processing as is required. Have a look at the modified code for the search button in [Example 2-4](#).

Example 2-4. Hooking up the event handler

```
Button:  
    text: "Search"  
    size_hint_x: 25  
    on_press: root.search_location() ❶
```

- ❶ The event handler is accessed as a property on the `Button` object with a prefix of `on_`. There are specific types of events for different widgets; for a button, the `press` event is kicked off by a mouse press or touch event. When the `press` event happens, the code following the colon—in this case, `root.search_location()`—is executed *as regular Python code*.

When you run this code, you should see the phrase `Explicit is better than implicit` display in the console every time you press the Search button in the interface. But what is actually happening?

When the `press` event fires, it triggers the event handler, which is essentially just a method on the `Button` class named `on_press`. Then it executes the contents of that method, which has been defined in the KV language file to contain the single line of code `root.search_location()`.

Assume, for a second, that the `root` variable points at an instance of the class that is leftmost indented in this KV language block—that is to say, the `<AddLocationForm>` class rule. This object has a `search_location` method, since you added it just a few moments ago, and that method is being called. So, each time you touch the button, the `print` statement inside `search_location` is executed.

In fact, that assumption is correct. When the KV language executes anything as raw Python code, as in these event handlers, it makes a few “magic” variables available. You just saw `root` in action; it refers to the leftmost indented object: the current class rule. The `self` variable refers to the rightmost indented object. If you accessed the `self.size` property from inside the `on_press` handler, you’d know how big the button was. Finally, the `app` variable refers to the subclass of `App` on which your code originally called the `run` method. In this code, it would be an instance of `WeatherApp`. This isn’t that useful in your current code, but when you start adding methods to `WeatherApp`, the `app` magic variable will be the way to access them.

Accessing Properties of KV Language Widgets

Before you can search for the value that the user entered into the text box, you’ll need to be able to access that value from inside the Python code. To do that, you need to give

the widget in question an identifier, and then provide a way for the Python file to access that named object.

This is a good time to delve into the Kivy concept of *properties*. Kivy properties are somewhat magical beings. At their most basic, they are special objects that can be attached to widgets in the Python code and have their values accessed and set in the KV language file. But they add a few special features.

First, Kivy properties have type-checking features. You can always be sure that a `String` property does not have an integer value, for example. You can also do additional validation, like ensuring that a number is within a specific range.

More interestingly, Kivy properties can automatically fire events when their values change. This can be incredibly useful, as you will see in later chapters. It's also possible to link the value of one property directly to the value of another property. Thus, when the bound property changes, the linked property's value can be updated to some value calculated from the former.

Finally, Kivy properties contain all sorts of knowledge that is very useful when you're interfacing between the KV language layout file and the actual Python program.

For now, just know that the `ObjectProperty` property can be bound to any Python object. Your KV language file will be set up to attach this property to the `TextInput` object. First, though, set up your `main.py` code to import `ObjectProperty` and add an instance of it with an empty value to `AddLocationForm`, as shown in [Example 2-5](#).

Example 2-5. Adding a property to point at the search input widget

```
from kivy.properties import ObjectProperty ❶

class AddLocationForm(BoxLayout):
    search_input = ObjectProperty() ❷

    def search_location(self):
        print("Explicit is better than Implicit")
```

- ❶ Remember to import the class.
- ❷ The property is created at the class level as an instance of the `ObjectProperty` class.

Next, modify the `weather.kv` file to do two things. First, you want to give the `TextInput` an `id` property so that it can be internally referenced from other parts of the KV language file. Note that these `ids` aren't useful outside of the KV language rules. That means you'll also have to set the value of the `search_input` property you just created to this `id`. The KV language will take care of setting the value in your Python code to

point directly at the `TextInput` widget object. Make the two modifications shown in [Example 2-6](#).

Example 2-6. Setting the search input id and property value

`AddLocationForm`:

```
<AddLocationForm>:
    orientation: "vertical"
    search_input: search_box # ❶
    BoxLayout:
        height: "40dp"
        size_hint_y: None
        TextInput:
            id: search_box # ❷
            size_hint_x: 50
        Button:
            text: "Search"
            size_hint_x: 25
            on_press: root.search_location()
        Button:
            text: "Current Location"
            size_hint_x: 25
    ListView:
        item_strings: ["Palo Alto, MX", "Palo Alto, US"]
```

- ❶ First, add an `id` attribute to the `TextInput` so it can be referenced by name elsewhere in the KV language file.
- ❷ Then set the value of the property, which was defined in [Example 2-5](#), to that `id`.

The Difference Between Kivy Properties and Python Properties

Kivy and the Python language both have concepts they call *properties*. In both cases, properties sort of represent named values on objects, but they are not the same thing, and you have to be careful to distinguish between them. They are not interchangeable at all. In the context of Kivy development, Kivy properties are more useful, but there is nothing stopping you from using Python properties as well, for other purposes.

A Python property is a method (or set of methods) that can be accessed as if it were an attribute. Different methods are called if the property is retrieved or set. This can be a useful form of encapsulation.

Kivy properties, on the other hand, are not a language feature, but are simply objects that wrap a bunch of logic for the various features described in the text. They are specified on widget classes, and the Kivy internals know how to seamlessly map them to each instance of those properties as used in the Python code or KV language file.

Kivy will take care of making sure that the `ObjectProperty` in the Python code directly references the `TextInput` widget object, with all the properties and methods that the `TextInput` has. Specifically, you can now access the value the user entered from inside the `search_location` method using the `text` property, as shown in [Example 2-7](#).

Example 2-7. Accessing a widget attribute via ObjectProperty

```
def search_location(self):
    print("The user searched for '{}'".format(self.search_input.text)) ❶
```

- ❶ Access the `text` property on the `search_input` widget. In this example, just print it out.

Populating the Search Result List

Now that you can access the value the user searched for, the next step is to look up possible matching cities. To do this, you need weather data to query.

One option, of course, would be to invest millions of dollars into setting up weather stations across the world; then you'd have your own private network of data to query. Unfortunately, that's slightly outside the scope of this book. Instead, you can take advantage of other services that have already done this part and have made their data publicly available.

I had a look around the vast reserves of the Internet and discovered [Open Weather Map](#), which supplies an international API for looking up weather data. I don't know how accurate it is, but this is what you'll be using to create your Kivy interface. It is free, allows essentially unlimited requests, and doesn't require an API key (though it is recommended for production systems). It's also founded on "open" principles like Wikipedia, OpenStreetMaps, Creative Commons, Open Source, and Gittip. I believe strongly in these principles.

Choosing APIs and Libraries

I just arbitrarily told you what API you are going to use to access weather data. This took a huge amount of effort out of the programming process for you. This is unfortunate, as determining what libraries to base your program on is a major part of the development effort. Programming books tend to introduce the subject as if you will be writing all of your work from scratch. This isn't true. The success of any new application is strongly impacted by what third-party libraries or APIs are used to create it. I spend a vast amount of time up front researching available options and trying to figure out which one will maximize the effectiveness of my app.

For any given problem that you need to solve, search the Web to see what existing libraries are available. Programmers hate duplicating work, and you'll find most tasks

have already been completed! Once you have a list of available libraries, study each one, paying attention to questions such as these:

- Is the license compatible with the license you want to use for your application?
- If not open source, how much does it cost to license the library?
- If open source, does the source code for the library look well maintained and easy to read?
- Does the library appear to be actively developed and has there been a recent release?
- Is there an active user community talking about the library?
- Does the library appear to have useful (readable, up-to-date, complete) documentation?
- What avenues of support are available if you have trouble?
- If Python-based, does the library boast Python 3 support?

Open Weather Map is a web service that returns data in JavaScript Object Notation (JSON). Python has a superb built-in JSON parsing library that converts the incoming data to Python dictionaries and lists. However, you still need a way to retrieve that incoming data. There are built-in tools to handle this in the Python standard library, but you're much better off using the `UrlRequest` class that Kivy provides. This class supplies a fully asynchronous API, which means that you can initiate a request and allow the user interface to keep running while you wait for a response.

Since this book is about Kivy, I'm not going to give you a lot of detail about the structure of the Open Weather Map data. Its website explains this in detail. The examples include all the code you'll need to actually perform these tasks.

The next step is to connect to the weather map service when the user clicks the Search button and retrieve a list of cities that match those search results. As [Example 2-8](#) illustrates, this is not a difficult task.

Example 2-8. Retrieving map data using requests and printing the list of cities to the console

```
def search_location(self):  
    search_template = "http://api.openweathermap.org/data/2.5/" +  
        "find?q={}&type=like" ①  
    search_url = search_template.format(self.search_input.text)  
    request = UrlRequest(search_url, self.found_location) ②  
  
def found_location(self, request, data): ③  
    cities = ["{} ({})".format(d['name'], d['sys']['country'])  
        for d in data['list']] ④  
    print("\n".join(cities))
```

- ❶ The {} in the URL is a placeholder for the user's query. The `str.format` method is used in the next line to replace this value with the value that the user actually searched for.
- ❷ You'll need `from kivy.network.urlrequest import UrlRequest` at the top of the file. This line is doing a lot of work on your behalf. It connects to the Open Weather Map URL and downloads the response. It then returns control to the UI, but when the response comes back from the network, it will call the `found_location` method, which is passed in as an argument.
- ❸ The data passed by `UrlRequest` is a parsed dictionary of JSON code.
- ❹ This list comprehension is also doing a huge amount of work. This command is iterating over one list and translating it into a different list, where the elements are in the same order but contain different data. The data, in this case, is a string with the name of the city and the country in which it's located.



There is a bug in Kivy 1.8.0 under Python 3. When you are using Kivy 1.8.0 and Python 3, `UrlRequest` fails to convert the incoming data to JSON. If you are using this combination, you'll need to add `import json` and put `data = json.loads(data.decode())` at the top of `found_location`.

Comprehensions

Comprehensions can be pretty incomprehensible to the uninitiated (and are therefore poorly named). However, they are one of Python's strongest language features, in my opinion. Newer Python users tend to overlook them, so I thought I'd give you a crash course here.

Python has built-in support for *iterators*; that is, container items that can have their elements looped over one by one. Built-in iterators include lists, tuples, strings, dictionaries, sets, and generators. It's trivial to extend these objects or create new objects that can be iterated over. The `for` loop is the traditional method of iteration.

However, one of the most common tasks of a `for` loop is to convert a sequence of objects into another, transformed sequence. Comprehensions allow us to do this in a compact and easy-to-read syntax. The transformations that can happen inside a comprehension include:

- Changing the container to a different type of sequence. For example, you can iterate over a set and store the results in a list or dictionary.
- Altering each value into a different format. For example, you can convert a list of strings containing numbers into a list of integers, or you can convert a list of strings into a list of strings with newlines on the end.

- Filtering out values that don't conform to a specific condition. For example, you can convert a list of integers into a list of only the even integers in the list, or you can convert a list of strings into a list of nonempty strings.

You'll see examples of comprehensions throughout this book, but if you want more information, search the Web for *list comprehensions*, *dictionary comprehensions*, or *set comprehensions in Python*.

Now all you need to do is figure out how to update the list of results on the screen instead of printing to the console. This is also surprisingly simple since the data is stored in a Kivy property on the `ListView` widget.

First, add an `id` to the `ListView` and set it up as an assigned property in the `weather.kv` file, as shown in [Example 2-9](#).

Example 2-9. Updating search results

`AddLocationForm:`

```
<AddLocationForm>:  
    orientation: "vertical"  
    search_input: search_box  
    search_results: search_results_list # ❶  
    BoxLayout:  
        height: "40dp"  
        size_hint_y: None  
        TextInput:  
            id: search_box  
            size_hint_x: 50  
        Button:  
            text: "Search"  
            size_hint_x: 25  
            on_press: root.search_location()  
        Button:  
            text: "Current Location"  
            size_hint_x: 25  
    ListView:  
        id: search_results_list # ❷  
        item_strings: [] # ❸
```

- ❶ You don't have an `ObjectProperty` in `main.py` yet, but assign it here anyway.
- ❷ Set an `id` on the `ListView` so it can be referenced in the property assignment above.
- ❸ Empty the default values from the list, since you won't be needing them for layout testing anymore.

Then, add the `search_results` `ObjectProperty` to the `AddLocationForm` class and update the contents of the property in the `found_location` method instead of printing results to the screen, as shown in [Example 2-10](#).

Example 2-10. Updating the list of search results on search click

```
def found_location(self, request, data):
    data = json.loads(data.decode()) if not isinstance(data, dict) else data ❶
    cities = ["{} ({})".format(d['name'], d['sys']['country'])
              for d in data['list']]
    self.search_results.item_strings = cities ❷
```

- ❶ Work around the aforementioned bug in which `URLRequest` doesn't parse JSON under Python 3. This line of code works on both Python 2 and Python 3 and should also work with future versions of Kivy that fix the bug. It is an ugly workaround, but at least the ugliness is constrained to one line. This line uses Python's ternary operator to check if the data has been converted to a `dict` already, and if not, it loads it using the `JSON` module. You'll need to add an `import json` at the top of the file.
- ❷ End the chapter with the easiest line of code imaginable: set the `item_strings` property on the `self.search_results` list to the list of cities.

And that's it. If you now run `python main.py`, you can search for Vancouver and get two expected results, as shown in [Figure 2-1](#).



When you test this search form, you can crash the application by searching for a place with no matches. Search for a real place. You'll explore error checking in the exercises.

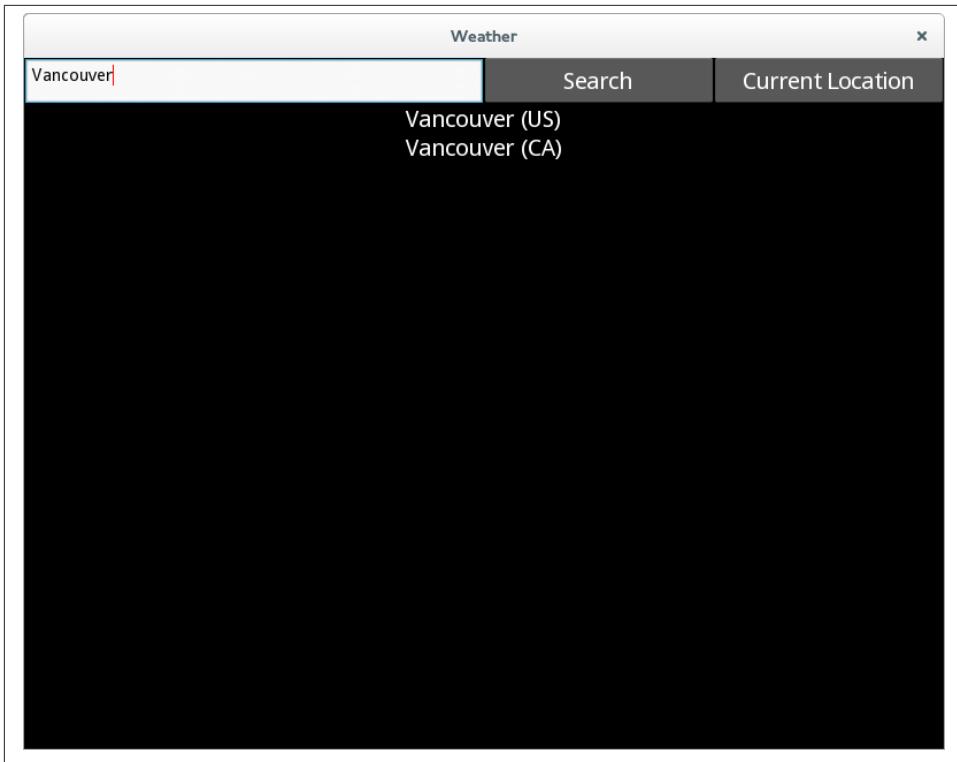


Figure 2-1. Rendering of search results in the basic container widget

File It All Away

We covered two important Kivy topics in this chapter: events and properties. I didn't get into a great deal of detail about either of them yet. You might want to try some of the following tasks to enhance and lock in your new knowledge:

- Accessing the GPS device in Android is covered in [Chapter 9](#), but for now, you could invite users to enter a `latitude,longitude` pair into the text field. If they click the Current Location button, it could signify that they intended to search by latitude and longitude instead of city name. If you look at the documentation for the Open Weather Map database, you can see that it allows searching by latitude and longitude. Try hooking up this button.
- This app crashes if your search doesn't have any matches. I had a great internal debate about this, but I have left error checking out of most of the examples to make sure the code you see is comprehensible. However, that makes the code unrealistic. All real-world code needs to have solid error checking. Try to make the `search_location` and `found_location` methods resilient against searching for places that

don't exist, transient network failures, and as many other problems as you can come up with.

- You've only seen the `on_press` event for buttons. See if you can figure out how to make `on_enter` on the `TextInput` object call the same function and perform a similar search.
- Read through the Kivy documentation for some of the basic widgets you've heard about to see what kinds of properties and events are supported for each.
- Try making a new toy app that links the text of a label to the text of an input, such that typing into the input changes the label. Hint: this is easier than you might guess and does not require setting up an `on_text` handler. It can be done with just a boilerplate `main.py` file; all the connections can happen in the KV language.

Manipulating Widgets

It's time to think about widgets again. In this chapter, you'll see how to dynamically change what widgets are displayed in the widget tree. You'll mainly be implementing searching and the rendering of search results. This will give you a good understanding of the intricacies of the Kivy `ListView` widget and its adapters, and you'll also learn how to create widgets and update the display dynamically in response to user or system events.

A More Extensible Root Widget

While the user will find it useful for the `Add Location` form to be rendered the first time the application is run, it's not actually appropriate to set it as the root widget on the app. It's better to have a custom root widget that knows how to manage the widgets that are displayed on it, such as the various forms I mentioned in [Chapter 1](#).

I expect the root widget to have several methods for manipulating the display of child widgets. Start by adding an empty class to the `main.py` file. Make it extend `BoxLayout`, but for now, the class can be otherwise empty (meaning it will behave exactly like a normal `BoxLayout`). See [Example 3-1](#).

Example 3-1. Empty root class

```
class WeatherRoot(BoxLayout):  
    pass
```

For now, set up the KV language file to render an instance of this as the root widget. Then set up a new rule for it to include `AddLocationForm` as a child, as demonstrated in [Example 3-2](#).

Example 3-2. Root widget with AddLocationForm child

`WeatherRoot:`

```
<WeatherRoot>:  
    AddLocationForm
```

Since the parent class is a `BoxLayout` with only one child, it will render `AddLocationForm` as taking up 100% of its surface area. So, running the application looks exactly the same as before.

You'll be adding some code to customize this widget class shortly, and a lot more throughout this book, but for now, this empty class is sufficient while you work out how to handle events on the `ListView` object.

ListView Adapters

The Kivy `ListView` API includes full support for managing and displaying selection. However, for starters, all you need it to do is hold a list of widgets that can respond to touch events. When the user touches a location in the Add Location list, you need to respond to the event appropriately. We'll deal with "appropriately" later; for now, just worry about responding to the event!

By default, the `ListView` renders a `Label` widget for each string in the list, but `Label` is an inert widget that doesn't care when it gets touched. Luckily, `ListView` can use different classes (including custom classes) as the widget to be displayed for each item. Kivy supplies two classes, `ListItemLabel` and `ListButtonItem`, that behave like normal `Label` and `Button` objects but also contain information for tracking selection. Tracking selection is mandatory for `ListView` widgets, so it's almost always a good idea to extend one of these classes, depending on whether you want to just display data (use `ListInputLabel`) or respond to touch events (use `ListButtonItem`).

Start by editing the `weather.kv` file. You'll need to add a couple of `import` statements at the top of the file first, as shown in [Example 3-3](#).

Example 3-3. Imports for adapter buttons

```
#: import ListItemButton kivy.uix.listview.ListItemButton  
#: importListAdapter kivy.adapters.listadapterListAdapter
```

KV imports work similarly to Python imports but use a different syntax. They exist because sometimes you need access to Python modules in your KV language file other than those that are magically available as part of the Kivy builder process. This normally happens in the small parts of the KV language file that map to actual Python execution.

Imports in the KV language start with the characters `#: import` followed by an alias for the module or member being imported. This is followed by the full path to the

module or class to be imported. The alias can then be used throughout the KV file as a reference to that item. In this case, you need to import `ListAdapter` and the `ListItemButton` classes. See [Example 3-4](#) to learn why.

Example 3-4. ListView with adapter specified

```
ListView:  
    id: search_results_list  
    adapter:  
        ListAdapter(data=[], cls=ListItemButton)
```

It's hard to see the boundary between the KV language and Python here. The adapter property is KV language, but its value is Python code in which you are constructing a `ListAdapter` object. The `ListItemButton` class is then passed into this initializer.

The main thing you need to know about the `ListAdapter` class is that it sits between the `ListView` and the data (in this case, a list of strings). It can do a few things while it's sitting there, like keeping track of which item is selected, making sure the view stays up-to-date when data changes, setting what widget class is used to render the data, and mapping data between the input format and widget properties.

The defaults for all of these settings work fine in this example, except the widget class, which is now set to a `ListItemButton` object instead of the default `ListItemLabel`. Unfortunately, running this code would break the interface because the Python code you wrote previously is not updating the new `ListAdapter`. It's still trying to update the default class on a `ListView`, called a `SimpleListAdapter`. This is easily remedied, as shown in [Example 3-5](#).

Example 3-5. Using the ListAdapter API in the search method

```
def search_location(self):  
    search_template = "http://api.openweathermap.org/data/2.5/" +  
        "find?q={}&type=like"  
    search_url = search_template.format(self.search_input.text)  
    request = UrlRequest(search_url, self.found_location)  
  
def found_location(self, request, data):  
    data = json.loads(data.decode()) if not isinstance(data, dict) else data  
    cities = ["{} ({})".format(d['name'], d['sys']['country'])  
        for d in data['list']]  
    self.search_results.item_strings = cities  
    self.search_results.adapter.data.clear() ❶  
    self.search_results.adapter.data.extend(cities) ❷  
    self.search_results._trigger_reset_populate() ❸
```

- ❶ You can't just set the data to an empty list because the container involved is an instance of `ObservableList`. Instead, clear the list...
- ❷ ...and then extend it with the new data.

- ③ `ListAdapter` is supposed to update the display when it sees the data change, but it's not doing its job, so you should force an update here. This is an undocumented method that it took me half an hour of searching through Kivy source code to find. Sometimes searching through source code is the best way to learn things. The Kivy sources are well written and easy to read; you can learn a ton from perusing them.

Now run the application and search for a location. The `ListView` renders buttons now, instead of the default labels, as shown in [Figure 3-1](#).



Figure 3-1. Rendering of buttons in the ListView

list.clear in Python 2 and Python 3

The `list` class, from which Kivy's `ObservableList` inherits, has a handy `clear` method. This method is being called in [Example 3-5](#) to remove any previous search results from the list.

Unfortunately, `clear` was introduced to the `list` class in Python 3 and isn't available in Python 2. The syntax you'll want to use instead is `del self.search_results.adapter.data[:]`, which effectively deletes all the objects in the list.

Note that you do *not* want to do something like `self.search_results.adapter.data = []`. This will have the effect of clearing the list, but you will have set the value to a normal list instead of the `ObservableList` that Kivy originally instantiated on the adapter. This means it won't be able to do the extra Kivy stuff (like listen for change events on the list), and the `ListView` will be broken.

Responding to ListView Item Events

Unfortunately, these buttons don't provide easy access to event handlers. You can remedy this by making a subclass of the `ListButtonItem` in `main.py`, as shown in [Example 3-6](#).

Example 3-6. Creating a subclass of ListButtonItem

```
from kivy.uix.listview import ListButtonItem

class LocationButton(ListButtonItem):
    pass
```

Next, update the imports in `weather.kv` to import this `main` module instead of the `ListButtonItem` class; see [Example 3-7](#).

Example 3-7. Importing a custom class from main

```
#: import main
#: importListAdapter kivy.adapters.listadapterListAdapter
```

Finally, update the `cls` reference, as shown in [Example 3-8](#).

Example 3-8. Point cls at the new class

```
ListView:
    id: search_results_list
    adapter:
       ListAdapter(data=[], cls=main.LocationButton)
```

With this slight modification, running the app won't look any different. However, you can now add style rules to the KV language file, including the event handler in [Example 3-9](#).

Example 3-9. KV rule for Location button

```
<LocationButton>:  
    on_press: app.root.show_current_weather(self.text)
```

In the KV language, the `app` magic variable points at the currently running App subclass. In your code, this is an instance of `WeatherApp`. The `App` class has a `root` variable that points at the root object defined in the KV language file—in this case, a `WeatherRoot` instance. That widget doesn't currently have a `show_current_weather` function, but you can add that next, as shown in [Example 3-10](#).

Example 3-10. Placeholder to show weather

```
class WeatherRoot(BoxLayout):  
    def show_current_weather(self, location):  
        from kivy.uix.label import Label  
        self.clear_widgets()  
        self.add_widget(Label(text=location))
```



Be careful not to confuse the `root` magic variable, which refers to the leftmost rule in the current indentation block, with `app.root`, which always refers to the root widget of the app. `app.root` refers to the same object anywhere in the KV language file, but `root` refers to a different thing depending on what rule it is found in.

This method is really just stubbed out as a placeholder. It creates a label in Python code, something you haven't seen before. So far, you've created all your widgets in the KV language file. Occasionally, you need to do it in Python. No widgets accept positional arguments upon construction, but some allow you to pass arbitrary properties into the constructor. Thus, you can set the `orientation` on a `BoxLayout` or the `size_hint_x` on a widget directly when constructing it in Python. This works fine, but it's less readable than the KV language and, more importantly, fails to separate interface concerns from logic.

I imported the `Label` class directly in the method because this is temporary code that I expect to remove soon. It is a good idea, when coding, to create something that works in as few lines of code as possible and test that before going on. This approach is far easier to debug and far more likely to generate comprehensible code with fewer errors than writing a hundred lines of code and hoping it's correct. I make this point because I want it to be clear that this style of development is valuable, and [Example 3-10](#) is not just a pedagogical example. See it running in [Figure 3-2](#). Note that you'll have to exit

the program after selecting the location; you'll be making the `AddLocationForm` reusable shortly.

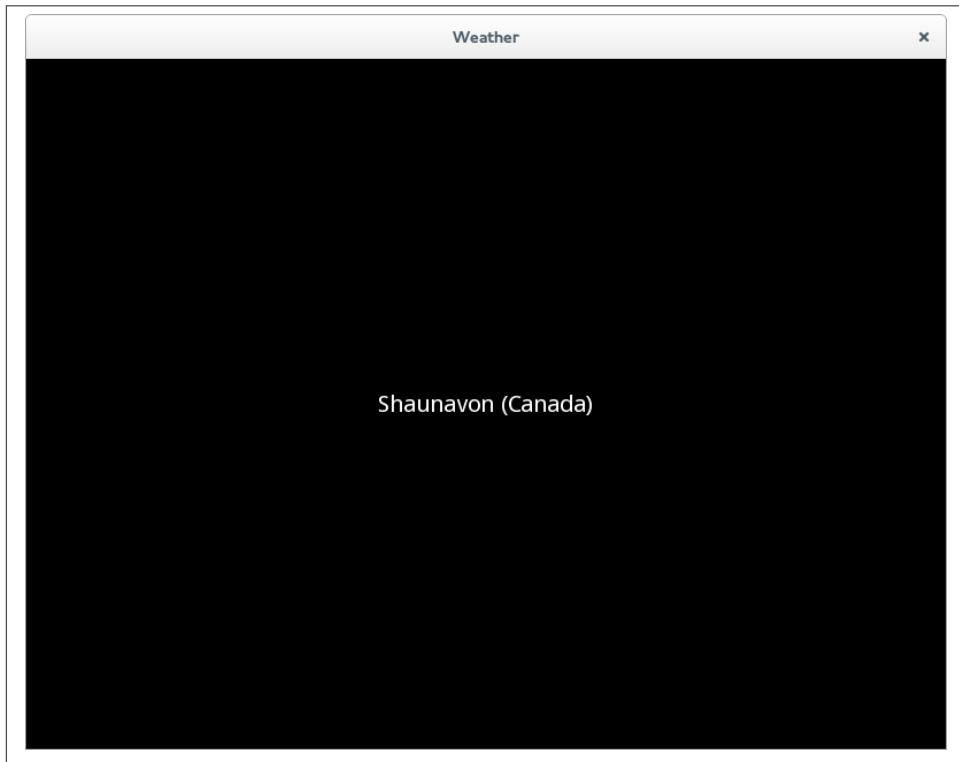


Figure 3-2. Label rendered after selecting a location

Swappable Widgets

You can probably guess that adding a `Label` directly to the root window isn't going to be a viable long-term solution. What you need is a way to switch between the `AddLocationForm` and the `CurrentWeather` widget. I'll go through the steps to do this, but take a moment to think about the problem first. How would you approach it?

I think it's pretty clear that another widget is required to hold the "current weather" data. Anytime you add a new widget to your Kivy project, you should ask yourself, "Does this widget need to have a class in the Python code, or can I use a dynamic widget?" `CurrentWeather` is largely going to be a display-only object, so a dynamic class seems sufficient for now. The entire widget is stubbed out in [Example 3-11](#).

Example 3-11. Basic layout for CurrentWeather widget

```
<CurrentWeather@BoxLayout>:  
    location: "" ①  
    conditions: None  
    temp: None  
    temp_min: None  
    temp_max: None  
    orientation: "vertical" ②  
    Label:  
        text: root.location ③  
    BoxLayout:  
        orientation: "horizontal"  
        size_hint_y: None ④  
        height: "40dp"  
        Button:  
            text: "Add Location"  
        Button:  
            text: "Forecast"
```

- ① These are the custom properties that I expect to set later when actually setting the weather.
- ② Setting inherited properties on dynamic classes is also allowed. This widget extends `BoxLayout`, but you want it to render vertically.
- ③ The root variable is referencing the `CurrentWeather` object itself. You're connecting the `text` property on the `Label` to the `location` property that was defined earlier. These are connected dynamically, such that updating the location field on the class will automatically update the displayed label text.
- ④ There's a good chance you've already forgotten that you must explicitly set `size_hint_y` to `None` if you are setting a `height`.

Now all you have to do is generate this class instead of a label in `main.py`. Since you're constructing a dynamic class, you won't be able to simply import it. Instead, add the `Factory` import to the top of the file, as shown in [Example 3-12](#).

Example 3-12. Importing Factory

```
from kivy.factory import Factory
```

Then adapt the `show_current_weather` method to construct an instance of this dynamic class from the factory, set the location, and render it. [Example 3-13](#) reveals all.

Example 3-13. Constructing a dynamic widget from Factory

```
class WeatherRoot(BoxLayout):  
    def show_current_weather(self, location):  
        self.clear_widgets()  
        current_weather = Factory.CurrentWeather()
```

```
current_weather.location = location  
self.add_widget(current_weather)
```

Notice how the dynamic class is constructed by the factory. Then it can be treated like any other widget, because it is one. If you run the app and render it, it will look like [Figure 3-3](#).

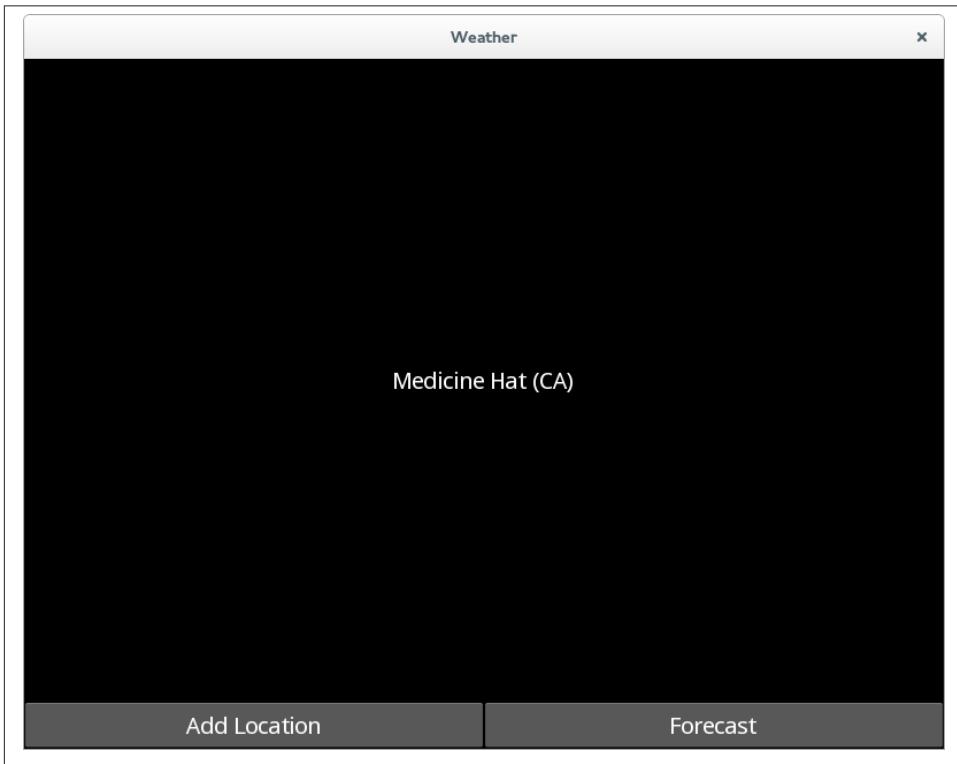


Figure 3-3. Making the widget dynamic

Switching Forms

Try hooking up the `on_press` handler on the Add Location button that is part of the `CurrentWeather` widget. It should be a very similar workflow to what you just saw in the previous section, except that instead of constructing a `CurrentWeather` widget, you'll construct an Add Location form.

Work on this on your own for a bit before looking at the minor changes in [Example 3-14](#) and [Example 3-15](#).

Example 3-14. Event handler for the Add Location button

```
Button:  
    text: "Add Location"  
    on_press: app.root.show_add_location_form()
```

Example 3-15. New event handling method on the WeatherRoot object

```
def show_add_location_form(self):  
    self.clear_widgets()  
    self.add_widget(AddLocationForm())
```

Your user can now move back and forth between the `AddLocationForm` view and the `CurrentWeather` view. You aren't rendering any real data yet, and the "Add" is a bit of a lie, since all you're doing is switching between locations, not adding them to a list. However, there's some structure coming to the application, and you can see that it will be pretty easy to hook up weather retrieval machinery in the next chapter.

File It All Away

In this chapter, you picked up some additional experience with Kivy properties and events. These concepts are central to any Kivy application. You also learned more details about the complex `ListView` API and how to manipulate the widget tree. Here are some additional explorations for you:

- Change the background color of the `LocationButton`. You'll need to check the Kivy docs to find what property to change and how to represent colors in Kivy.
- Rendering the Add Location form every time is unnecessary. Try storing the entire widget as an `ObjectProperty` on `WeatherRoot` and add it to or remove it from the view as needed.
- Play with the layout of the Current Weather form to render some more placeholders (`Label` is sufficient) for Current Temp, High/Low, and Current Conditions.
- If you're looking for something a little more intense, you now have enough knowledge to make a basic to-do list application in Kivy.

CHAPTER 4

Iterative Development

For the most part, I have been designing the weather app you are now building exactly as I would have designed it without you along for the ride. I am a firm believer in *iterative development*. The basic principle of iterative development is to perform small design changes, one step at a time, such that at the end of each step, you have a working application. It may not be complete in terms of the design requirements, but it is complete in terms of the current version of itself.

Each chapter in this book is a development iteration. This is convenient for me, as an author, because it gives me an end game to focus on for each chapter. However, this is just a lucky coincidence. I hope that you will follow a similar iterative process in developing your own Kivy applications. Indeed, if you really want your iterations to make sense, I advise that your version-control commit messages tell a story, much like this book.



Iterative development is indoctrinated in various formal methodologies of software development. These are useful when you are coordinating development teams, as the more developers a project has, the more communication overhead there is.

If you're working in a team environment (and you will be, at some point), you might want to search the Web for terms such as *extreme programming* or *Scrum*. However, if you're developing mobile Kivy applications by yourself, you can probably get away with informal iterations and a notebook of ideas.

It's impossible to complete everything a project needs in a single development sprint. Therefore, you have to focus on the tasks you want to get done and organize the things that are being set aside. While each iteration is different, I find there are two broad categories:

- New feature development, where one or two major features are added in a single sprint. At the end of the iteration, the features will be working and functional, though they may not be complete.
- Code cleanup, where minor tweaks are made to a variety of previously implemented features to take it from a working demo to a usable product.

This chapter is going to be one of the latter type. You'll learn a few new Kivy principles while solidifying your knowledge of the topics we've already covered. At the end of it, you'll have a functional program that actually renders weather information. It might not be ready for consumption by the general public, but it will work!

Improving the Add Location Form

It would be handy for the search box text input to be automatically focused when the Add Location form is displayed. We can easily accomplish this using the `focus` property on the `TextInput` widget.

You can also hook up the widget such that an Enter keypress fires the search, by using the `on_text_validate` event. However, that event fires only if the `TextInput` has had multiline mode disabled (since the Enter key would insert a line break in multiline mode). For this particular `TextInput`, multiline mode doesn't make sense anyway.

The best part is that this change only has to be made in the `weather.kv` file, as the Python code was designed with the reusable `search_location` method. You can borrow this method in the `on_text_validate` event handler, and the form will respond exactly as though the Search button had been clicked.

These two properties, along with the new `focus` property, are displayed in [Example 4-1](#).

Example 4-1. Three new properties on TextInput

```
TextInput:  
    id: search_box  
    size_hint_x: 50  
    focus: True  
    multiline: False  
    on_text_validate: root.search_location()
```

If you run the app now, it will look the same, but you'll notice that it is much less painful to interact with. This is a big usability win for three lines of code!

Caching Widgets

Once created, widgets don't always have to be descended from the root window. Obviously, if they are not, they won't be visible on the screen. For example, when the user

switches from the `CurrentWeather` to the `Forecast` view and back, it probably makes sense to place the same widget back on the screen, rather than hitting the network and rendering the data all over again.

This chapter doesn't feature a `Forecast` view just yet, but in preparation for it, add to `AddLocationForm` a cached property and a Cancel button that switches back to the previous location when clicked. Most of this work can happen in the `show_current_weather` method, as shown in [Example 4-2](#).

Example 4-2. Caching the CurrentWeather widget

```
current_weather = ObjectProperty() ❶

def show_current_weather(self, location=None): ❷
    self.clear_widgets()

    if location is None and self.current_weather is None: ❸
        location = "New York (US)"
    if location is not None: ❹
        self.current_weather = Factory.CurrentWeather()
        self.current_weather.location = location
    self.add_widget(self.current_weather) ❺
```

- ❶ Create an `ObjectProperty` on the class to store the widget in.
- ❷ Add a default value to the `location` parameter so that API users (including your future self) know that `None` is an option and will check the method contents to see what happens.
- ❸ A rather ugly special case: if both `location` and `self.current_weather` are `None`, hardcode a default location. This method is typically called in one of two ways. In the first, a location is passed in, because the user just searched for a new location. In that case, the first conditional is skipped, and a whole new `self.current_weather` widget is constructed in the second conditional. The second way is to pass `None` into the method, which indicates that the user clicked Cancel on the Add Location form. In this case, both `if` statements are bypassed and the `self.current_weather` that was previously displayed is shown once again. The special case happens if there is no `self.current_weather` widget because the user pressed Cancel the very first time the form was shown. Then the first conditional triggers, and it replaces the `None` value with a hardcoded location as if the user had actually searched for New York.
- ❹ If the `location` is not `None`, either because it was passed in explicitly or hardcoded above, construct a new `CurrentWeather` widget. Immediately cache its value inside the `ObjectProperty`.
- ❺ Regardless of whether the cached widget was constructed from scratch or previously stored, add it back into the window.

There are two so-called *code smells* in this function. The first is the hardcoded value for location. This is going to cause grief later if you change the format of the location; this hardcoded value won't be in the new format and will have to be updated separately.

The second is the special case on location. If location is None, the method is supposed to render the previously rendered widget. However, the special case occurs if there is no previously rendered widget. Your code has to either explicitly check for this special case, as in [Example 4-2](#), or ensure that the case never occurs. I mention two options for exploring this in the exercises for this chapter.

This isn't a horrible amount of code, but it's about as much code as I ever want to write without testing that it's working properly. To test it, add the Cancel button to the *weather.kv* file, being sure to call the `show_current_weather` method in its `on_press` handler. Place the button at the same indentation level as the `ListView` so it takes up the full width of the screen. You can probably figure this one out on your own by now to confirm; have a look at [Example 4-3](#).

Example 4-3. Adding a Cancel button to the Add Location form

```
Button:  
    height: "40dp"  
    size_hint_y: None  
    text: "Cancel"  
    on_press: app.root.show_current_weather(None)
```

Running this code changes the form slightly to look like [Figure 4-1](#).

You should test all three branches through this code. If you run the program and immediately click Cancel, it should render the location as New York (US). If you click Add Location, do a search, and select a different city, it should render that city. Click Add Location once again followed by Cancel to see that the previously selected city still works.

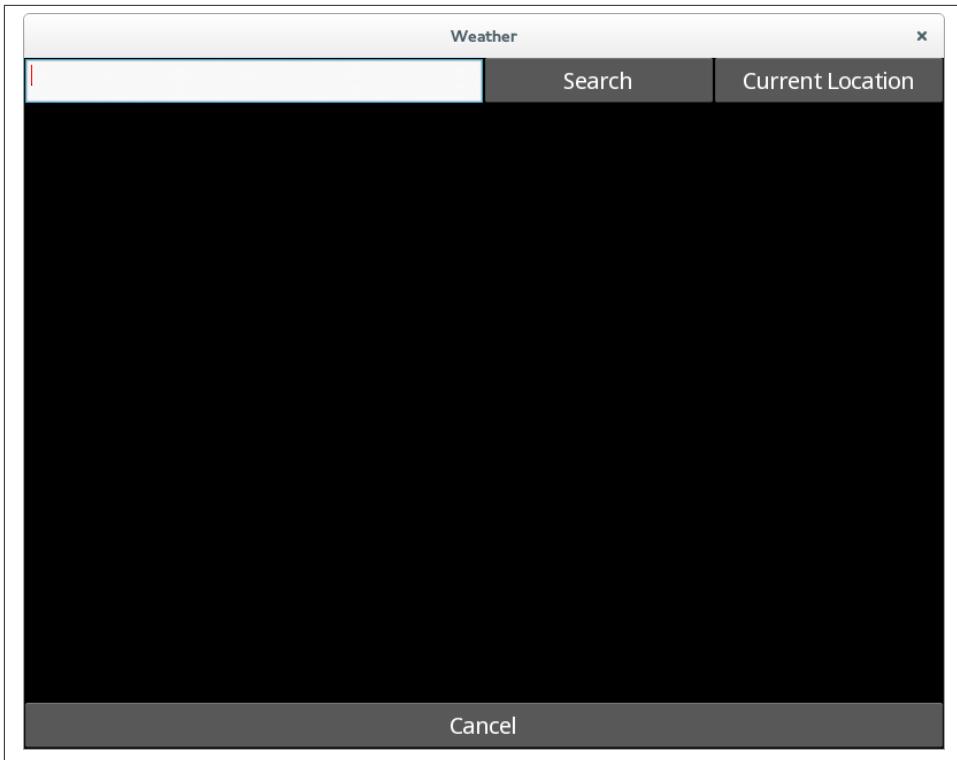


Figure 4-1. Adding a Cancel button to the Add Location form

Storing Actual Locations and Converting Arguments

The [Open Weather Map](#) API expects the city and country name to be specified in a comma-separated list. However, so far, I have combined it into a somewhat more human-readable `city (CC)` format, where CC is the country code. (I'm not sure what Open Weather Map does if more than one city in a country has the same name!) Take a few minutes to think of some ways to solve this code design issue.

Off the top of my head, I can think of three possible solutions:

- Use regular expression matching to split the city and country back into their component parts. This would probably work flawlessly, but it makes me a bit nervous in case there is some bizarre city out there that has brackets in its name or something.
- Change the format stored in the string to a `city,CC` value so it can be submitted directly to Open Weather Map. This would also work all right, but would it not be overly readable for the user and would eventually break when Open Weather Map changes its API.

- Store the city and country as a tuple of values so that their structure can be derived and rendered independently. This is probably best for long-term maintenance and will help avoid surprises or difficulty in the future.

The `ListAdapter` API allows you to separate data from representation of the data. Since you're already using a `ListAdapter`, you can easily change the representation of the `cities` assignment in the `found_location` function to store a list of tuples instead of a list of formatted strings. See [Example 4-4](#).

Example 4-4. Cities as a list of tuples

```
cities = [(d['name'], d['sys']['country']) for d in data['list']]
```



If you read the documentation for the `ListView` API, you will discover that there is also a `DictAdapter` class that allows you to store data in a dictionary instead of a list. This API requires you to maintain both a dictionary and a list of the dictionary's keys (to provide ordering) inside the adapter.

I personally recommend never using this API. Find a way to change your data so that the `ListAdapter` API works instead. Some options include keeping a separate dictionary and storing only the keys in the `ListAdapter`, or making the `ListAdapter` store tuples of `(key, value)` pairs or, possibly, a list of dictionaries.

After you change the strings to tuples, though, if you run the app, it will break. The default behavior of `ListAdapter` is to assume it is storing a list of strings and set the `text` property on whatever display class is being used (`LocationButton`, in this case) to whatever value that is. Trying to set the `text` property to a tuple causes Kivy to crash.

So, you need a way to convert the data from a list of tuples to a set of property associations on the `LocationButton`. Kivy does this very Pythonically, by assigning a custom function called `args_converter`. This function should accept two values: the index of the item being rendered, and the item itself. Kivy will call this function repeatedly for each item in the underlying data list. This allows you to store the data in whatever format makes sense for your application's underlying data model, and then to convert it to the format that makes sense for your widget's UI only when it is time to invite the UI to render it. Kivy takes care of all of this internally; all you really need to know is that your `args_converter` takes an item from the data list as input and outputs a dictionary. The keys in this dictionary are any properties (including custom properties) that can be set on the item being rendered (`LocationButton`). The values are, of course, the values to set for those properties. [Example 4-5](#) summarizes the new method added to the `AddLocationForm` class.

Example 4-5. args_converter method on AddLocationForm

```
def args_converter(self, index, data_item):
    city, country = data_item
    return {'location': (city, country)}
```

All it does is set a `location` property on the button. However, `LocationButton` doesn't have a `location` property, so we'll alter that next. You'll want a `ListProperty`, so adjust your imports first, as shown in [Example 4-6](#).

Example 4-6. Importing ListProperty

```
from kivy.properties import ObjectProperty, ListProperty
```

Now it's a trivial thing to add the `location` property to the `LocationButton` class. See [Example 4-7](#).

Example 4-7. New property on LocationButton

```
class LocationButton(ListItemButton):
    location = ListProperty()
```

Then you'll also want to set the `text` property in the KV language file from this `location` and pass `location` rather than `text` into `show_current_weather`, as shown in [Example 4-8](#).

Example 4-8. New properties on LocationButton KV

```
<LocationButton>:
    text: "{} ({})".format(self.location[0], self.location[1]) ❶
    height: "40dp"
    size_hint_y: None
    on_press: app.root.show_current_weather(self.location) ❷
```

- ❶ The `text` is set from the value of the `location` property.
- ❷ The argument passes the `location` property, rather than `text`.

This still won't work because you haven't actually told the `ListAdapter` what function to use as an `args_converter`. Do this in the KV language file when the `ListView` is constructed. [Example 4-9](#) illustrates.

Example 4-9. Setting the args_converter on theListAdapter

```
adapter:
    ListAdapter(
        data=[],
        cls=main.LocationButton,
        args_converter=root.args_converter)
```

Now the `ListView` will render correctly, but when you select a location from the list, it will crash spectacularly. The `show_current_weather` function is receiving a tuple instead of the text it currently expects. You could solve this by changing the location back to a string at this point, but it actually makes more sense to change the KV file, as shown in [Example 4-10](#).

Example 4-10. Converting location to text

```
<CurrentWeather@BoxLayout>:  
    location: ['New York', 'US'] ❶  
    conditions: None  
    temp: None  
    temp_min: None  
    temp_max: None  
    orientation: "vertical"  
    Label:  
        text: "{} ({})".format(root.location[0], root.location[1]) ❷  
    BoxLayout:  
        orientation: "horizontal"  
        size_hint_y: None  
        height: "40dp"  
        Button:  
            text: "Add Location"  
            on_press: app.root.show_add_location_form()  
        Button:  
            text: "Forecast"
```

- ❶ You have to convert the location to an implicit `ListProperty`. I tried it without this and it crashed with an `IndexError`.
- ❷ Format the text based on the location. There's another code smell here, because we're formatting locations in multiple places. As an exercise, you may want to find a way to refactor this into a static method.

Remember also to update the default location in `main.py` to be a tuple instead of a string. I told you this design was going to come back and bite me! See [Example 4-11](#).

Example 4-11. Default location

```
if location is None and self.current_weather is None:  
    location = ("New York", "US")
```

Well! That was a lot of work to make the application continue to do exactly what it was doing before. However, this code refactor makes it almost trivial to implement the code that looks up the actual weather, which we'll do in the next section.

Refactoring

The process you just went through—changing program internals to make code easier to use and read without changing the user-facing API—is called *refactoring*. Refactoring is a vital aspect of ensuring the long-term maintainability of a project, and it is rarely discussed in books or tutorials like this one.

I deliberately wrote this book at the same time that I wrote the example program so that you could see some of the “mistakes” made and how to recover from them. Far too many novice programmers become frustrated because they are given the impression that advanced developers always code it right the first time. In fact, nothing could be further from the truth. Refactoring code is one of the key duties of my day-to-day work. I assure you that no author’s textbook examples look as pat and neat the first time around as they do when you ultimately see them in print!

Retrieving Weather Data

Now it’s time to actually retrieve the weather information from the Internet and render it. This code should clearly go in its own method. In the Python file, the new method could maybe go on the `WeatherRoot` class. However, it would be better to put that method on the `CurrentWeather` class, which contains the data that is being updated. So, do one more minor refactor first: change the dynamic `CurrentWeather` class into one that is defined in the `main.py` file. The new class is shown in [Example 4-12](#) (note that you’ll have to add `StringProperty` and `NumericProperty` to the list of imports). Notice how the properties that were originally defined in the KV language file have been moved here.

Example 4-12. New class for current weather

```
class CurrentWeather(BoxLayout):
    location = ListProperty(['New York', 'US'])
    conditions = StringProperty()
    temp = NumericProperty()
    temp_min = NumericProperty()
    temp_max = NumericProperty()
```

You’ll also want to construct the new class directly in `show_current_weather`, rather than using the factory. See [Example 4-13](#) (remember to remove the `Factory` import).

Example 4-13. Constructing a CurrentWeather class

```
if location is not None:
    self.current_weather = CurrentWeather(location=location)
```

The KV language file has also changed for this refactor. However, for once, the changes have all been to make the code simpler! The class is no longer dynamic because the @BoxLayout has been removed from the rule. Also, all the properties have been removed. The top of the rule is displayed in [Example 4-14](#).

Example 4-14. Making a dynamic class static

```
<CurrentWeather>:  
    orientation: "vertical"
```

Now you can add a simple method to the CurrentWeather class that updates the weather from Open Weather Map using the same URLRequest technique you used for searching. The new methods are displayed in their entirety in [Example 4-15](#). Notice that, being Canadian, I prefer to get my weather in metric. If you're of the old school, you can set the units in the weather_template to imperial instead. Otherwise, you'll get strange values from Open Weather Map that don't make much sense at all, no matter where you are from.

Example 4-15. Update weather method

```
def update_weather(self):  
    weather_template = "http://api.openweathermap.org/data/2.5/" +  
        "weather?q={},{}&units=metric"  
    weather_url = weather_template.format(*self.location)  
    request = URLRequest(weather_url, self.weather_retrieved)  
  
def weather_retrieved(self, request, data):  
    data = json.loads(data.decode()) if not isinstance(data, dict) else data  
    self.conditions = data['weather'][0]['description']  
    self.temp = data['main']['temp']  
    self.temp_min = data['main']['temp_min']  
    self.temp_max = data['main']['temp_max']
```

Remember to call the method after constructing the CurrentWeather widget in `show_current_weather`. It also turns out that you can simplify the special cases now, since the location is hardcoded in the new class. Simplifying (or removing) special cases is one of the most satisfying kinds of refactoring! See [Example 4-16](#).

Example 4-16. Simplified show_current_weather method

```
def show_current_weather(self, location=None):  
    self.clear_widgets()  
  
    if self.current_weather is None:  
        self.current_weather = CurrentWeather()  
  
    if location is not None:  
        self.current_weather.location = location
```

```
self.current_weather.update_weather()  
self.add_widget(self.current_weather)
```

The final step is to update the `weather.kv` file to reference the new properties. You can lay this out however you like. I suggest doing some sketches on paper or in a mockup app before you actually start laying things out. The KV language is very easy to work with and can be useful for mocking out interfaces. However, if you don't actually draw it out on paper, you might end up doing what I did and forget to include the current temperature! My mockup looks like [Figure 4-2](#).

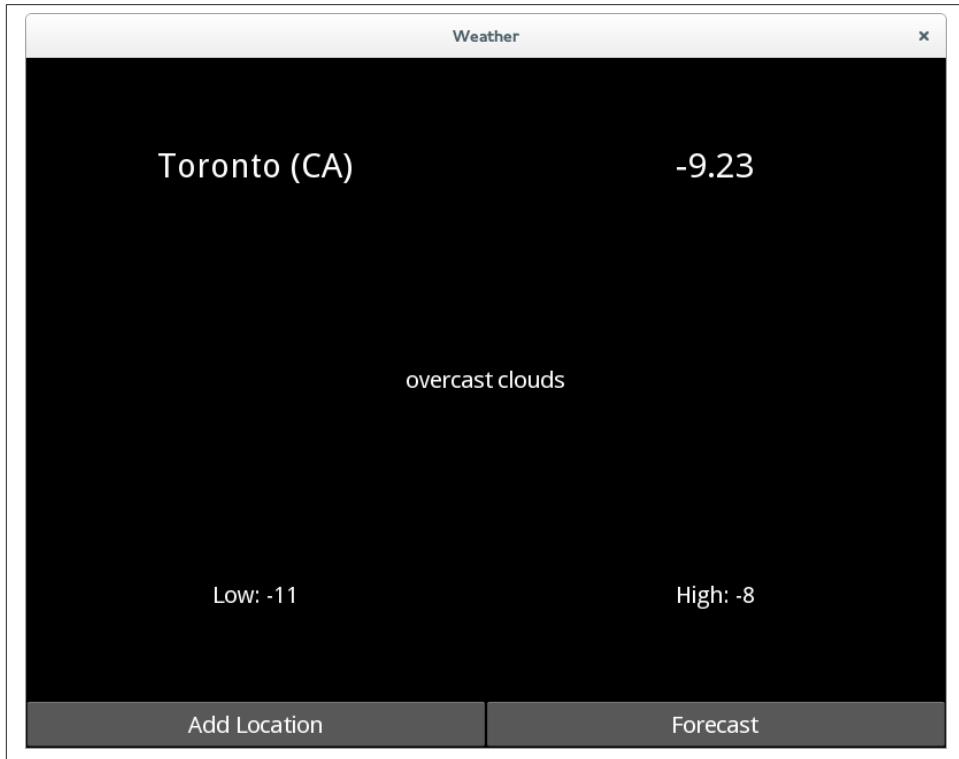


Figure 4-2. Quick mockup of how the current weather tab might look

I didn't mimic this exactly in my code, as displayed in [Example 4-17](#), but I did get all the elements in place.

Example 4-17. Laying out some weather information

```
<CurrentWeather>:  
    orientation: "vertical"  
    BoxLayout:  
        Label:
```

```

        text: "{} ({})".format(root.location[0], root.location[1])
        font_size: "30dp"
    Label:
        text: "{}".format(root.temp)
        font_size: "30dp"
    Label:
        text: root.conditions
BoxLayout:
    orientation: "horizontal"
    Label:
        text: "Low: {}".format(root.temp_min)
    Label:
        text: "High: {}".format(root.temp_max)
BoxLayout:
    orientation: "horizontal"
    size_hint_y: None
    height: "40dp"
    Button:
        text: "Add Location"
        on_press: app.root.show_add_location_form()
    Button:
        text: "Forecast"

```

Now you can run the app to check the weather for some common cities. [Figure 4-3](#) shows that it is somewhat chilly in Toronto today.

File It All Away

In this chapter, you iterated on your previous work. You refactored your code into a more maintainable codebase. While you didn't add too much new functionality, aside from actually looking up the current conditions and temperature, you made huge strides. Your future work will go much more quickly because of the changes you made here.

You might want to explore some additional refactorings or new features. Here are some suggestions:

- Don't render the Cancel button on the Add Location form on the initial run of the application. This should reduce the need for the special case in `show_current_weather`.
- While the search request is being performed, clear any previous search results. This will be important if you do a search and then search for a different location without selecting anything in the result list.
- If you're feeling particularly adventurous, render a pop-up while the search is being performed. As it is, the interface provides no indication that the network request occurred. This is barely noticeable on a Silicon Valley Internet connection, but on

a cellular network in the desert it's going to be a frustrating wait to answer the question, "How damn hot is it, anyway?"

- See if you can use the `index` parameter to the `args_converter` method to alternate the background color of individual `LocationButtons`.
- The code now has two functions that construct a URL from a template string and request data from that URL. Perhaps these lines of code should be refactored into a module-level function. Duplicate code is a bad thing. Don't repeat yourself.
- For clarity, I didn't do any error checking on either of those requests. This is fatal in production, because the Internet *never* stays on all the time. Handling errors in Kivy can be ugly, not because the API is bad, but because there are so many decisions that need to be made, and many of them involve the user. You'll need to learn how to do this if you want to release your apps in the wild.

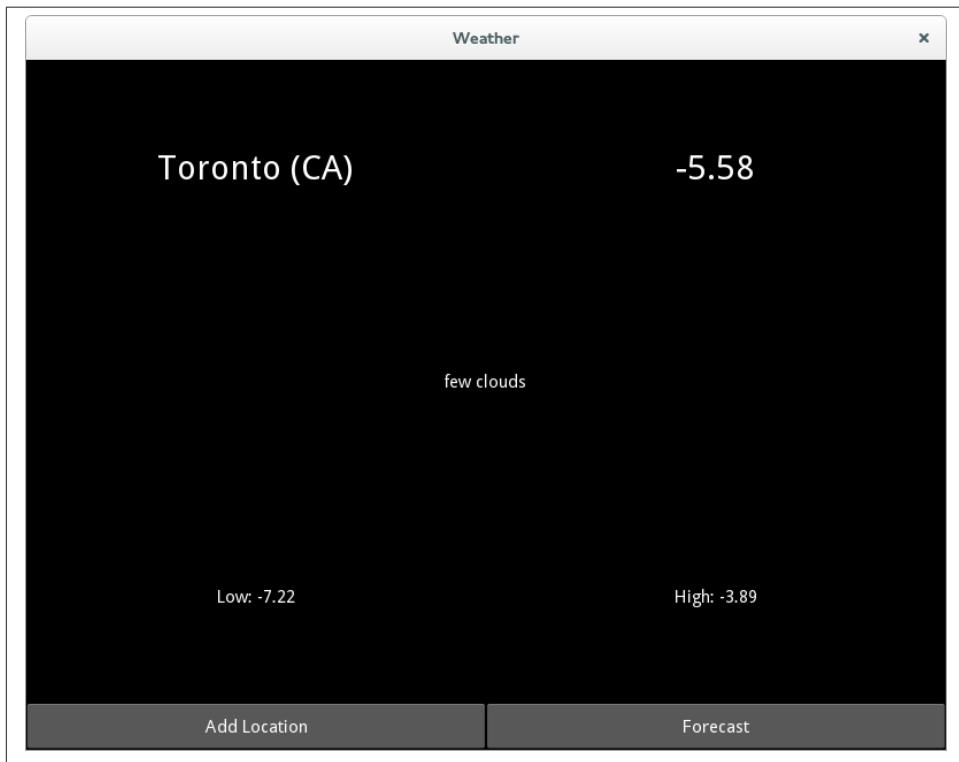


Figure 4-3. The CurrentWeather view

CHAPTER 5

Kivy Graphics

Kivy provides sophisticated graphics capabilities using OpenGL and SDL instructions. These can be useful if you're creating an interactive game rather than an application with widgets.

In this chapter, you'll learn the basics of the Kivy canvas and graphics primitives. You'll be creating a set of icons (some animated!) to render on your current conditions screen. These aren't going to be phenomenal works of art, unless you choose to modify them to be a lot nicer than mine.

If you're keeping your work in version control, you might want to make a separate branch for this chapter. If not, copy the entire project to a separate directory so you have a backup.

This chapter is a huge amount of fun (at least, it was fun to write!), but you'll be reverting a lot of these explorations at the end of it. It'll be easier if you make a copy now.

A Conditions Widget

Start by adding an `UnknownConditions` widget to the KV file using a dynamic class, as shown in [Example 5-1](#).

Example 5-1. A simple conditions widget

```
<UnknownConditions@BoxLayout>:  
    conditions: ""  
    canvas:  
        Color:  
            rgb: [0.2, 0.2, 0.2]  
        Ellipse:  
            pos: self.pos  
            size: self.size  
    Label:  
        text: root.conditions
```

There are a few things to notice about this short snippet. The first is that there is a `Label` widget, just like you've seen in previous examples. I point this out because it is not immediately obvious that you can simultaneously have graphics instructions and child widgets. It is probably more common to do this with layouts that give more control over widget position than `BoxLayout`. For example, you might use a widget as a positioned sprite that moves in front of a background for a mobile game.

Second, notice the `canvas` property. If you want to interact with graphics primitives, you need to create instructions on a canvas. Here, you construct two instruction objects, a `Color` instruction and an `Ellipse` instruction. These have attributes such as the RGB (red green blue) `Color` value and the size and position of the `Ellipse`.

Unlike normal widgets, which are considered independent objects rendered on the screen, instructions should be thought of in aggregate. They can affect each other sequentially. Thus, the `Color` instruction, which says "do things in gray," affects the next instruction, which says "draw an ellipse." Together, they say "draw a gray ellipse."

Thus, even though a similar syntax is used to lay out objects and properties on a widget, it is better to think of instructions as verbs—that is, actions—while widgets are better thought of as nouns.

Finally, observe how the `Ellipse` instruction is able to reference properties on the `self` object. In a canvas, `self` refers to the object on which the canvas is being rendered. Thus, `canvas` is a property of `self`, not a new child widget. The ellipse is being drawn to take up the entire area of the `self` object, with the same position and size as the parent widget.

Now render this `conditions` object in the `CurrentWeather` KV definition by replacing the `Label` that currently renders conditions as a string with [Example 5-2](#). (I don't know what "proximity shower rain" means, even if I look out my Palo Alto window.)

Example 5-2. Rendering the conditions widget

```
BoxLayout:  
    id: conditions  
    UnknownConditions:  
        conditions: root.conditions
```

The encompassing `BoxLayout` is given an `id` so that later you can easily change the child widget to something different depending on the current weather conditions.

If you render the weather now, it will look like [Figure 5-1](#).

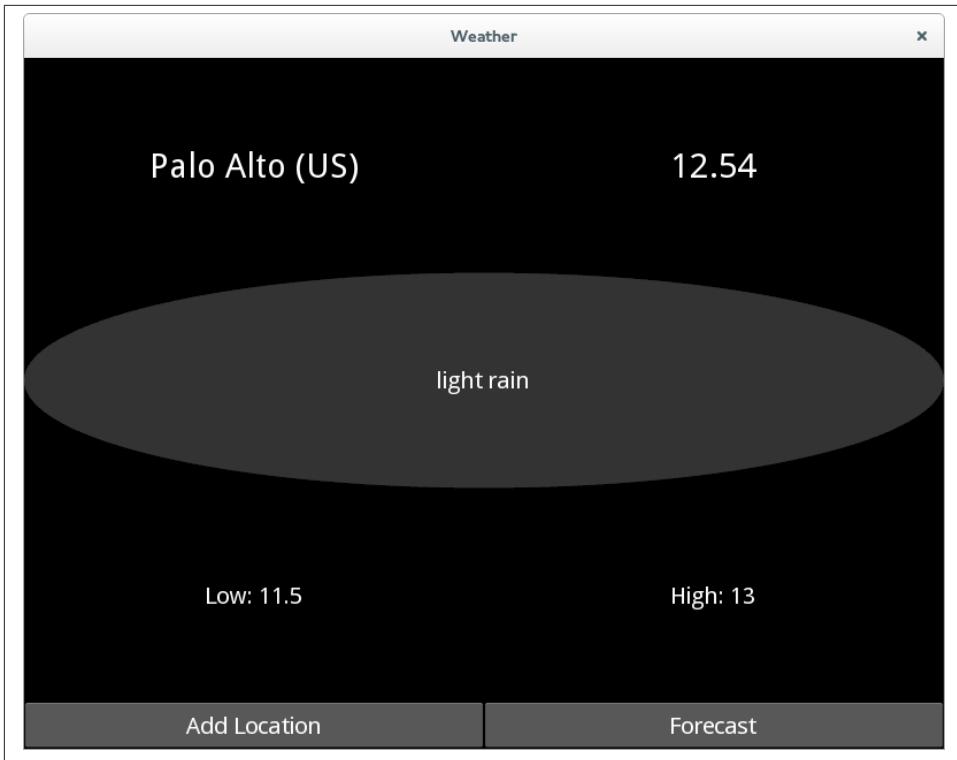


Figure 5-1. Your first graphics instruction

Dynamic Conditions

While it might be reasonable to render unknown weather as a gray ellipse, you really want things to be more dynamic. One option is to make the `conditions` property into a widget instead of a string and then render whatever the chosen widget is from the Python code.

See if you can work out how to do this as an exercise; you've done something just like it in a previous chapter. Create a new method called `render_conditions` on the `CurrentWeather` class that uses `Factory` to construct an `UnknownConditions` object. If you have trouble, refer to the KV file in [Example 5-3](#) and the Python code in [Example 5-4](#).

Example 5-3. Referring to widget by id

```
<CurrentWeather>:  
    orientation: "vertical"  
    conditions: conditions ①  
    BoxLayout:  
        Label:  
            text: "{} ({})".format(root.location[0], root.location[1])
```

```

        font_size: "30dp"
Label:
    text: "{}".format(root.temp)
    font_size: "30dp"
BoxLayout:
    id: conditions ②

```

- ② The `id` is still specified here, but you are no longer constructing a default `UnknownConditions`.
- ① Set the value of the property to the widget with the `id` so it can be referenced in Python code.

Example 5-4. Setting a widget dynamically

```

class CurrentWeather(BoxLayout):
    location = ListProperty(['New York', 'US'])
    conditions = ObjectProperty() ①
    temp = NumericProperty()
    temp_min = NumericProperty()
    temp_max = NumericProperty()

    def update_weather(self):
        weather_template = "http://api.openweathermap.org/data/2.5/" +
            "weather?q={},{}&units=metric"
        weather_url = weather_template.format(*self.location)
        request = UrlRequest(weather_url, self.weather_retrieved)

    def weather_retrieved(self, request, data):
        data = json.loads(data.decode()) if not isinstance(data, dict) else data
        self.render_conditions(data['weather'][0]['description']) ②
        self.temp = data['main']['temp']
        self.temp_min = data['main']['temp_min']
        self.temp_max = data['main']['temp_max']

    def render_conditions(self, conditions_description):
        conditions_widget = Factory.UnknownConditions() ③
        conditions_widget.conditions = conditions_description
        self.conditions.clear_widgets()
        self.conditions.add_widget(conditions_widget) ④

```

- ① Change `conditions` to be an `ObjectProperty` rather than a `StringProperty`.
- ② Call the new `render_conditions` function with the `conditions` string, rather than setting the value of the string.
- ③ Remember to add `from kivy.factory import Factory` at the top of the file.
- ④ Add the widget dynamically using Python instead of having it hardcoded in the KV file.

With this refactor, the program will still look like [Figure 5-1](#), but now you can easily create a new widget for clear skies, as shown in [Example 5-5](#).

Example 5-5. Drawing a little sunshine

```
<ClearConditions@BoxLayout>:  
    conditions: ""  
    canvas:  
        Color:  
            rgb: [0.8, 0.7, 0.3]  
        Line:  
            cap: "round"  
            width: 3  
            points:  
                [self.center_x - (self.height / 2),  
                 self.center_y,  
                 self.center_x + (self.height / 2),  
                 self.center_y]  
        Line:  
            cap: "round"  
            width: 3  
            points:  
                [self.center_x,  
                 self.center_y - (self.height / 2),  
                 self.center_x,  
                 self.center_y + (self.height / 2)]  
        Line:  
            cap: "round"  
            width: 3  
            points:  
                [self.center_x - (self.height * .35355),  
                 self.center_y - (self.height * .35355),  
                 self.center_x + (self.height * .35355),  
                 self.center_y + (self.height * .35355)]  
        Line:  
            cap: "round"  
            width: 3  
            points:  
                [self.center_x - (self.height * .35355),  
                 self.center_y + (self.height * .35355),  
                 self.center_x + (self.height * .35355),  
                 self.center_y - (self.height * .35355)]  
        Color:  
            rgb: [0.6, 0.5, 0.0]  
        Ellipse:  
            pos: self.center_x - ((self.height - 40) / 2), self.pos[1] + 20  
            size: [self.height - 40, self.height - 40]  
  
    Label:  
        text: root.conditions
```

It'll be easier to understand the math if you first look at the effect in [Figure 5-2](#) (your app won't look like this until you hook up the `main.py` code in a couple minutes).

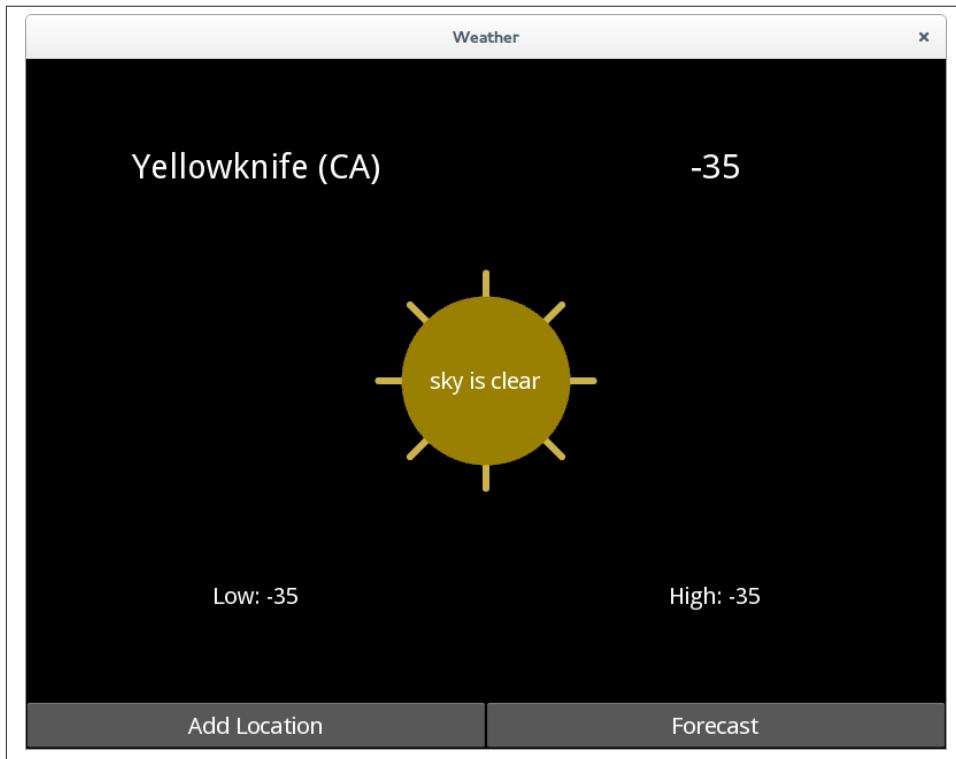


Figure 5-2. Rendering of clear, cold skies

This simple sunshine graphic is composed of some relatively simple instructions and some not completely simple mathematics. I'll describe each instruction in turn.

First, a `Color` instruction sets a nice yellow-orange color in RGB format. It has 80% red, 70% green, and 30% blue, since Kivy RGB settings range from 0 to 1 in floating point.

This is followed by four `Line` instructions. These all have the same structure, composed of `cap`, `width`, and `points` properties. The `width` is obviously the width of the line. The `cap` can be set to a few different values; "round" gives the ends of the line a nice radiused feeling. The `points` property is a list of values for the line. Alternating values are `x` and `y` coordinates in the coordinate space of the window. This means that `0, 0` is the lower-left corner of the window. Therefore, it is typically wise to adjust the `points` relative to the `pos` or `center` of the widget holding the canvas to which you are issuing instructions.

Each line has four values in the `points` list. These values are used to draw a single line between two points. Each of the lines is the length of the height of the widget, and is centered on the widget. The first line has the same `y` coordinate (the middle of the window) for both points, so it represents a horizontal line. The second similarly represents a vertical line.

The latter two lines represent a cross at a 45-degree angle to the other lines. You can safely think of the value `0.35355` as “magic” unless you know basic trigonometry, in which case it is an approximation of $\sqrt{2}/4$, which combines the sine of 45° with a division by 2 on the height.

Finally, the color is made a bit darker, just for fun, and an ellipse with equal height and width (a circle) is drawn in front of the lines. This circle is smaller than the length of the lines, so they poke out behind it like a radix. Note my minor attempt at style: by making the color quite dark, I’ve made the white label readable in front of it.

Admittedly, that was not a lot of fun. It took me several minutes of fiddling to get the image to look the way I wanted it to. It isn’t normal to tweak graphics primitives by hand in the KV language, though it can be useful. Mathematically derived graphics are more often created in Python code, while artistic effects should be applied as textures to an image rather than being encoded in primitives.

If you’ve created this widget in `weather.kv`, you might be wondering how to turn it on in `main.py`. You can do this with a simple conditional in the `render_conditions` function, as you can see in [Example 5-6](#).

Example 5-6. Rendering different widgets depending on conditions

```
def render_conditions(self, conditions_description):
    if "clear" in conditions_description.lower():
        conditions_widget = Factory.ClearConditions()
    else:
        conditions_widget = Factory.UnknownConditions()
    conditions_widget.conditions = conditions_description
    self.conditions.clear_widgets()
    self.conditions.add_widget(conditions_widget)
```

Abstracting Common Widgets

I’ve mentioned in previous chapters how much you should hate duplicate code. Hopefully you were annoyed at the way the `conditions` label had to be applied in both `ClearConditions` and `UnknownConditions`. Inheritance can help abstract away this duplicate code.

Note that sometimes such a refactor is not a good idea. This label adds only three lines of code per widget, and right now there are only two widgets. In this case, I probably

wouldn't normally go to the trouble of refactoring, since I'd actually be adding more lines of code to maintain, and a heavy layer of abstraction.

However, as more conditions widgets are added, the duplicate code will expand. What if you later want to change the label to have a different font? Changing it in a dozen widgets would be rather irritating. Further, I want to explain this for pedagogical reasons; your own widget hierarchies are sure to be more complex than a single label.

Start by making a new class in `main.py` that extends `BoxLayout`. Don't forget to explicitly create the `conditions` property that was created dynamically in the KV classes. This property is now maintained in only one place (this class), rather than separately in the two widgets. See [Example 5-7](#).

Example 5-7. A simple conditions widget

```
class Conditions(BoxLayout):
    conditions = StringProperty()
```

The styling for this widget in the KV language file can have the `Label` that was previously included in both the conditions widgets. The rule is described in [Example 5-8](#).

Example 5-8. Basic conditions styling

```
<Conditions>:
    Label:
        text: root.conditions
```

You'll also need to modify both the widgets as described in [Example 5-9](#). Remember to do the same thing in the more complicated `ClearConditions` class.

Example 5-9. The simplified UnknownConditions dynamic class

```
<UnknownConditions@Conditions>: ❶
    canvas.before: ❷
        Color:
            rgb: [0.2, 0.2, 0.2]
        Ellipse:
            pos: self.pos
            size: self.size
    ❸
```

- ❶ Extend `Conditions` instead of `BoxLayout`.
- ❷ Change `canvas` to `canvas.before`.
- ❸ Remove the `conditions` property and the old `Label`.

If you did not change `canvas` to `canvas.before`, your label would not be visible. It would render when the parent class was painted, but then the canvas would paint its graphics on top of the label. The `canvas.before` property is a (kind of hackish, in my opinion)

way to tell Kivy to draw graphics instructions before rendering widgets. There is a similar `canvas.after` property if you want to delay rendering until later in the pipeline. After this refactor, your code will run exactly the same as previously, but now it's much more readable.

Basic Animation

Animation in Kivy can be trivially easy. I'll illustrate this with a snow widget. I'll define this widget entirely in Python rather than trying to build it in the KV language, since defining individual flakes in KV would be troublesome.

So as not to bore you, I'm not going to show you the entire process of experimentation I went through to come up with this example. However, I don't want you to get the impression that I just rattled this off the first time. Programming, especially programming involving visual design, requires a lot of trial and error. This example took about an hour to compose. I actually had a more complicated animation going, but I simplified it so the example didn't take too many pages. You can, of course, tweak it as much as you like if animation interests you.

You'll need to import a few modules that I'll explain in a moment. Add the imports from [Example 5-10](#) to the top of your `main.py` file.

Example 5-10. Imports for snow animation

```
import random
from kivy.graphics import Color, Ellipse
from kivy.clock import Clock
```

You may as well also update `render_conditions` to render the to-be-defined widget if the conditions warrant it. See [Example 5-11](#).

Example 5-11. Rendering the snow widget for snowy weather

```
elif "snow" in conditions_description.lower():
    conditions_widget = SnowConditions()
```

And now, my entire animated `SnowConditions` class is displayed in [Example 5-12](#).

Example 5-12. The animated SnowConditions class

```
class SnowConditions(Conditions):
    FLAKE_SIZE = 5      ❶
    NUM_FLAKES = 60
    FLAKE_AREA = FLAKE_SIZE * NUM_FLAKES
    FLAKE_INTERVAL = 1.0 / 30.0

    def __init__(self, **kwargs):
        super(SnowConditions, self).__init__(**kwargs)
        self.flakes = [[x * self.FLAKE_SIZE, 0]
                      for x in range(self.NUM_FLAKES)] ❷
```

```

Clock.schedule_interval(self.update_flakes, self.FLAKE_INTERVAL) ③

def update_flakes(self, time):
    for f in self.flakes: ④
        f[0] += random.choice([-1, 1])
        f[1] -= random.randint(0, self.FLAKE_SIZE)
        if f[1] <= 0:
            f[1] = random.randint(0, int(self.height))

    self.canvas.before.clear()
    with self.canvas.before: ⑤
        widget_x = self.center_x - self.FLAKE_AREA / 2 ⑥
        widget_y = self.pos[1]
        for x_flake, y_flake in self.flakes:
            x = widget_x + x_flake ⑦
            y = widget_y + y_flake
            Color(0.9, 0.9, 1.0) ⑧
            Ellipse(pos=(x, y), size=(self.FLAKE_SIZE, self.FLAKE_SIZE))

```

- ❶ I defined some constants on the class to make it a little clearer what is happening in later code. These are pretty easy to understand from their names, except possibly FLAKE_INTERVAL, which says that snowflake positions will update about 30 times per second.
- ❷ This list comprehension may seem rather odd. It creates a list of 60 tuples of (x, y) coordinates representing the position of each flake. This position is relative to a sort of internal reference system with (0, 0) at the bottom of a rectangular area that is self.height units high and FLAKE_AREA units wide. This square will be positioned in the center of the widget, but these (x, y) coordinates don't know that yet. Each flake starts equally spaced 5 units apart in the x axis at position 0 (the bottom) in the y axis. Why the bottom? I'll explain in a second.
- ❸ The Clock object is a very useful tool for animations. This call tells Kivy to call self.update_flakes 30 times per second.
- ❹ This loop does the complete job of animation. It loops over every flake's position and alters its coordinates. It moves each flake 1 unit either to the left or to the right to give it a bit of a "drift" effect. It also moves each flake a random number of units down, causing the occasional "hang" effect. Finally, if the flake is at the bottom of the box, it is randomly popped up at some other position inside the box. This also repositions all the flakes after they've started at position 0.
- ❺ In Python, canvas instructions can be wrapped in a context manager for easier readability. In this case, I used canvas.before so the conditions Label in the parent class is still visible.

- ⑥ The position of each flake is adjusted to be relative to the position of the widget. These coordinates represent the position in the window where the $(0, 0)$ of the individual flakes should be positioned: centered on the widget.
- ⑦ Add the flake position relative to the coordinate system relative to the window to get the absolute position of the flake.
- ⑧ Graphics instructions are constructed as objects, similar to in the KV language but with more verbosity.

The picture obviously isn't animated, but my screen looks something like [Figure 5-3](#). One of the hardest things to do in this chapter was find cities that had the weather conditions I wanted to test graphics for!

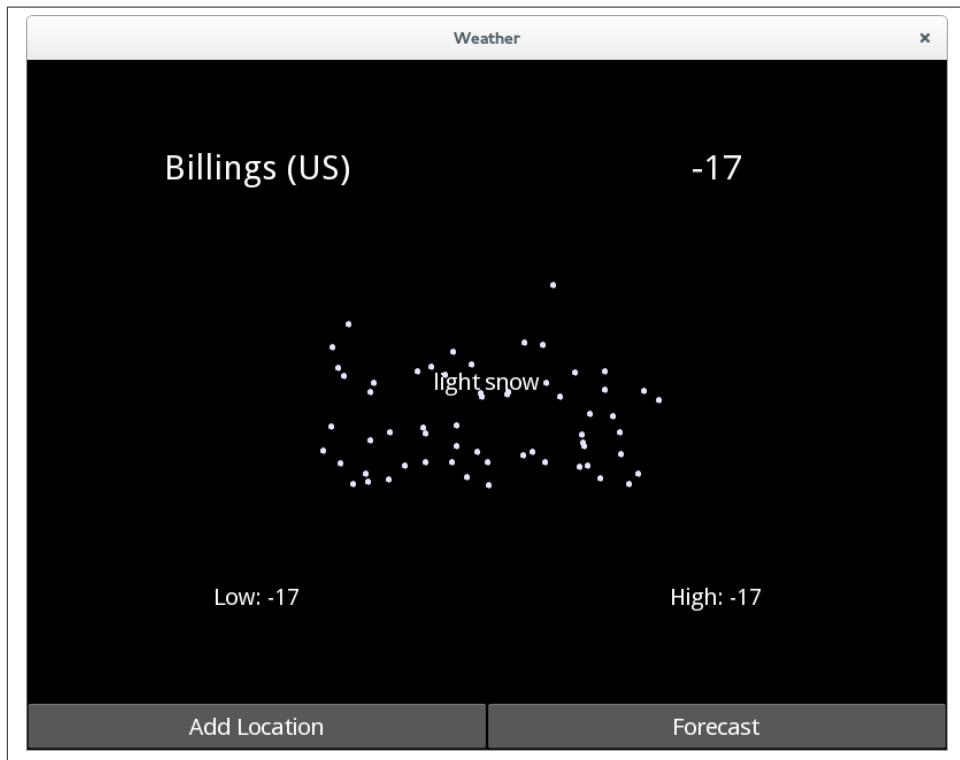


Figure 5-3. Still screenshot of the snow animation

super in Python 2 and Python 3

The `super` keyword has been revamped in Python 3 so that the default case is easier to write. The default case is to call “the parent class of the object that is being instantiated,” and we can invoke it by passing no arguments into the `super` method.

In Python 2, you have to explicitly pass two arguments into `super`; the current class and the `self` object. Thus, the `super` call in [Example 5-12](#) would have to read `super(SnowConditions, self).__init__(**kwargs)` in Python 2.

Luckily, the Python 2 syntax is still supported in Python 3, so if you are looking to support both languages, you can use the more verbose syntax and it will run on either interpreter.

Using Icons Instead

While it’s fun to draw primitive graphics, doing so for all the possible weather conditions would soon become monotonous. To be honest, if I hadn’t wanted to introduce you to the Kivy canvas, I would never have gone down this route at all. Instead, I would have used the weather icons supplied by Open Weather Map.

In fact, that’s what I’ll be doing in future chapters. You’re free to keep the graphics code if you prefer, but if you want to follow along closely, you might want to revert to the state of things before you started this chapter.

Now prepare to be shocked at how easy it is to load an icon from the Internet in Kivy. See the changes to `CurrentWeather` in [Example 5-13](#) and `weather_retrieved` in [Example 5-14](#). Also remember to add a `conditions_image` `StringProperty` to the class.

Example 5-13. Using AsyncImage to load an image from the network

```
BoxLayout:  
    orientation: "horizontal"  
    Label:  
        text: root.conditions  
    AsyncImage:  
        source: root.conditions_image
```

Example 5-14. Setting the conditions icon

```
self.conditions_image = "http://openweathermap.org/img/w/{}.png".format(  
    data['weather'][0]['icon'])
```

The `AsyncImage` widget is an example of Kivy’s modern approach to things. While most GUI toolkits would force you to download and render the image in separate steps, Kivy is aware that most applications are connected to the Web and gives us a convenient widget to grab icons from the network.

If you run this and search for Seattle, you'll almost certainly get the "light rain" icon (see [Figure 5-4](#)). It's always rainy in Seattle (this is not technically true; Seattle residents perpetuate this myth to keep the beautiful days to themselves). You don't need to write an app to know that.



Figure 5-4. Rainy in Seattle

File It All Away

I apologize for the anticlimax of going from coding your own animation to using a stock icon. However, you're now in good shape to think about persistent storage in the next chapter! Here are a few additional paths you may want to explore:

- Add an animated rain widget inspired by the snow widget. I'd use short lines instead of circles for drops, but you could also do ellipses with little triangle hats.
- Make the snow movement more realistic. An algorithm that is a bit less random about when to hesitate or drift in a specific direction would be suitable.
- You can also experiment with randomly sized snowflakes. I did this and it looked pretty neat.

- Experiment with some of the other instructions in the Kivy API. These include Bézier curves, triangles, and meshes, as well as transform instructions such as scale and rotate.
- Read up on using textures and shaders in Kivy if you’re looking to do more advanced graphics in animated games.
- Experiment with using the `Clock` object to automatically update the weather every hour.

CHAPTER 6

Kivy Storage

So far, every time you run your weather app, it asks you to search for a location. It would be much more convenient if it could store your last location and render it by default.

Kivy is a Python library, which means you have access to the full gamut of Python storage modules. You could use basic file I/O, compression, encryption, pickling, JSON, SQLite3, an external SQL or NoSQL database, or any number of online storage services.

Depending on the data being stored, these are certainly useful tools worth checking out. However, Kivy also provides a simple but powerful key/value storage API for storing local data. Its primary advantage is that because Kivy is aware of the module, it works across the wide variety of platforms that Kivy uses without having to take into account filesystem structure or other differences between various operating systems.

Maintaining a List of Locations

Before looking at storing the locations, update the app to have a Locations tab. This involves nothing you haven't studied before, so you may want to think of it as an exercise. I'll try to keep this section brief so as not to bore you with knowledge you already have. If you want to skip this section, you can download the [example code from O'Reilly](#) and proceed to the next section.

Here's what you need to do, step by step. As mentioned, there is some example code for the more complicated steps. Note in advance that the `ListView` of locations behaves exactly like the `ListView` for search results, so you get to reuse a lot of functionality.

1. Add a new `locations ObjectProperty` on `WeatherRoot` for the new `Locations` widget.
2. Turn the `args_converter` into a module-level function instead of a method, and call it as `main.locations_args_converter` in the KV file for both `ListViews`.

3. Add the new Locations dynamic class in KV to actually render the list of locations in a ListView. See [Example 6-1](#).
4. Add a Locations button to the CurrentWeather widget that calls a new show_locations method on WeatherRoot when pressed. As [Example 6-2](#) shows, this method is very simple.
5. Update show_current_weather to additionally append a new LocationButton to the locations ListView. The new code is highlighted in [Example 6-3](#).

Example 6-1. Locations class to store the list of locations you have searched for

```
<Locations@BoxLayout>:
    orientation: "vertical"
    locations_list: locations_list    ❶
    ListView:
        id: locations_list
        adapter:
            ListAdapter(
                data=[],
                cls=main.LocationButton,
                args_converter=main.locations_args_converter) ❷
    BoxLayout:
        orientation: "horizontal"
        size_hint_y: None
        height: "40dp"
        Button: ❸
            text: "Add Location"
            on_press: app.root.show_add_location_form()
```

- ❶ This is a dynamic class, so the ObjectProperty is created dynamically.
- ❷ Remember to also change this function call to a module-level function in AddLocationForm, where the same args_converter is used.
- ❸ This Button was moved from the CurrentWeather widget, where it was replaced with a Button to render the Locations view.

Example 6-2. The simple show_locations method on WeatherRoot

```
def show_locations(self):
    self.clear_widgets()
    self.add_widget(self.locations)
```

Example 6-3. The new show_current_weather function

```
def show_current_weather(self, location=None):
    self.clear_widgets()

    if self.current_weather is None:
        self.current_weather = CurrentWeather()
    if self.locations is None: ❶
```

```

        self.locations = Factory.Locations()

    if location is not None:
        self.current_weather.location = location
        if location not in self.locations.locations_list.adapter.data: ②
            self.locations.locations_list.adapter.data.append(location)
            self.locations.locations_list._trigger_reset_populate()

    self.current_weather.update_weather()
    self.add_widget(self.current_weather)

```

- ① As with CurrentWeather, construct the widget if it doesn't exist.
- ② If a location was specified but it isn't already in the adapter, add the data. This works because the `args_converter` expects a (`city`, `country`) tuple, which was passed into `show_current_weather` by the LocationButton.

Storing the Location List

As with most of Kivy, the `Storage` API is layered, with a generic API routing to different backend services. This is how, for example, Kivy is able to use different audio or video devices seamlessly, without any guidance from you.

However, with storage, you have to choose what kind of backend you will use. Kivy currently supports three options:

- A `DictStore` that stores data in a Python dictionary in memory. This does not persist if the application closes.
- A `JsonStore` that stores data in JSON format on the local filesystem.
- A `RedisStore` that allows you to store data locally or remotely in a Redis filesystem.

The `DictStore` isn't too useful to you, since the adapter is already storing data in memory on your behalf. The `RedisStore` might be useful if you wanted to sync data to a central database where you could access it from multiple devices. However, I'll demo the `JsonStore`, which is more suitable to the use case at hand.

Constructing a `JsonStore` is very easy. In this case, you should build it as an instance property on the `WeatherRoot` class. This means you'll have to override the `__init__` method as shown in [Example 6-4](#), first adding an import for `from kivy.storage.json_store import JsonStore` at the top of the file.

Example 6-4. Initializer for WeatherRoot

```

def __init__(self, **kwargs):
    super(WeatherRoot, self).__init__(**kwargs) ①
    self.store = JsonStore("weather_store.json")

```

- ❶ Remember, Python 3 can use `super` without arguments. I can never remember which order the arguments go in, so Python 3 saves me a lot of trial and error!

Kivy permits multiple inheritance and automatic property assignment by never passing positional arguments into the `__init__` method. Thus, you should accept arbitrary `kwargs` and pass them up to the parent class, just in case. Give the object a relative filename. The store should take care of ensuring it's saved to a reasonable location that can be found again on different devices.

Then you can use the `put` method to store the known locations whenever a new one is added. Do this only when a new item is appended to the `ListView` inside the conditionals in `show_current_weather`. See [Example 6-5](#).

Example 6-5. Putting a value to the store when a location is added

```
if location not in self.locations.locations_list.adapter.data:  
    self.locations.locations_list.adapter.data.append(location)  
    self.locations.locations_list._trigger_reset_populate()  
    self.store.put("locations",  
        locations=list(self.locations.locations_list.adapter.data))
```



Note that `put` requires one positional key and then an arbitrary number of named values. Each value is passed as a keyword argument. In this case, I supplied only one argument, `locations`, where the value is a `list` of `tuple` objects. This serializes easily to JSON inside the store. If you call `put` again, it will overwrite *all* the values for that key, even if you specify different values.

Finally, if the store exists, load the data into the adapter after constructing the `Locations` object in `show_current_weather`, as shown in [Example 6-6](#).

Example 6-6. Loading data from the store

```
if self.locations is None:  
    self.locations = Factory.Locations()  
    if (self.store.exists('locations')):  
        locations = self.store.get("locations")['locations']  
        self.locations.locations_list.adapter.data.extend(locations)
```

Note that `get` returns a dictionary where the keys are any keyword arguments you passed into `put` for that key.

See if you can work out how to store the current location in the same key and, if it is set, render it when the application starts. [Example 6-7](#) in `show_current_weather` and [Example 6-8](#) in the `WeatherRoot` initializer demonstrate how simple this can be.

Example 6-7. Putting the current location

```
if location is not None:  
    self.current_weather.location = location  
    if location not in self.locations.locations_list.adapter.data:  
        self.locations.locations_list.adapter.data.append(location)  
        self.locations.locations_list._trigger_reset_populate()  
    self.store.put("locations",  
                  locations=list(self.locations.locations_list.adapter.data),  
                  current_location=location)
```

Example 6-8. Loading the current location and rendering

```
def __init__(self, **kwargs):  
    super(WeatherRoot, self).__init__(**kwargs)  
    self.store = JsonStore("weather_store.json")  
    if self.store.exists('locations'):  
        current_location = self.store.get("locations")["current_location"]  
        self.show_current_weather(current_location)
```

The User Settings Dialog

Kivy has built-in support for storing user settings backed by a configuration file. In fact, Kivy has a bunch of built-in configuration settings that the user can change. You don't have to do anything to enable these; they're already there. On your desktop machine, just press F1 to display the settings, as shown in [Figure 6-1](#).



The default settings are pretty technical and a bit overwhelming for the average user. Depending on your use case, you might want to leave them in, as I did in this chapter for pedagogical reasons. However, if you want to hide them, it's as simple as adding a `use_kivy_settings = False` line to the `WeatherApp` class.

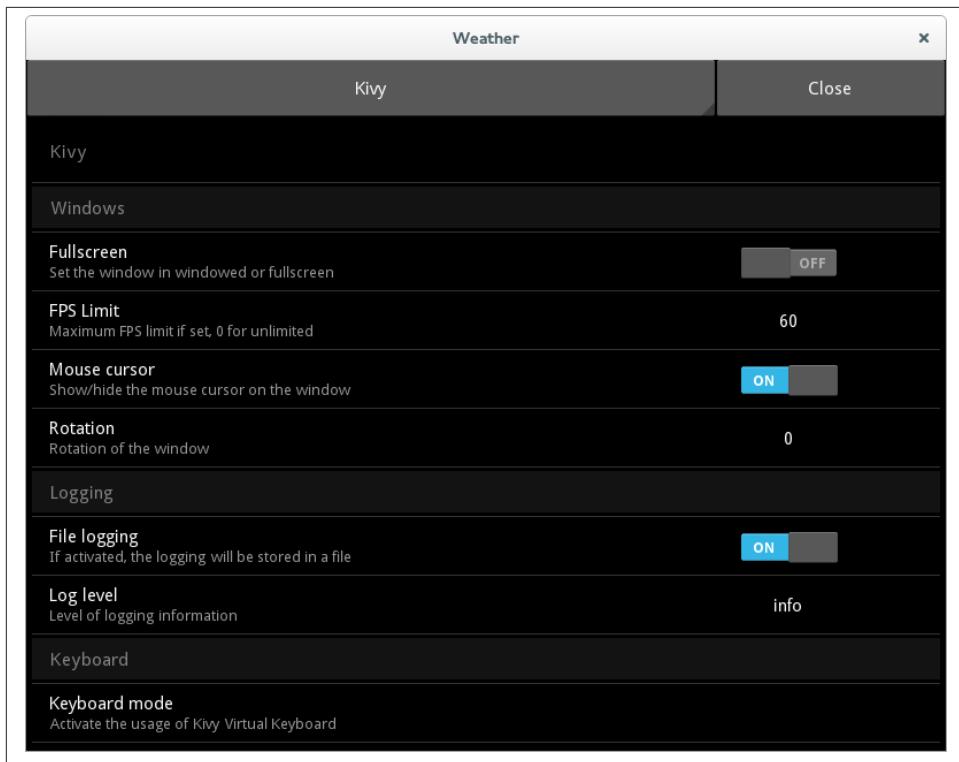


Figure 6-1. Kivy settings dialog

The Kivy settings are stored in a user-editable `.ini` file named after your application class, with the same name mangling used to guess the `.kv` filename. Thus, the settings for the `WeatherApp` class appear in `weather.ini`.

Don't ship this file with your application. Instead, add a `build_config` method to your `WeatherApp` class. It will automatically generate the file the first time it is called. This method should set up the structure of the file and all default values for your app. Remember, an `.ini` file has sections with key/value pairs inside each section. For this example, I'll just add one configuration setting: what system to render the temperatures in. Put it in the General section, as shown in `build_config` in [Example 6-9](#).

The next step is to configure your settings panel to allow the user to change these settings. We must do this using JSON, for reasons I don't understand (I would have used a KV language syntax).

The `build_settings` method in [Example 6-9](#) demonstrates how to do this.

Example 6-9. Creating a settings panel and configuration management

```
class WeatherApp(App):
    def build_config(self, config):
        config.setdefault('General', {'temp_type': "Metric"})

    def build_settings(self, settings):
        settings.add_json_panel("Weather Settings", self.config, data="""
            [
                {"type": "options",
                 "title": "Temperature System",
                 "section": "General",
                 "key": "temp_type",
                 "options": ["Metric", "Imperial"]}
            ]
        """)

The key invocation here is the add_json_panel call, which accepts three arguments. The first is the title of the panel, as rendered in the settings dialog. It's possible to have multiple settings panels, including the default Kivy panel you saw earlier. The second parameter is almost always self.config, the configuration object that was set up in build_config. Finally, you can supply either filename or data as a keyword argument to load JSON data from a file or string.
```

The example uses the `data` argument and encodes the data inline. The options are straightforward, but fairly verbose considering that I am describing only one setting object.

The `type` defines how the setting is rendered. I chose `options` since I want to select between two choices. Other values `type` can take include:

- `bool`
- `numeric`
- `string`
- `path`
- `title` (acts as a placeholder between sections)

The `title` is the user-readable label to give the setting inside the dialog. The `section` parameter maps directly to whatever section you specified in `config.setdefault`, while `key` maps to a key inside the dictionary passed into that function. Finally, since this is an `options` setting, the actual options are specified in a JSON list.

If you run the program and press F1, you're given a very simple settings panel, as shown in [Figure 6-2](#).

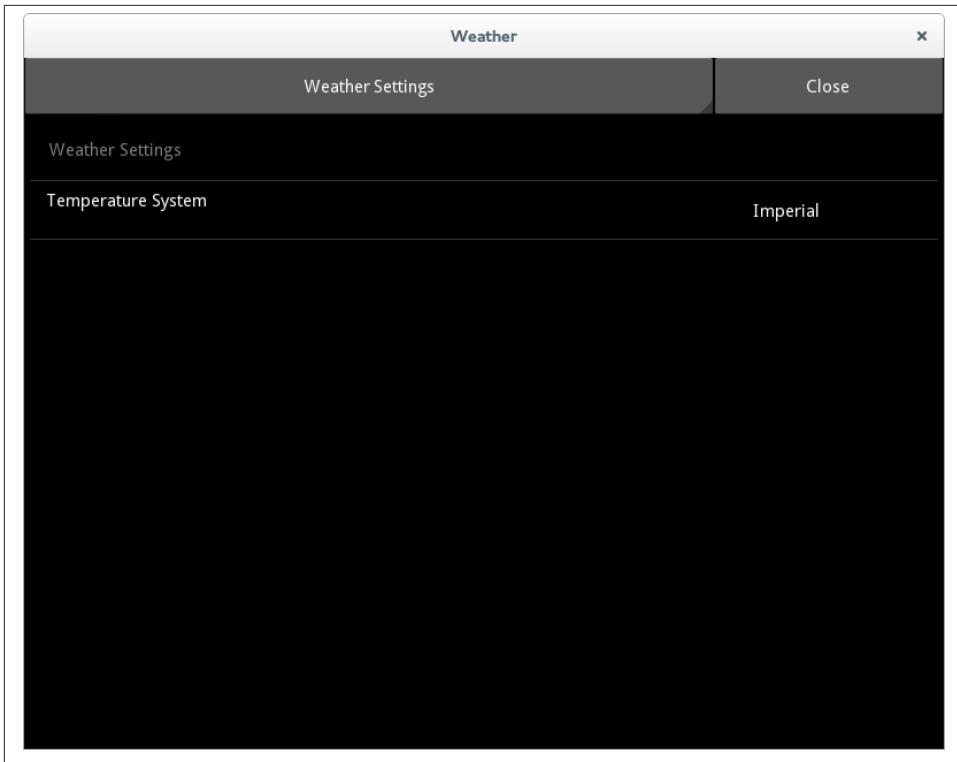


Figure 6-2. Temperature system setting

The setting is saved by default as soon as the user closes the dialog. The next time the program runs, the user's choice is rendered instead of the default.

The next step, of course, is to actually use this setting in production. This requires some minor changes to `update_weather` so that you are requesting the appropriate units from Open Weather Map. See [Example 6-10](#).

Example 6-10. Requesting data in the user's selected measuring system

```
def update_weather(self):
    config = WeatherApp.get_running_app().config      ❶
    temp_type = config.setdefault("General", "temp_type", "metric").lower() ❷
    weather_template = "http://api.openweathermap.org/data/2.5/" +
        "weather?q={},{}&units={}" ❸
    weather_url = weather_template.format(
        self.location[0],
        self.location[1],
        temp_type) ❹
    request = UrlRequest(weather_url, self.weather_retrieved)
```

- ❶ `get_running_app` is a static method that returns the singleton running app. Simply request the `config` variable from it.
- ❷ `getdefault` returns the value stored in the configuration in the `temp_type` key under the General section. If that section or key doesn't exist, it returns the default value, `metric`.
- ❸ `weather_template` is changed to have the units passed in a format string instead of being hardcoded (removing hardcoded values should yield a tremendous sense of accomplishment).
- ❹ The template string now needs to have three values substituted in the `format` call.

This should now be working fine, with one small bug. If you press F1 from the `CurrentLocation` view, it doesn't update the display until `update_weather` is called, which requires you to select a different location.

Luckily, you can listen for changes by adding an `on_config_change` method to the `WeatherApp` class. This method calls `update_weather` immediately, as shown in [Example 6-11](#). This example uses the “ask forgiveness rather than permission” approach to determine if the current root window has an `update_weather` function. I suspect this will be useful when we implement the Forecast tab in the next chapter.

Example 6-11. Updating weather on_config_change

```
def on_config_change(self, config, section, key, value):
    if config is self.config and key == "temp_type":
        try:
            self.root.children[0].update_weather()
        except AttributeError:
            pass
```

Last, add a button to display the settings window manually. Users don't necessarily know that the F1 key will display the settings window. Kivy will map the menu button on Android devices to the settings window, but modern Android devices don't have a menu key.

For brevity, I'm just going to throw a button on the Locations window to display settings. This isn't exactly good interface design, but [Example 6-12](#) will get the pertinent points across.

Example 6-12. A button to display the settings

```
Button:
    text: "Settings"
    on_press: app.open_settings()
```

File It All Away

I have to tell you, folks, I'm surprised at how easy this chapter was to write. I haven't used the settings or storage APIs before. I knew from my experience with other Kivy APIs that it would be simple, but I was able to write, test, and document all these examples in a single day! I hope this chapter was as informative and fun for you as it was for me.

There are, as always, numerous activities you can try to extend your knowledge on your own. Try some of these, for example:

- The code that updates the results list after the user searches for a location is very similar to the code that updates the list of locations when one is selected. I think this could be elegantly refactored into a single `LocationListView` class that has methods that take care of updating the data and calling the `trigger_reset_populate` function.
- The `Locations` view has no way to remove a location once it's added. Explore ways to solve this. Personally, I'd look at extending `LocationButton` to have a button inside it (yes, it is possible to have a button on a button) that connects to a `remove` token. Remember to update the `JsonStore` object, too.
- I think it would be elegant if there were a version of `ListAdapter` that automatically stored its value inside a `JsonStore` object whenever it was updated. I wouldn't be surprised if the Kivy team would accept a pull request with such an adapter if you were up for some open source contribution!
- Add some more settings for fun. One thing you might try is conditionally rendering additional data (such as humidity or wind speed) depending on whether the user has requested it. Or you could set an option for how often the weather should be updated using the `Clock` object, if you did the last exercise in the previous chapter.

CHAPTER 7

Gestures

Kivy was designed from the ground up with fingers, rather than pointing devices, in mind as a primary method of input. You haven't had much direct interaction with input devices in this book; instead, we've focused on touch events that are built into widgets supplied with Kivy. Buttons can be pressed, inputs can have text entered into them, and `ListView`s can be scrolled with a gesture.

In this chapter, you'll delve a bit deeper into Kivy's event system and add a few basic gestures to the app. The gestures will be *swipe left* and *swipe right* on the current weather and forecast widgets, which will switch to the other widget. The *swipe down* gesture will be used to refresh the weather. This is a fairly standard interaction feature in mobile computing.

The Forecast Tab

First, take some time to implement the forecast widget, so you have something to use gestures to switch between. As in [Chapter 6](#), this should be old hat for you, so I'm just going to summarize the changes. Then I can focus on giving you new and interesting content! I recommend you try to implement these steps before referring to the example code.

1. Create a mockup of how you would like the forecast to look. Bear in mind that your widget has to fit on a narrow mobile screen. See [Figure 7-1](#).
2. Add a `ForecastLabel` class to `weather.kv` to render individual forecast data. Put an icon, conditions, and temperature min and max on it. See [Example 7-1](#).
3. Add a `Forecast` class extending `BoxLayout` to `main.py` and `weather.kv`. Give it a `BoxLayout` with a named `id` so that `ForecastLabel` objects can be added to it later. Also give it a button to switch to the `CurrentWeather` widget and hook up the event listener. See [Example 7-1](#).

4. Create an `update_weather` method on `Forecast` that downloads three days' worth of weather (remember to query the config for metrics) from Open Weather Map's forecast page and creates three `ForecastLabel` objects on the `BoxLayout`. You'll probably want to import and use Python's `datetime` module here (see [Example 7-2](#)).
5. Create an appropriate `show_forecast` function on `WeatherRoot`, as shown in [Example 7-3](#). Also hook up event listeners to call it from the button on `Current Weather`.

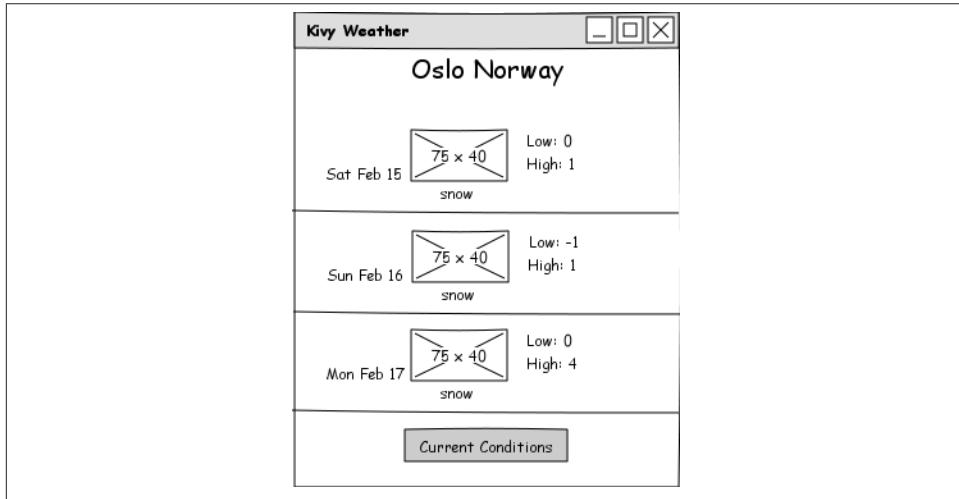


Figure 7-1. A three-day forecast

Example 7-1. ForecastLabel and Forecast classes

```
<ForecastLabel@BoxLayout>:
    date: ""
    conditions_image: ""
    conditions: ""
    temp_min: None
    temp_max: None
    canvas.before:
        Color:
            rgb: [0.2, 0.2, 0.2]
        Line:
            points: [self.pos[0], self.pos[1], self.width, self.pos[1]]
    Label:
        text: root.date
    BoxLayout:
        orientation: "vertical"
        AsyncImage:
            source: root.conditions_image
        Label:
```

```

        text: root.conditions
BoxLayout:
    orientation: "vertical"
Label:
    text: "Low: {}".format(root.temp_min)
Label:
    text: "High: {}".format(root.temp_max)

<Forecast>:
    forecast_container: forecast_container
    orientation: "vertical"
Label:
    size_hint_y: 0.1
    font_size: "30dp"
    text: "{} ({})".format(root.location[0], root.location[1])
BoxLayout:
    orientation: "vertical"
    id: forecast_container
BoxLayout:
    orientation: "horizontal"
    size_hint_y: None
    height: "40dp"
Button:
    text: "Current"
    on_press: app.root.show_current_weather(root.location)

```

Example 7-2. Forecast class with update_weather method

```

class Forecast(BoxLayout):
    location = ListProperty(['New York', 'US'])
    forecast_container = ObjectProperty()

    def update_weather(self):
        config = WeatherApp.get_running_app().config
        temp_type = config.getdefault("General", "temp_type", "metric").lower()
        weather_template = "http://api.openweathermap.org/data/2.5/forecast/" +
            "daily?q={},{}&units={}&cnt=3"
        weather_url = weather_template.format(
            self.location[0],
            self.location[1],
            temp_type)
        request = UrlRequest(weather_url, self.weather_retrieved)

    def weather_retrieved(self, request, data):
        data = json.loads(data.decode()) if not isinstance(data, dict) else data
        self.forecast_container.clear_widgets()
        for day in data['list']:
            label = Factory.ForecastLabel()
            label.date = datetime.datetime.fromtimestamp(day['dt']).strftime(
                "%a %b %d")

            label.conditions = day['weather'][0]['description']
            label.conditions_image = "http://openweathermap.org/img/w/{}.png".format(

```

```

        day['weather'][0]['icon'])
label.temp_min = day['temp']['min']
label.temp_max = day['temp']['max']
self.forecast_container.add_widget(label)

```

Example 7-3. show_forecast method

```

def show_forecast(self, location=None):
    self.clear_widgets()

    if self.forecast is None:
        self.forecast = Factory.Forecast()

    if location is not None:
        self.forecast.location = location

    self.forecast.update_weather()
    self.add_widget(self.forecast)

```

As Figure 7-2 shows, the forecast widget isn't beautiful, but it gets the job done.

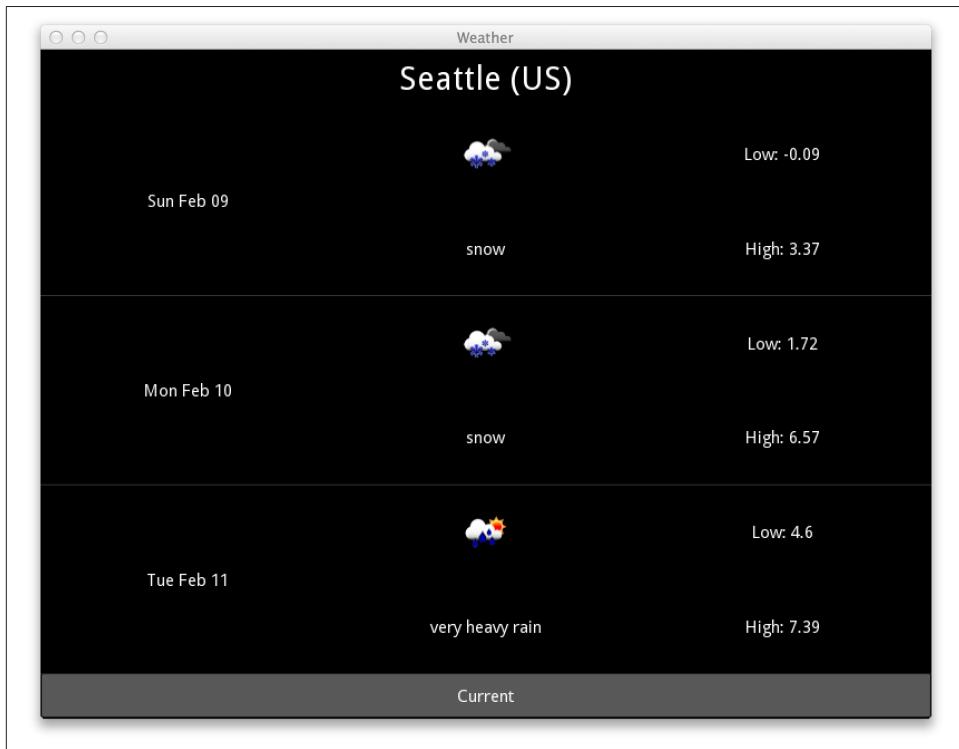


Figure 7-2. Seattle is going to get snow

Recording Gestures

The mathematics behind computational gesture recognition are quite complicated. Luckily, the Kivy developers have supplied a basic gesture library that allows you to record a gesture using an example tool, and then match user input gestures against the recording to test if it's the same gesture. Sound simple? It's not hard, but the process is a bit involved.

The first thing you want to do is to record the encoded representation of the three gestures you want to recognize. Do this using the `gesture_board.py` example that ships with Kivy. Hopefully you already have the Kivy source code checked out, either because you built it from scratch in [Chapter 1](#) or because you've been diligently reading through the source when you get stuck trying to understand something and the documentation is insufficient. If not, check it out with the command `git clone http://github.com/kivy/kivy`.

Getting Git

If you use Linux, Git is probably preinstalled, since Linux is a developer's operating system. Git was originally designed for the distributed development of the Linux kernel and is an integral part of modern Linux development culture. If it's not installed, it'll be a simple process to install it using your distribution's package manager.

If you've configured Mac OS for development by installing Apple's XCode, you will also have Git installed. You're going to need to do this anyway if you want to deploy to iOS devices, and XCode contains a dazzling number of other tools that may or may not be useful in your future endeavors as a developer on an Apple machine.

If you use Windows, you'll want to install the [MSysGit package](#). Windows was once considered a second-class citizen for Git usage, but MSysGit changes this. In addition to giving you the Git version control tool, it also provides an easy installer for the powerful bash command-line shell. You can (and should) use this shell instead of the default Windows command prompt for all your development, not just Git.

Then, in a terminal, `cd` into the `kivy/examples/gestures` directory. Run the command `python gesture_board.py`.

This will pop up a familiar black window. It looks like the default blank Kivy window with no widgets on it. This is a bit misleading, though, because it does have a widget that is designed to recognize Kivy gestures. The demo comes with four gestures pre-installed. If you draw a clockwise circular shape on the screen, as shown in [Figure 7-3](#), you should get some output on the terminal similar to [Example 7-4](#).

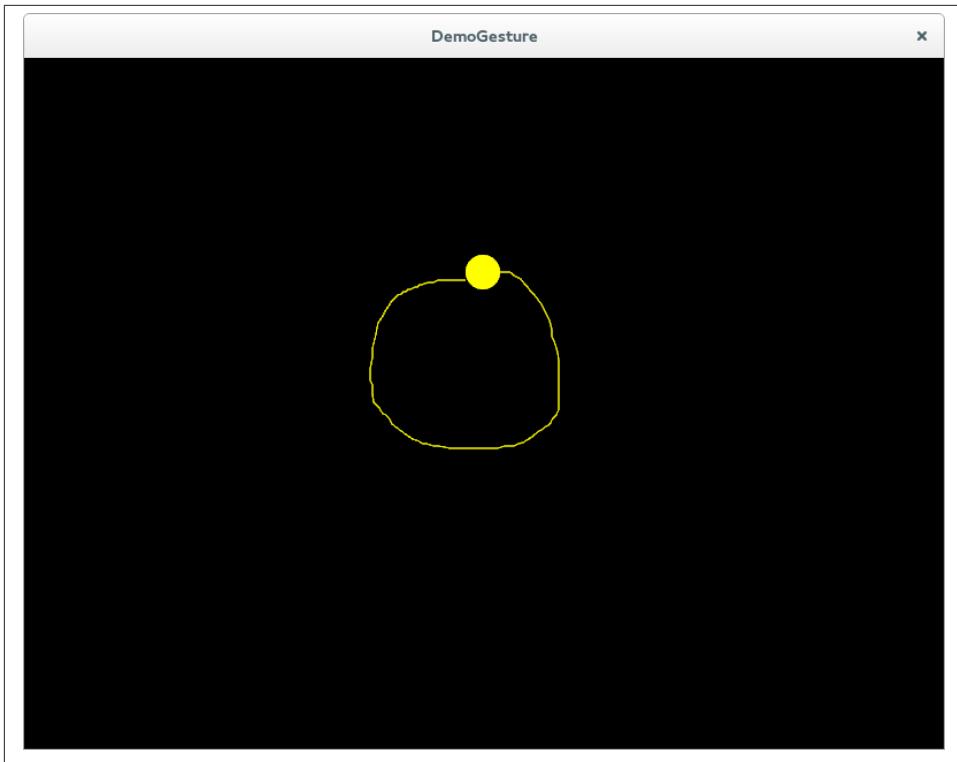


Figure 7-3. A circular gesture

Example 7-4. Output after drawing a circular gesture

```
gesture representation: <a very long random string of characters>
cross: 0.3540801575248498
check: -2.4878193071394503
circle: 0.9506637523286905
square: 0.7579676451240299
(0.9506637523286905, <kivy.gesture.Gesture object at 0x7f513df07450>)
circle
```

Read this output from bottom to top. The last line of the output indicates that the app (correctly) guessed that I drew a circle. The line above that indicates the actual gesture object that was matched and with what confidence. The four lines of text above that provide the matching scores for the four sample gestures. Unless I happened to draw exactly the same circle that whoever recorded these gestures did, I will not get a score of 1.0, but the closer it is to 1.0 the more likely it is that my drawing is a representation of the same gesture.

The first line of text, which I snipped out of this example to save you from having to read a page full of gibberish (and O'Reilly from having to print it), is a textual repre-

smentation of the gesture I drew. Don't bother trying to interpret it; it's meaningless in this form. However, this line (likely several lines since it wraps across your terminal, but there's no newline character, so treat it as a single line) is the information you need to record if you want to create your own gestures and match them.

So, we'll do that next. There are three gestures you want to record: a left-to-right horizontal line, a right-to-left horizontal line, and a bottom-to-top vertical line. They are pretty simple gestures. Create a new Python file named *gesture_box.py*. Put each string inside a dictionary named `gesture_strings`, as summarized in [Example 7-5](#), bearing in mind that your strings will be both different and longer.

Example 7-5. Summary of three gestures

```
gesture_strings = {
    'left_to_right_line': 'eNp91XtsU...<snip>...4hSE=',
    'right_to_left_line': 'eNp91ULME...<snip>...Erg==',
    'bottom_to_top_line': 'eNp91HlsD...<snip>...NMndJz'
}
```

Now you need to write some code to convert those strings back into the format that Kivy recognizes as gestures. In the same *gesture_box.py* file, add some imports and construct a `GestureDatabase`, as shown in [Example 7-6](#).

Example 7-6. Constructing a GestureDatabase

```
from kivy.gesture import GestureDatabase

gestures = GestureDatabase()
for name, gesture_string in gesture_strings.items():
    gesture = gestures.str_to_gesture(gesture_string)
    gesture.name = name
    gestures.add_gesture(gesture)
```

Now you have a module-level database of gestures. This database can compare gestures the user makes to its three stored gestures and tell us if the user input matches any of them.

Touch Events

The next step is to record the gestures that the user makes on the screen. My plan is to create a new widget that listens to input touch events, distinguishes gestures, and fires new events for each gesture it recognizes. In short, you're about to learn a lot more about Kivy's event system!

Start by creating a new class named `GestureBox` in *gesture_box.py*. Make it extend `BoxLayout` (remember to import the `BoxLayout` class, since it isn't available in this file yet).

You've worked with higher-level events in most of the previous chapters. Now it's time to get a little closer to the hardware. Kivy is designed with touchscreens in mind, so you'll be working with touch events, even if you're using a mouse.

There are three different kinds of touch events:

- `touch_down`, which corresponds to the user touching a finger on the touchscreen or pressing the mouse button.
- `touch_move`, which corresponds to the user dragging a finger after touching it onto the screen, or dragging the mouse with the button down. There may be multiple (or no) move events between a down and an up event.
- `touch_up`, which corresponds to lifting the finger off the screen or releasing the mouse button.

Kivy has full multitouch support, so it's possible for more than one `touch_down`-initiated touch event to be active at one time. The down, move, and up events are linked for each touch, such that you can access in the `touch_move` and `touch_up` events data that was set earlier in the `touch_down` event. You do this by passing a `touch` argument into the event handlers that contains data about the touch itself, and to which you can add arbitrary data in typical Pythonic fashion.

To recognize a gesture, you'll need to start recording each individual event in the `touch_down` handler, add the data points for each call to `touch_move`, and then do the gesture calculations when all data points have been received in the `touch_up` handler. Refer to [Example 7-7](#).

Example 7-7. GestureBox down, up, and move events

```
class GestureBox(BoxLayout):
    def on_touch_down(self, touch):
        touch.ud['gesture_path'] = [(touch.x, touch.y)]
        super(GestureBox, self).on_touch_down(touch)

    def on_touch_move(self, touch):
        touch.ud['gesture_path'].append((touch.x, touch.y))
        super(GestureBox, self).on_touch_move(touch)

    def on_touch_up(self, touch):
        print(touch.ud['gesture_path'])
        super(GestureBox, self).on_touch_up(touch)
```

As with other Kivy events, you can hook up event handlers in your Python code by implementing `on_eventname_`. The `touch` object passed into each event has a `ud` (short for user data) dictionary that is the same for each event. Construct a `gesture_path` list in the down event, append each subsequent motion event to it in the move event, and

then simply print it in the up event. Each event also calls its super method so that the buttons at the bottom of the screen still work.

Now, to test this code, modify the `main.py` file to include a `from gesture_box import GestureBox` import. Then make the `CurrentWeather` and `Forecast` widgets extend this new class instead of `BoxLayout`. The layout functionality will be the same. However, if you now drag the mouse on these widgets, you will see a collection of points output on the terminal when you release the button.

Recognizing Gestures

Now that you have the points that the user created available, you can construct a `Gesture` object. Then you simply have to invite the `GestureDatabase` object to detect whether or not the user's input matches any of the gestures you created. [Example 7-8](#) demonstrates.

Example 7-8. Recognizing if a gesture occurred

```
def on_touch_up(self, touch):
    if 'gesture_path' in touch.ud:
        gesture = Gesture() ①
        gesture.add_stroke(touch.ud['gesture_path']) ②
        gesture.normalize() ③
        match = gestures.find(gesture, minscore=0.90) ④
        if match:
            print("{} happened".format(match[1].name)) ⑤
        super(GestureBox, self).on_touch_up(touch)
```

- ① You'll also want a `from kivy.gesture import Gesture` at the top of the file.
- ② The `add_stroke` method accepts the list of (`x`, `y`) tuples that have been attached to the user data in the `down` and `move` methods.
- ③ Normalizing a gesture basically forces it to be converted to a unit box. This means that gestures that have the same shape, but different sizes, will match at each point.
- ④ `minscore` represents how confident the algorithm is that the gesture matches anything in the database. It will return the highest-matching gesture, provided the match is higher than this score.
- ⑤ The `match` object returns a tuple of (`score`, `gesture`). The name of the gesture was stored with each gesture when the `GestureDatabase` was populated. Here, you just print it.

Firing Events

Of course, it isn't much use to just print that a gesture happened. It would be better to fire a new event that other classes can interpret. This is reminiscent of how you listen for `press` events rather than `touch_down` events on a button.

So, time to create a new event! Instead of creating a single `on_gesture` event, I'm going to dynamically create a new event type for each of the three gestures I've defined. I'll end up with `on_left_to_right_line`, `on_right_to_left_line`, and `on_bottom_to_top_line` events. This might not be the most sensible design, but it does make it trivial to respond to individual gestures from inside the KV language file.

The first step is to register the new event type with the `EventDispatcher`. Every widget extends the `EventDispatcher` class, so we can do this trivially inside a new `__init__` method on the `GestureBox` class in `gesture_box.py`, as shown in [Example 7-9](#).

You also need to add default event handlers for each of those events, also shown in [Example 7-9](#). The default activity can be to do nothing, but the methods still need to exist.

Example 7-9. Registering new event types

```
def __init__(self, **kwargs):
    for name in gesture_strings:
        self.register_event_type('on_{}'.format(name))
    super(GestureBox, self).__init__(**kwargs)

def on_left_to_right_line(self):
    pass

def on_right_to_left_line(self):
    pass

def on_bottom_to_top_line(self):
    pass
```

Then all you have to do to fire an event is call the `self.dispatch` method, optionally passing any arguments that you would like to arrive with the event. In [Example 7-10](#) I don't pass any arguments, since gestures are binary (either they happened or they didn't) and there is no data to supply. If you created a generic `on_gesture` event instead of different events for each gesture, you might pass in the gesture name as an argument. In this case, the call would be `self.dispatch(on_gesture, gesture.name)`.

Example 7-10. Firing an event with self.dispatch

```
if match:
    self.dispatch('on_{}'.format(match[1].name))
```

Now that your events are firing reliably, you can add a few event handlers to your KV language file, as shown in [Example 7-11](#) and [Example 7-12](#).

Example 7-11. Handling the gesture events on CurrentWeather

```
<CurrentWeather>:  
    orientation: "vertical"  
    on_right_to_left_line: app.root.show_forecast(root.location)  
    on_bottom_to_top_line: root.update_weather()
```

Example 7-12. Handling gesture events on the Forecast widget

```
<Forecast>:  
    forecast_container: forecast_container  
    orientation: "vertical"  
  
    on_left_to_right_line: app.root.show_current_weather(root.location)  
    on_bottom_to_top_line: root.update_weather()
```

File It All Away

At this point, you have a fully functional weather app with the current conditions and a three-day forecast. You can switch between the two views with a simple gesture. There are a few areas of further exploration that you can study:

- The `Locations`, `CurrentWeather`, and `Forecast` classes all contain a `BoxLayout` that has several properties (`orientation`, `size_hint_y`, and `height`) in common. Refactor the KV code so that these properties are stored in a dynamic class named `ButtonBar`.
- For practice, add a new gesture (maybe down or a curve or circle) that does something interesting. If you want to get fancy, look into multitouch gestures. There isn't a lot of documentation on this, but it is doable.
- Experiment with creating new events. Perhaps you could add something to the `update_weather` method to fire an event if the temperature changes.
- You can make the `GestureBox` initializer dynamically create the default event handlers by calling `setattr` on `self` and attaching an empty method to it. This way, you won't have to create a new default handler if you add a new gesture.

Advanced Widgets

Your weather app is now fully functional and you could do an initial release already. However, there are a few things you can do to make it better. This chapter is a large code refactor. The functionality won't change very much, but the usability will improve and the amount of code involved will shrink, which means fewer bugs and easier maintenance.

Kivy has an abundant collection of built-in widgets, and this book can't cover all of them. In this chapter, you'll see three of them in detail: the `Carousel`, `ModalView`, and `Action Bar`. These widgets will largely replace much of the screen management code you have written manually so far.

Be prepared. This will be a large refactor, and you will probably have to do quite a bit of debugging to get everything working correctly. This is great real-world practice, though, as reworking existing code is an important part of the software development process. Applications that don't evolve over time are inevitably superceded.

Before you start, remove your brand new `gesture_box.py` file altogether and revert the two classes in `main.py` to extend `BoxLayout` instead of `GestureBox`. You'll also need to remove an `import` statement.

Also remove the custom gesture event listeners (such as `on_right_to_left_line`) from the KV language file.

If your refactor begins with removing entire files of custom code that you no longer have to maintain, you're probably doing something right!

Carousel

The `Carousel` widget allows for swiping between multiple widgets in a screen. This is a large part of what you implemented manually in [Chapter 7](#) (if you're wondering why

I didn't implement `Carousel` in the first place, it's because I wanted to give you some lower-level experience with Kivy events). However, `Carousel` adds fancy animation and takes care of several edge cases that I ignored while presenting that chapter.

The three widgets `Carousel` will switch between are `Locations`, `CurrentWeather`, and `ForecastLabel`. Ignore the `AddLocationForm` widget for now. You will now be adding all these widgets in the KV file instead of trying to create them dynamically in Python. Hook each existing `ObjectProperty` to a widget `id`, as shown in [Example 8-1](#), and remember to add a new `carousel = ObjectProperty()` to the `WeatherRoot` widget in `main.py`.

Example 8-1. Adding a carousel to WeatherRoot

```
<WeatherRoot>:  
    carousel: carousel  
    locations: locations  
    current_weather: current_weather  
    forecast: forecast  
    Carousel:  
        id: carousel  
        Locations:  
            id: locations  
        CurrentWeather:  
            id: current_weather  
        Forecast:  
            id: forecast
```



Crash alert: you'll probably have to delete your `weather_store.json` file before running this example successfully, and don't click the Add Location button. This will get fixed in the next section.

If you run the program now, you'll discover that all the weather functionality is broken, but you can drag the mouse left and right on the screen to easily switch between the three widgets. That's progress... right?

You'll also find that the buttons on the bottom bar only sort of work. As you'll recall, each of these manually replaces the contents of the `WeatherRoot` widget with a new child. This means that the `Carousel` is removed. Thus, after you've clicked a button, the swipe actions no longer work.

To solve this, set the button clicks to do nothing more than change slides on the `Carousel`. For example, in the `CurrentWeather` widget, the two buttons will look like [Example 8-2](#).

Example 8-2. Event handlers on the CurrentWeather buttons

```
Button:  
    text: "Locations"  
    on_press: app.root.carousel.load_slide(app.root.locations)  
Button:  
    text: "Forecast"  
    on_press: app.root.carousel.load_slide(app.root.forecast)
```

Remember to make similar changes to the button on the Forecast slide.

You'll be doing more refactoring on the code in *main.py* later, but in order to see those future changes working, fix up the `AddLocationForm` widget next.

The ModalView Widget

`ModalView` and its more featureful subclass, `Popup`, allow widgets to be displayed in front of existing widgets. This is what you should use for displaying the `Add Location` form instead of completely replacing the contents of the root widget.(((displays, popup windows))

This particular refactor involves just a few changes, but they're spread all over both files. First make the `AddLocationForm` class in *main.py* extend `ModalView` (which you will need to import as `from kivy.uix.modalview import ModalView`). Then replace the `show_add_location_form` method on `WeatherRoot` with [Example 8-3](#), remembering to add a new `add_location_form = ObjectProperty()` to the `WeatherRoot` object.

Example 8-3. Using ModalView.open to render a view

```
def show_add_location_form(self):  
    self.add_location_form = AddLocationForm()  
    self.add_location_form.open()
```

If you run this code and click the `Add Location` button, you may be in for a bit of a surprise. As [Figure 8-1](#) illustrates, the widgets were all drawn on top of each other instead of being laid out as expected.

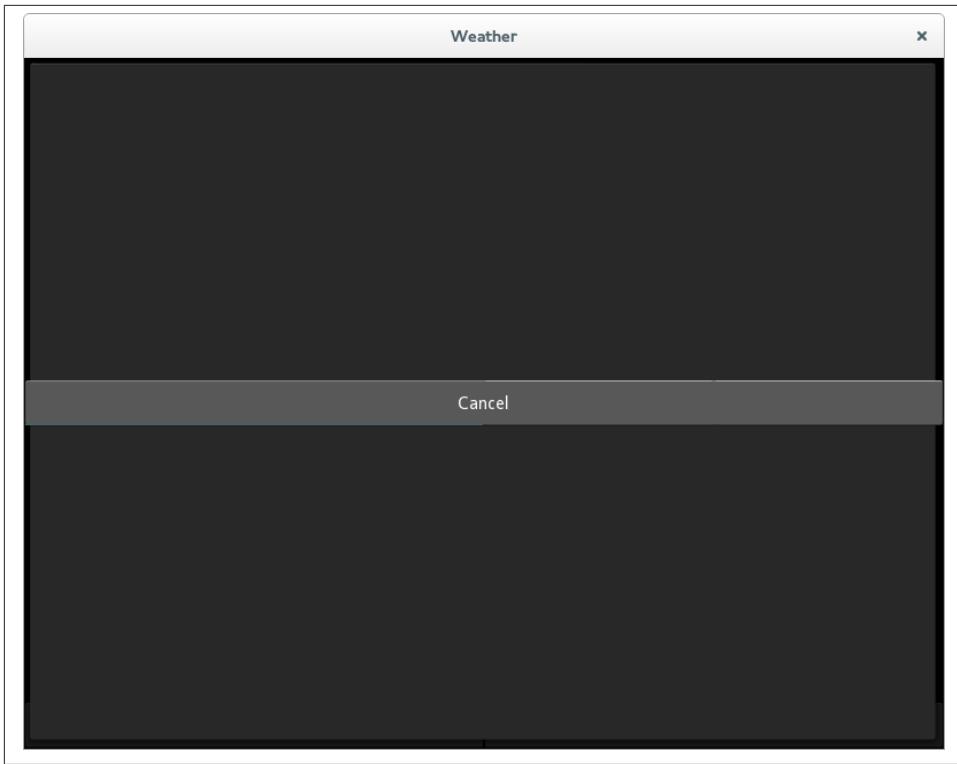


Figure 8-1. The layout of the form is completely broken

This oversight is because `ModalView` does not extend `BoxLayout`. To get the old behavior back, simply wrap the entire contents of `AddLocationForm` in the `weather.kv` file with an extra `BoxLayout`, as shown in [Example 8-4](#).

Example 8-4. BoxLayout as the child of ModalView

```
<AddLocationForm>:  
    search_input: search_box  
    search_results: search_results_list  
    BoxLayout: ❶  
        orientation: "vertical" ❷  
        BoxLayout:  
            height: "40dp"  
            size_hint_y: None  
            TextInput:  
                id: search_box
```

- ❶ The new `BoxLayout` now has everything below it further indented.
- ❷ The `orientation` property is moved from the parent widget to the `BoxLayout`.

Now the form will render as you are used to. Change the `on_press` event on the Cancel button to dismiss the dialog instead of calling `show_current_weather`. [Example 8-5](#) illustrates.

Example 8-5. The Cancel button event handler

```
Button:  
    height: "40dp"  
    size_hint_y: None  
    text: "Cancel"  
    on_press: root.dismiss()
```

Completing the Refactor

The next step is to clean up `WeatherRoot`, especially the `show_current_weather` method. Start, however, by outright removing a couple of methods that are no longer required:

- `show_locations` has been superceded by the selection of a slide on the `Carousel`.
- `show_forecast` has also been superceded. The act of updating the forecast will be moved into the `show_current_weather` method shortly.

Next, remove the code from `show_current_weather` that clears the current widget as well as the two conditionals that construct `CurrentWeather` and `Locations` widgets if they don't exist. In the `Carousel`, these widgets always exist, even when they aren't visible.

Before removing the locations conditional, note that it contains some code for updating the locations from a store. If you were doing this refactor without my guidance, I would recommend updating your to-do list (it's a good idea to start refactors with a text file listing the things you need to complete) to include “update locations from the store” so you don't forget that functionality when the refactor is complete.

Your code is no longer calling this method with a possible `location=None` parameter, so you can call the location-updating code without checking the conditional.

Now you have to add a couple of lines of code to set the `location` on the `Forecast` object as well. This slide needs to be updated as soon as the location is loaded now, instead of after it is displayed.

Next, replace the `add_widget` call with a call to `load_slide`, and finally, dismiss the `add_location_form` if it is visible. Remember that `show_current_weather` can be called both from `AddLocationForm` and from the `Locations` slide, so it may or may not be set at this time.

That was a lot of description. I hope it made sense, but if not, the new, much simpler method in [Example 8-6](#) should compare favorably to your previous version.

Example 8-6. The new show_current_weather method

```
def show_current_weather(self, location):
    if location not in self.locations.locations_list.adapter.data:
        self.locations.locations_list.adapter.data.append(location)
        self.locations.locations_list._trigger_reset_populate()
        self.store.put("locations",
                      locations=list(self.locations.locations_list.adapter.data),
                      current_location=location)

    self.current_weather.location = location
    self.forecast.location = location
    self.current_weather.update_weather()
    self.forecast.update_weather()

    self.carousel.load_slide(self.current_weather)
    if self.add_location_form is not None:
        self.add_location_form.dismiss()
```

Now fix up the `__init__` method on `WeatherRoot` to set up the stored locations list as well as the current location when the widget is constructed. Additionally, if no stored location exists, automatically pop up the Add Location form on the next clock cycle. See [Example 8-7](#).

Example 8-7. The updated on_config_change method

```
def __init__(self, **kwargs):
    super(WeatherRoot, self).__init__(**kwargs)
    self.store = JsonStore("weather_store.json")
    if self.store.exists('locations'):
        locations = self.store.get('locations')
        self.locations.locations_list.adapter.data.extend(locations['locations'])
        current_location = locations["current_location"]
        self.show_current_weather(current_location)
    else:
        Clock.schedule_once(lambda dt: self.show_add_location_form())
```

Finally, make the `on_config_change` method on the `WeatherApp` update the weather on the `CurrentWeather` and `Forecast` widgets directly, as shown in [Example 8-8](#). Otherwise, when you change the config setting, the values won't get set.

Example 8-8. The updated __init__ method

```
def on_config_change(self, config, section, key, value):
    if config is self.config and key == "temp_type":
        try:
            self.root.current_weather.update_weather()
            self.root.forecast.update_weather()
```

```
except AttributeError:  
    pass
```

This last change illustrates a danger inherent in refactoring. I didn't notice this problem when I originally wrote this chapter. Because the exception being thrown happened to be caught by the nasty code, there were no errors to indicate that the values were not being updated when the user changed the preferred measurement unit. I picked up on it when I was writing [Chapter 9](#), and had to come back and fix it. Be wary!

Adding an Action Bar

The Kivy API comes with an `ActionBar` widget that mimics the Android action bar, making it possible to integrate a little better with the Android ecosystem. Even without our worrying about Android integration, the `ActionBar` can give a better user experience than the buttons you have at the bottom of your existing `Carousel` widgets.

The `ActionBar` comes with its own set of widgets, including the following (it's also possible to define your own `ActionItem` subclasses):

- `ActionCheck`
- `ActionButton`
- `ActionToggleButton`
- `ActionSeparator`
- `ActionGroup`
- `ActionOverflow`
- `ActionPrevious`

These classes are mostly self-explanatory, with the exception of the last three. `ActionPrevious` renders an icon and title into the left side of the action bar. In typical Android usage, touching this icon behaves like pressing the back button: it goes to the previous screen. However, this can be disabled by setting a `with_previous` setting. `ActionGroup` is just a drop-down “menu” in which you can put other `ActionItem` objects. `ActionOverflow` can explicitly contain other `ActionItems` as well. However, the neat thing about `ActionOverflow` is that if the `ActionBar` becomes too narrow, it will automatically move items into the `ActionOverflow` area so that they are still available in a drop-down. `ActionOverflow` is represented much like the menu icon on recent Android devices.

[Example 8-9](#) shows the entire `ActionBar` on the `WeatherRoot` widget. It shows up in a `BoxLayout` above the `Carousel`. The Add Location and Settings buttons go inside an overflow, while the other buttons show up in the main view.

Example 8-9. Putting an ActionBar above the Carousel

```
<WeatherRoot>:  
    carousel: carousel  
    locations: locations  
    current_weather: current_weather  
    forecast: forecast  
    BoxLayout:  
        orientation: "vertical"  
        ActionBar:  
            ActionView:  
                use_separator: True  
                ActionPrevious:  
                    title: "Kivy Weather"  
                    with_previous: False  
                ActionOverflow:  
                    ActionButton:  
                        text: "Add Location"  
                        on_press: app.root.show_add_location_form()  
                    ActionButton:  
                        text: "Settings"  
                        on_press: app.open_settings()  
                    ActionButton:  
                        text: "Locations"  
                        on_press: app.root.carousel.load_slide(app.root.locations)  
                    ActionButton:  
                        text: "Current"  
                        on_press: app.root.carousel.load_slide(app.root.current_weather)  
                    ActionButton:  
                        text: "Forecast"  
                        on_press: app.root.carousel.load_slide(app.root.forecast)  
    Carousel:  
        id: carousel  
        Locations:  
            id: locations  
        CurrentWeather:  
            id: current_weather  
        Forecast:  
            id: forecast
```

At this point, you can remove all the old `BoxLayout` and `Button` definitions that were showing up at the bottom of the other views. You'll probably want to leave the Cancel button on the Add Location form, though. This makes the source code a lot neater, and as you can see from [Figure 8-2](#), the interface also looks a lot cleaner!

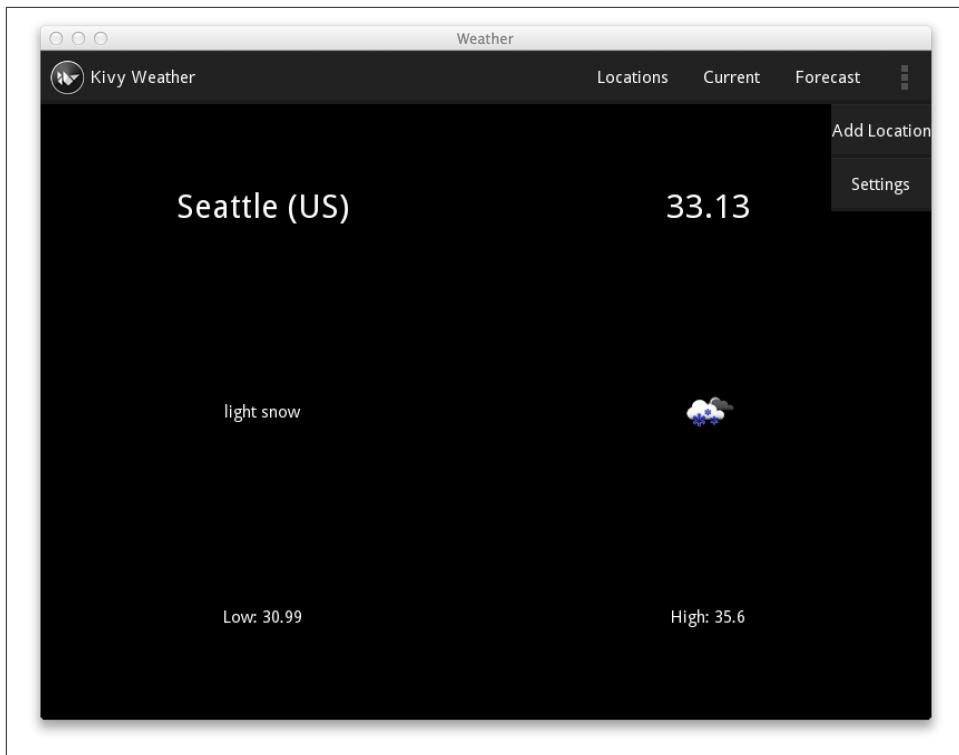


Figure 8-2. The ActionBar with the overflow area open

File It All Away

In this chapter, you did a fairly large code refactor and were introduced to three more advanced Kivy widgets—Carousel, ModalView, and ActionBar. Your application looks pretty good and might be considered production-ready. You’ll test that theory in the next chapter, when you deploy it to your Android or iOS device.

In the meantime, here are a few additional things you might want to try to enhance your understanding:

- The `location` attribute on `CurrentWeather` and `Forecast` now seems somewhat redundant because those widgets are always updated at the same time, by `show_current_weather` (which should probably be named `change_location` at this point). It might make more sense to store just one `current_location` on the Weather Root and have the child widgets access it from there.

- You might be able to enhance the look of the `ActionBar` by setting icons on the buttons. You could also put the metric/imperial switch directly into the `ActionBar` (as an `ActionCheck`) and do away with the settings overlay overhead.
- You could turn the `ActionBar` buttons into an `ActionToggle` to indicate which slide you are on. You'll need to listen to property changes on the `Carousel` to update the toggle button state when the slide changes.
- Consider the advantages and disadvantages of using `Popup` instead of `ModalView` for `AddLocationForm`.
- Take a look at the `kivy.uix` package for a wide variety of other useful Kivy widgets.

Releasing to Android and iOS

Now that you have a functional weather application, it's time to actually deploy it to your mobile device. In this chapter we'll discuss how to deploy to Android, which can be done from a Linux or Mac OS machine, and to iOS if both your host and device are Apple products. Kivy has a custom-built deployment tool called *Buildozer*. This tool is both a blessing and a curse. On the positive side, it works very hard (and very well) to take care of all the crazy dependencies that are required to deploy to these disparate platforms, and it has the second-coolest name in the packaging industry (Arch Linux's *pacman* package manager is number one). On the negative side, it can be difficult to debug when things go wrong and is another build system you have to learn. I find this frustrating, as I'm already familiar with so many other build tools--*setuptools*, *pip*, *Make*, *Ant*, *buildout*, *Paver*, and more. I'd have preferred to see *Buildozer*'s features incorporated into the standard Python ecosystem. However, since they weren't and it's here and it works, I'm going to show you how to use it!

Getting Buildozer

Buildozer lives on Kivy's [GitHub page](#). It's currently alpha software, but it's far less cumbersome than older Kivy deployment methods, so I recommend you use it. I also recommend you use the master branch rather than one of the releases. The Kivy developers keep this project up-to-date with the ever-changing landscape of Android and iOS development, and it's rarely in a broken state. Unfortunately, however, Buildozer is not currently supported on Windows. In fact, there is no reliable way to deploy Kivy to Android devices from a Windows environment. The Kivy team provides a Linux virtual machine that you can run from inside your Windows box if you want to tackle deploying, but it's not a painless process.

If you have Git installed, which you should if you're serious about software development, the easiest way to install Buildozer is to clone the repository using the simple command `git clone https://github.com/kivy/buildozer.git`. I'd do this from whatever di-

reictory holds the code for your Kivy project so you can keep all your Kivy stuff in one place.

If you're just toying around and prefer not to install Git at this time, you can download a ZIP file directly from the [Buildozer GitHub page](#). Click the Download ZIP button, which at the time of this writing appears in the right sidebar on the GitHub page, as shown in [Figure 9-1](#).

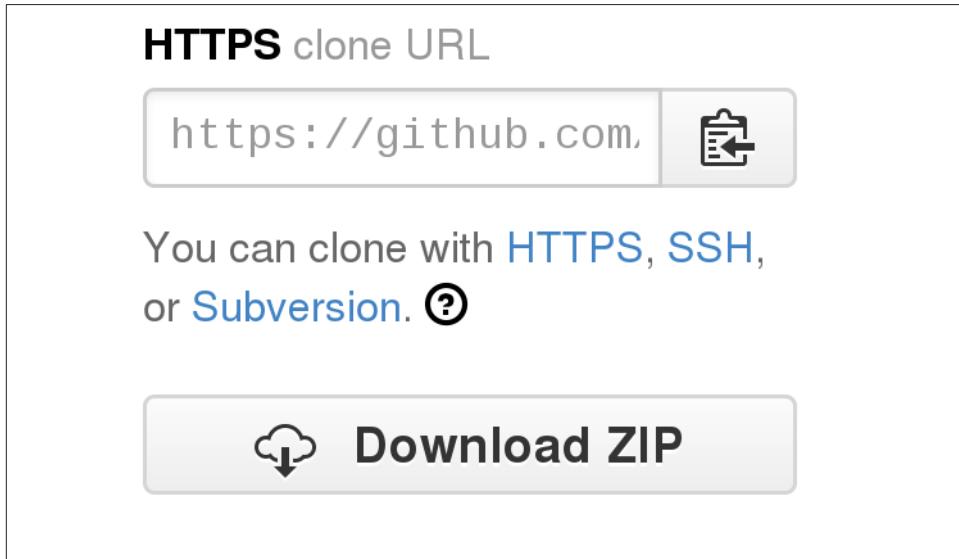


Figure 9-1. The GitHub Download button

Once you've downloaded and extracted the Buildozer file, cd into the new `buildozer` directory and run the command `python2 setup.py install`. You may have to run this with sudo, depending on how your Python and operating system are set up.

Deploying Your Application

In this section, I'll focus on deploying your weather app to an Android device, as it's a bit simpler than for iOS. The iOS section will build on it, so you'll want to read both sections if you're an Apple user.



At the time of writing, even though Kivy supports Python 3, Buildozer is Python 2 only and installs a Python 2 environment onto your Android device. This means that if you have been developing in Python 3, you may have to make a couple of changes, which I have noted throughout the book, to get the application running on Android.

Namely, there is a call to `super` that needs to be changed to Python 2 format, and the `clear` method on the list needs to be replaced with an explicit `del`.

Buildozer works from a file named `buildozer.spec`, which allows you to describe and configure how your Kivy application will be deployed. Start by generating a default specification running the command `buildozer init` in the folder that contains your `main.py` and `weather.kv` files. Open the resulting `buildozer.spec` file in your text editor. You'll find that it contains a ton of settings, some of which are commented out, and all of which are described inside the file. [Example 9-1](#) illustrates the changes I made to the default settings.

Example 9-1. Buildozer specification for an Android build

```
[app]

# (str) Title of your application ①
title = Weather

# (str) Package name ②
package.name = weather

# (str) Package domain (needed for android/ios packaging)
package.domain = org.example

# (str) Source code where the main.py live
source.dir = .

# (list) Source files to include (let empty to include all the files)
source.include_exts = py,png,jpg,kv,atlas

# (list) Source files to exclude (let empty to not exclude anything)
#source.exclude_exts = spec

# (list) List of directory to exclude (let empty to not exclude anything)
#source.exclude_dirs = tests, bin

# (list) List of exclusions using pattern matching
#source.exclude_patterns = license,images/*/*.jpg

# (str) Application versioning (method 1)
# version.regex = __version__ = '(.*)'
```

```

# version.filename = %(source.dir)s/main.py

# (str) Application versioning (method 2) ❸
version = 0.1

# (list) Application requirements ❹
requirements = kivy

# (str) Presplash of the application
#presplash.filename = %(source.dir)s/data/presplash.png

# (str) Icon of the application
#icon.filename = %(source.dir)s/data/icon.png

# (str) Supported orientation (one of landscape, portrait or all) ❺
orientation = all

# (bool) Indicate if the application should be fullscreen or not
fullscreen = 0

#
# Android specific ❻
#

# (list) Permissions
android.permissions = INTERNET

# (int) Android API to use
android.api = 14

# (int) Minimum API required (8 = Android 2.2 devices)
android.minapi = 8

# (int) Android SDK version to use
android.sdk = 21

# (str) Android NDK version to use
android.ndk = 9

# (bool) Use --private data storage (True) or --dir public storage (False)
android.private_storage = True

# (str) Android NDK directory (if empty, it will be automatically downloaded.)
#android.ndk_path =

# (str) Android SDK directory (if empty, it will be automatically downloaded.)
#android.sdk_path =

# (str) Android entry point, default is ok for Kivy-based app
#android.entrypoint = org.renpy.android.PythonActivity

```

```

# (list) List of Java .jar files to add to the libs so that pyjnius can access
# their classes. Don't add jars that you do not need, since extra jars can slow
# down the build process. Allows wildcards matching, for example:
# OUYA-ODK/libs/*.jar
#android.add_jars = foo.jar,bar.jar,path/to/more/*.jar

# (list) List of Java files to add to the android project (can be java or a
# directory containing the files)
#android.add_src =

# (str) python-for-android branch to use, if not master, useful to try
# not yet merged features.
#android.branch = master

# (str) OUYA Console category. Should be one of GAME or APP
# If you leave this blank, OUYA support will not be enabled
#android.ouya.category = APP

# (str) Filename of OUYA Console icon. It must be a 732x412 png image.
#android.ouya.icon.filename = %(source.dir)s/data/ouya_icon.png

# (str) XML file to include as an intent filters in <activity> tag
#android.manifest.intent_filters =

# (list) Android additionnal libraries to copy into libs/armeabi
#android.add_libs_armeabi = libs/android/*.so

# (bool) Indicate whether the screen should stay on
# Don't forget to add the WAKE_LOCK permission if you set this to True
#android.wakelock = False

# (list) Android application meta-data to set (key=value format)
#android.meta_data =

# (list) Android library project to add (will be added in the
# project.properties automatically.)
#android.library_references =

#
# iOS specific
#

# (str) Name of the certificate to use for signing the debug version
# Get a list of available identities: buildozer ios list_identities
#ios.codesign.debug = "iPhone Developer: <lastname> <firstname> (<hexstring>)"

# (str) Name of the certificate to use for signing the release version
#ios.codesign.release = %(ios.codesign.debug)s

[buildozer]

```

```

# (int) Log level (0 = error only, 1 = info, 2 = debug (with command output)) ⑦
log_level = 2

# -----
# List as sections
#
# You can define all the "list" as [section:key].
# Each line will be considered as a option to the list.
# Let's take [app] / source.exclude_patterns.
# Instead of doing:
#
#     [app]
#     source.exclude_patterns = license,data/audio/*.wav,data/images/original/*
#
# This can be translated into:
#
#     [app:source.exclude_patterns]
#     license
#     data/audio/*.wav
#     data/images/original/*
#


# -----
# Profiles
#
# You can extend section / key with a profile
# For example, you want to deploy a demo version of your application without
# HD content. You could first change the title to add "(demo)" in the name
# and extend the excluded directories to remove the HD content.
#
#     [app@demo]
#     title = My Application (demo)
#
#     [app:source.exclude_patterns@demo]
#     images/hd/*
#
# Then, invoke the command line with the "demo" profile:
#
#     buildozer --profile demo android debug

```

- ① Change the title to something meaningful.
- ② The package name should be unique to your dev environment. It will be concatenated to the package.domain, to create something that is globally unique.

- ❸ There are two ways to specify the version: scraping it from `main.py` or specifying it in `buildozer.spec`. The former is a better idea if your version number is referenced in multiple places, but since I'm only using the version for deploying, I specify it here. You have to remember to bump your version with each new release, or Google Play and the iTunes App Store won't pick it up.
- ❹ This is a list of third-party (nonstandard library) Python modules your app depends on. The weather app depends only on Kivy, but you can specify any other libraries you may require.
- ❺ The weather app can take advantage of autorotating.
- ❻ Uncomment several Android-specific options.
- ❼ Things will probably crash, so a debugging `log_level` is a good idea. Reset this before making your app public, or use the Buildozer Profiles feature.

Having updated this file to suit your fancy (you may want to add an icon, for example), you are almost ready to push it to your phone. The first thing you need to do is enable developer access on your phone, if it's running a recent version of Android. You might want to search the Web for how to do this on your specific device, but for recent versions of Android, it typically means finding the Build Number in the About menu (for me, it's buried inside `About → Software information → More → Build Number`) and tapping on it seven times. This is a strange, magical incantation, but eventually it'll tell you that you've unlocked developer options on your phone. You'll then need to find the "Developer options" menu and enable USB Debugging.

The next step is to run the command `buildozer android debug deploy run`. You can easily tell what this command is supposed to do, but it will probably fail multiple times before you get it running. If it fails, edit the `buildozer.spec` file. Find the section titled `[buildozer]` toward the end of the file and change the `log_level` setting to 2 for debugging. Next time you run Buildozer, it will give you informative errors telling you that you are missing dependencies. I personally had to install a ton of packages, including Cython, virtualenv, g++, Ant, and a Java compiler before it would run. However, on the fourth attempt, it managed to complete after taking *ages* to download all the Android dependencies (don't do this on a rate-limited 3G network!), compile them, compile the `.apk`, upload it to the phone, and, eventually, open it on the phone. Go grab a coffee. Assuming the app is working, when you get back you should be able to interact with it just as you did when it was running on your desktop.

Of course, it's not safe to assume everything is working. Android has a variety of useful debugging tools that you can use to debug your application. I can't describe them all here, but I'll discuss a couple that I think are absolutely vital.

Buildozer provides the `logcat` command, which calls `adb logcat` under the hood (you may already be familiar with Android Debug Bridge, or `adb`). You can run it with

`buildozer android logcat`. This command provides all sorts of diagnostic information in the terminal. Most importantly, you can see any Python or Java tracebacks related to your program. Try running `buildozer run` in a different terminal while the log is being displayed. You'll see the Kivy logging info pop up, and if you've got a Python error in your program, you'll see the traceback.

Another tool that is useful (more for prototyping and experimenting than for debugging) is the Kivy Remote Shell. You can access it from [Kivy's GitHub page](#) using Git or by downloading the ZIP file as you did with Buildozer. Kivy Remote Shell ships with a Buildozer spec file. Once you have cloned it, you simply have to run `buildozer android debug deploy run` to get the Kivy Remote Shell installed.

But what is the Kivy Remote Shell? It's kind of the Python shell equivalent of `adb log cat`. You can run the app on your phone and then connect to it from a computer on the same wireless network using `ssh` (`ssh` is preinstalled on most Linux and Mac OS systems; on Windows, you'll want to look up a program called PuTTy). The exact command you need to enter to log in to the device is displayed on the phone's screen. You'll be asked for a password, which is `kivy`. Once you've logged in, you'll be presented with a Python prompt that you can use to control code on the phone. The `app` object is available, and you can add Kivy widgets to the window using `app.root.add_widget`. This is useful for seeing how layouts look on the phone, but I mostly use it for experimenting with `pyjnius`, the Python-to-Java bridge that can be used for manipulating Java Android classes on a phone.

Finally, the absolute best tool for Kivy debugging is called Internet Relay Chat (IRC). If you're having trouble getting Buildozer working, get in touch with the Kivy team using IRC or the Kivy mailing list. Some of the tools discussed in this chapter are still alpha, and bug reports from people who are willing to help the developers understand the problems are the most important means of turning them into the solid software that is the rest of Kivy.

In Which the Author Digresses

I have a strong aversion to having separate interfaces for developers and so-called “normal” users. I believe this creates a culture of inequality. The unbelievable arrogance of the software engineer who decided that normal users needed to be protected from developer options is disturbing and disheartening. This engineer was clearly a “deatheater” who thinks the “muggles” of the world need to be kept further in the dark, rather than enlightened.

The world is coming to entirely depend on technology, and we need to welcome the inexperienced users, make them feel comfortable, help them become adept, and, if we are lucky, prompt them to become new developers themselves. The generation of children who grew up on locked-down tablets and mobile phones never had a chance to

explore and experiment, to break and fix things. If you have kids, buy them a Raspberry Pi to prevent another generation from missing the chance for free learning. Assuming that your users cannot handle the systems you give them is the most horrible disservice you can do them.

This does not mean that interfaces should not be intuitive and easy to use. A system that is easy to use should be equally accessible for experienced power users and new users. Setting sensible defaults, using convention over configuration, and implementing other paradigms can ease this process. But the developer culture must stop enforcing user ignorance.

Deploying to iOS

Unlike Android, Apple's draconian development policies require that you have an Apple developer license before you can test or debug your application on an iOS device. This allows Apple to ensure the quality of the applications available for these devices. For normal iOS development, Apple provides access to an emulator tool, but for Kivy, you'll probably want to test on a real device. If you don't already have a developer license, follow the instructions on the [Apple developer website](#) to get one.

Once you've paid your dues and logged in to the Apple development center, you can download and install XCode if you don't have it already. Run XCode and plug in your iOS device. The XCode Device Organizer should pop up automatically. Select the iOS device from the menu and click the "Use for Development" button. You will be prompted for an Apple ID that is associated with a development account. You will then be invited to request a certificate for the device. Follow this process and confirm that the certificate shows up in your Apple Developer Account in the web browser.

That should be all the extra work you need to do to get permission to develop from Apple. You can now return to the Kivy development process. Create a *buildozer.spec* file similar to [Example 9-1](#) (if you are deploying to both Android and iOS, you can use the same *buildozer.spec* file). You can ignore the Android section this time, but you'll need to add a string to the "iOS specific" section. This string is constructed from the certificate you just created, and can be tricky to get right. Luckily, Buildozer has a command to do this for you: `buildozer ios list_identities`. If your XCode is set up and your iOS device is connected, you should get output like [Example 9-2](#).

Example 9-2. Output of buildozer ios list_identities

```
1) <LONG HEX STRING> "iPhone Developer: Your Full Name (<HEXSTRING>)"
   1 valid identities found
Available identities:
 - "iPhone Developer: Your Full Name (<HEXSTRING>)"
```

Copy the contents of the quoted string under “Available identities” into the “iOS specific” section of your `buildozer.spec` file, remembering to uncomment both `ios.codesign` lines. See [Example 9-3](#) (other than this section, the file is unmodified from [Example 9-1](#)).

Example 9-3. Buildozer specification for an iOS build

```
#  
# iOS specific  
  
# (str) Name of the certificate to use for signing the debug version  
# Get a list of available identities: buildozer ios list_identities  
ios.codesign.debug = "iPhone Developer: Dustin Phillips (XAQ2M755YE)"  
  
# (str) Name of the certificate to use for signing the release version  
ios.codesign.release = %(ios.codesign.debug)s
```

Now you can run the command `buildozer ios debug deploy run`, similarly to the Android deployment. If all goes well, your Kivy app should run cleanly on your iOS device.

Buildozer Dependencies on Mac OS

The first time I ran Buildozer on my Mac, it complained about some missing packages, including `pkgconfig`, `autoconf`, and `automake`. You may have to do some research to figure out how to install these if you don’t already have them. You will have the best luck using `homebrew` or `macports`, very useful tools if you do much Unix programming.

Alternatively, you can manually download and install packages with typical Unix commands (available if you have XCode installed). For example, I had to download the [latest version of pkg-config](#) and install it using the typical Unix process:

```
./configure --with-internal-glib  
make  
sudo make install
```

Unfortunately, I can’t guess which dependencies you might need to install or already have available. Dependency management is an integral part of programming, and you’ll have to get good at it for whichever operating system you choose to use. Normally, the Buildozer process will fail with a clean error message telling you what you need to install, but it won’t tell you how. Stack overflow and a web search are definitely your friends here.

For debugging, you can open XCode and view the logging output from the device, similar to what you see when you run the `logcat` command on Android. The command `buildozer xcode` will open the actual XCode project associated with your Kivy project.

Android Bonus: Accessing the GPS

Before I get into this section, I want to apologize to iOS users for not including them. The Kivy team has developed an API for accessing native features (including the accelerometer, camera, GPS, and notifications) on a variety of operating systems. Sadly, like Buildozer, the library is still in alpha as I write this, and the only feature supported on iOS is the accelerometer. The good news is that you can use this API with your Android device, and once the Kivy team adds support for iOS devices, your code should run virtually unmodified. The even better news is that all Kivy libraries are completely open source, and the team would be delighted to receive a pull request if you add iOS support for their API.

If you aren't currently deploying to an Android device, you can skip to the next section.

The Kivy team has created an awesome library called `pyjnius` that allows you to access Java classes from inside Python. This is how they provide all the Kivy goodness on Android. There is a similar library for accessing Objective-C classes on iOS called `pyobjus`. Both of these are very powerful, but they require a deep knowledge of the underlying classes being accessed. Fortunately, the Kivy team has also created a platform-independent API called `plyer` that wraps these features in an easy-to-use and consistent Python API.

The `plyer` library is not bundled with Kivy, so you'll need to install it yourself. You can do this through Git or by downloading the ZIP file as you did with Buildozer. The command `python setup.py install` should install it for you.

The next step is to hook up the Current Location button on the Add Location form to a method that knows how to use the GPS. [Example 9-4](#) illustrates.

Example 9-4. Callback for the Current Location button

```
Button:  
    text: "Current Location"  
    size_hint_x: 25  
    on_press: root.current_location()
```

Of course, this will just crash the app if you don't actually add the method being called. You'll need a few new imports first, as shown in [Example 9-5](#).

Example 9-5. Imports for accessing the GPS

```
from plyer import gps  
from kivy.clock import Clock, mainthread  
from kivy.uix.popup import Popup  
from kivy.uix.label import Label
```

The method itself, along with a stub callback, is displayed in [Example 9-6](#).

Example 9-6. Start accessing the GPS and show a pop-up if it's not available

```
def current_location(self):
    try:
        gps.configure(on_location=self.on_location)
        gps.start()
    except NotImplementedError:
        popup = Popup(title="GPS Error",
                      content=Label(text="GPS support is not implemented on your platform"))
        ).open()
    Clock.schedule_once(lambda d: popup.dismiss(), 3)

@mainthread
def on_location(self, **kwargs):
    print(kwargs)
```

The `@mainthread` decorator essentially wraps the method in a `Clock.schedule_once` call so that it always runs on the main Kivy thread. Depending on the underlying implementation, the `plyer` GPS module may be executed in a background thread that isn't allowed to access the Kivy main loop.

I tested this first on my Linux laptop, for which GPS is not supported. As expected, the pop-up is displayed for three seconds and then disappears. The next step is to check it out on the Android phone. However, before you can do that, you need to add the `plyer` requirement and a couple of permissions to your `buildozer.spec` file, as shown in [Example 9-7](#) and [Example 9-8](#).

Example 9-7. Accessing GPS permissions

```
# (list) Permissions
android.permissions = INTERNET,ACCESS_FINE_LOCATION,ACCESS_COARSE_LOCATION
```

Example 9-8. Depending on plyer

```
# (list) Application requirements
requirements = kivy,plyer
```

If you now run `buildozer android debug deploy run logcat`, your app should pop up on the phone, and when you click the Current Location button on the Add Location form, you should get some output on the console. Now all you need to do is implement the `on_location` function to look up the user's current location on Open Weather Map. Luckily, Open Weather Map has an API to request by latitude and longitude. We could request the weather details that way, but as you can see in [Example 9-9](#), I cheated and just grabbed the location from the response. Then I pass this into the `show_current_weather` method, and presto, everything works!

Example 9-9. Looking up the location on Open Weather Map

```
@mainthread
def on_location(self, **kwargs):
```

```
search_template = "http://api.openweathermap.org/data/2.5/" +
    "weather?lat={}&lon={}"
search_url = search_template.format(kwargs['lat'], kwargs['lon'])
data = requests.get(search_url).json()
location = (data['sys']['country'], data['name'])
WeatherApp.get_running_app().root.show_current_weather(location)
```

Run `buildozer android debug deploy` run again. If you hit up the Add Location form and touch Current Weather, it should locate you (if your GPS is on) and search for the weather wherever you are.

Keeping It Running

You'll notice that as soon as the screen turns off, your Kivy app exits, and it restarts when you turn it on again. This isn't a horrible thing for a weather application, but it's not exactly desirable. Luckily, Kivy supports a so-called pause mode that allows you to keep the window open. All you have to do is add an `on_pause` method to the `WeatherApp` class that returns `True` instead of the default `False`. See [Example 9-10](#).

Example 9-10. Enabling pause on mobile

```
def on_pause(self):
    return True
```

Deploy it to your phone using Buildozer, and you can switch back and forth between your Kivy app and other applications with ease.

File It All Away

Your Kivy app is functionally complete! It runs on your Android or iOS phone, and you have app files (they live in the `bin` directory) that can be submitted to the Google Play Market or iTunes App Store. In my experience, a program is never finished. However, books have endings, so there are several things I will leave you to explore on your own:

- The `plyer` library provides access to the accelerometer. You could create a “shake to change from forecast to current weather” feature.
- `plyer` also has a notification system that you can integrate in a few different ways.
- If you have Android or iOS experience (or if you want to get some), see if you can figure out how to access other features of the underlying OS using `pyjnius` or `pyobjus`.
- Write another Kivy app from scratch. And another and another!

That's all, folks. I hope you've enjoyed reading this book at least half as much as I've enjoyed writing it. I also hope you've learned even more than I did from the process!

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About the Author

Dusty Phillips is a Canadian software engineer and author. He holds a master's degree in computer science and is an active member of various open source communities, most notably Python, Arch Linux, and Gittip. He has written two previous books and won the 2010 Django Dash.

Colophon

The animal on the cover of *Creating Apps in Kivy* is a kiang (*Equus kiang*). Native to the Tibetan plateau, the kiang is the largest of all wild asses and has never been domesticated. They bear a resemblance to donkeys and mules, although they are generally brown and tan as opposed to gray.

Adult kiangs can reach 13.3 hands (or 55 inches) tall at the shoulder and weigh around 900 pounds. They have large heads with convex muzzles and short, upright manes. A dark brown dorsal stripe reaches from the mane to the tail, a feature that can be found on many varieties of wild ass.

The kiang's Tibetan habitat is mostly alpine meadows and steppe country, where there is plenty of grass and shrubbery for grazing. The only predators the kiang faces, aside from humans, are wolves. The first response of a kiang is to flee from danger, but they will also use their powerful kick to deter an attacker if necessary.

Sometimes kiangs gather together in large herds, but most of the time they are separated into smaller groups. Older males have harems of females that can grow to almost 50 members. Each stallion controls an area of about two square miles, and vicious fights often occur when a younger male challenges a stallion's supremacy.

Although population numbers have declined in recent years due to encroaching human territory and having to share grazing space with farmers' herds, the kiang is still considered a common sight and is not listed as threatened or endangered. In 1950, Thubten Jigme Norbu, the elder brother of the 14th Dalai Lama, was traveling through northern China and observed a herd of kiang moving across the plateau. He wrote, "They look wonderfully graceful and elegant when you see them darting across the steppes like arrows, heads stretched out and tails streaming away behind them in the wind."

The cover image is from Cassell's *Natural History*. The cover fonts are URW Typewriter and Guardian Sans. The text font is Adobe Minion Pro; the heading font is Adobe Myriad Condensed; and the code font is Dalton Maag's Ubuntu Mono.